UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Department of Management Science

Pension fund and fund manager performance measurement

by

B. E. Morris, B.Sc. (Hons)

Thesis submitted for the degree of Master of Philosophy of the University of London and the Diploma of Membership of the Imperial College of Science and Technology.

LONDON, January, 1979

PENSION FUND AND FUND MANAGER

PERFORMANCE MEASUREMENT

by B.E. MORRIS

In the absence of any published comprehensive survey of the different available techniques for estimating the time-weighted rate of return and for analysing portfolio performance into components of return, this study examines all available published material plus existing commercial services to eventually identify certain approaches which are argued to be the best alternatives from an overall point of view. Alternative methods are in each case considered on the basis of their merits from both a theoretical and practical viewpoint. It is concluded that the estimation of a fund's time-weighted rate of return is best achieved through the use of an approximation first suggested by the Society of Investment Analysts. A performance analysis system which is the best compromise between useful and accurate feedback on the one hand, and simplicity and ease of understanding on the other, is chosen here as a combination of the best features of existing analysis systems, but without the respective disadvantages.

Existing risk-adjusted performance measures based on the Capital Asset Pricing Model (CAPM) are rejected as being too impractical for application to pension funds. This study shows however that the basic ideas of the CAPM can be used to derive a risk-adjusted measure of portfolio performance which has some major advantages (in practical terms) over the traditional CAPM-derived measures. This measure is derived through the application of CAPM ideas to the wider context of a market consisting of many sectors, rather than just the equity sector to which all uses of the CAPM seem to restrict themselves. It is shown that this process is in fact equivalent to the combination of academic work on risk-adjustment with what has been the separate development in the professional literature of methods for the decomposition of return into components of performance.

Finally, the methods chosen as best were embodied in a software package which was written as the major piece of practical work in this study. The software was applied to the data of 5 pension funds over a number of years in order to prove its validity. It also embodies other contributions of this thesis, such as a set of components for the analysis of overseas performance and a refinement of investment simulation relative to previously suggested methods. It is argued that the package forms the basis for a management reporting system which is suitable for a financial institution which specialises in pension fund management.

ACKNOWLEDGEMENTS

Involved in the whole of this study were my supervisor, Anne Benjamin, and the co-operating parent and merchant bank which provided the initial stimulus and data, without which this work could not have had its practical bent. The author is particularly grateful to the Operational Research Group of the parent bank, which has taken an interest in and fostered this project from beginning to end. The co-operation of stockbrokers Phillips and Drew and the London Business School in the provision of indices is also gratefully acknowledged.

The patience and artistic skill of my wife Ruth is evident in every diagram, while the excellent typing performance of Miss Karen Bamping was beyond measurement.

CONTENTS

ABSTRACT

ACKNOWLEDGEMENTS

LIST OF TABLES (viii)

LIST OF FIGURES (ix) - (xi)

LIST OF NOTATION (xii) - (xv)

PART A - PERFORMANCE MEASUREMENT

PAGE

1. INTRODUCTION 1

I. Pension funds as institutional investors 1
II. Why measure performance? 3
III. Increasing interest in performance measurement 4
IV. Previous work 8
V. Aims and organisation of this study 10
VI. Source of data 11
VII. Performance measurement of other types of portfolios 13

2. CONCEPTUAL PROBLEMS OF PERFORMANCE MEASUREMENT 14

I. Measuring fund performance 14
II. Measuring fund manager performance 15
III. Valuation of assets 18

3. RATE OF RETURN MEASURES 25

I. Continuous versus discrete compounding 25
II. Ideal properties of a ROR measure 26
III. Money-weighted rate of return 27
IV. Time-weighted rate of return 28
V. Comparison of MWR and TWR 32
VI. ROR measures used in this study 40

4. ESTIMATION OF RATES OF RETURN 41

I. Estimation of the money-weighted ROR 41
II. Estimation of the time-weighted ROR 43
III. Relative merits of TWR approximations 64
IV. TWR estimation method used in this study 71

PART B - ANALYSIS OF PERFORMANCE

PAGE

5. GENERAL PRINCIPLES OF ANALYSIS SYSTEMS 74

I. Need for performance analysis 74
II. Classification of performance analysis methods 77
III. Choice of coverage 79
IV. Notional versus inter-fund standard of comparison 79
V. Choice of internal standard 90
VI. Components of performance 94
VII. Symbolic representation of component analysis 98
VIII. Choice of mathemetical structure 103
IX. Choice of type of portfolio decomposition 110
X. Choice of reference point 115
XI. Model fund reference points 119
XII. Choice of components and auxiliary analyses 126
XIII. Components of overseas performance 135

6. SURVEY OF EXISTING PERFORMANCE ANALYSIS SYSTEMS AND SOME PROPOSED NEW ONES 141

I. Additive dynamic portfolio decompositions 141
II. Multiplicative dynamic portfolio decomposition 145
III. Additive constant portfolio decomposition 145
IV. Multiplicative constant portfolio decomposition 149
V. Inter-fund comparisons 153
VI. Ideal characteristics of a performance analysis system 154
VII. Relative merits of existing systems 158
VIII. Previously unconsidered variations of systems 160
IX. Performance analysis system used in this study 163

PART C - RISK

7. PORTFOLIO RISK AND THE CAPITAL ASSET PRICING MODEL 164

I. Definition of risk 164
II. Net versus gross risk 168
III. Measurement of risk 169
IV. Relation between risk and return 174
V. Logic behind risk adjustment of performance 175
VI. Capital asset pricing theory 182
VII. Differences between CAPM and average risk/return relationship 192

PAGE

8. ADJUSTMENT OF PERFORMANCE FOR RISK 194

I. Risk-adjusted performance measures 194
II. Realism of the C.A.P.M. 202
III. Evidence for the validity of the CAPM 205
IV. Usefulness of CAPM risk-adjusted performance measures 208
V. Components of performance as risk-adjusted measures of performance 212
VI. The equivalent components 219
VII. Risk-adjusted performance measured in this study 226

PART D - SPECIFICATION AND USE OF THE SOFTWARE PACKAGE

9. INDICES 228

I. Factors affecting choice of an index 228
II. Problems of using indices 230
III. Available sector indices 231
IV. Construction of notional portfolios 245

10. SYSTEM DESIGN AND INPUT REQUIREMENTS 251

I. Published performance measurement system designs 251
II. System design in this study 253
III. Level of analysis 264
IV. Input data 265
V. Input data modification 286
VI. Estimation of unknown income figures 289

11. TECHNICAL SPECIFICATION OF METHODS 302

I. SIA's simulation method 302
II. Simulation method of this study 308
III. Organisation of the simulation in the program 322
IV. Estimation of income data 324
V. Simulation of overseas performance 324
VI. Calculation of RORs for the whole fund 325
VII. Contents and organisation of history files 331
VIII. Organisation of files and fund reviews 339
IX. Miscellaneous statistics 342

12. FUND PERFORMANCE REPORT 348

I. Format of a report 348
II. Interpretation of current performance results 361
III. Funds analysed in this study 375
IV. Performance of the five funds 378
V. Interpretation of current versus past performance results 390
VI. Validation of the software 400

PAGE

13. FUND COMPARISON REPORT 403

I. Input requirements 405
II. Interpretation 410
III. Use of the report 417

14. CONCLUSIONS 422

I. Rate of return estimation 422
II. Analysis of performance 423
III. Adjustment of performance for risk 425
IV. Suggestions for further work 427

REFERENCES 431

APPENDICES

3-I The BAI formula for the TWR 439
4-I Effect on MWR of ignoring interest-on-interest 440
5-I Use of U.K. govt. statistics to derive a proxy for the average U.K. pension fund 442
6-I Eadie's additive constant portfolio decomposition 445
9-I Market-wide composite gilt index 448
9-II Notional income indices 450

10-I Formats of input data 452
10-II Error messages 456
10-III Computer routines to do data modifications 457

11-I Computer routines concerned with investment simulation 459
11-II Income estimation 463
11-III Computer routines concerned with overseas sector investment simulation 476
11-IV Computer routines concerned with ROR estimation 477
11-V Computer routines concerned with simulated charges 479
11-VI Computer routines concerned with historical data 480
11-VII Program WRITER 485

12-I Extracts from a Fund Performance Report over a review period of one year 494

13-I Extracts from a Fund Comparison Report with a larger number of funds 496
13-II Program REPORT 502

LIST OF TABLES

TABLE	TITLE	PAGE
3.1	Conceptual comparison of TWR and MWR	33
3.2	Examples of the difference between the MWR and TWR	34
4.1	Various approximations to MWR	44
5.1	Society of Investment Analyst's (additive) components system	101
5.2	S.I.A.'s system of components expressed with a multiplicative structure	105
5.3	Example of an (additive) constant portfolio performance analysis system	114
5.4	Additive system with both initial fund and trustee policy reference points	117
5.5(a)	Additive system using both model and trustee reference points	120
5.5(b)	SIA's additive system with a timing component	120
6.1	Specification of published and/or marketed additive dynamic portfolio performance analysis systems	142
6.2	Specification of published and/or additive constant portfolio performance analysis systems	147
6.3	Specification of published and/or multiplicative constant portfolio performance analysis systems	148
6.4	Previously unconsidered variations on existing performance analysis systems	161
11.1	Charges used for investment simulation by software	314
11.2	Example of calculation of a realignment charge	314
12.2	Characteristics of the 5 funds used to test the software	376
12.3	Performance statistics relating to the "market" of the 5 funds reviewed in this study	380,381
12.4	Estimated error in estimation of TWR	403
14.1	Parallels in ROR analysis and risk analysis	426

LIST OF FIGURES

FIGURE	TITLE	PAGE
4.1	Schematic representation of actual fund and market during review period with one money flow	60
5.1	Decisions in the creation of a performance measurement system	78
6.1	Logic of 13 existing performance analysis systems, plus that used in this study	142
7.1	See text: I.1, Ch.7	167
7.2	Position of 7 hypothetical funds in risk-return space	176
7.3	Line of best fit through scatter of risk/return points	176
7.4	Curve of best fit through scatter of risk/return points	176
7.5	Risk-adjusted performance assessment using fitted average linear relationship	176
7.6	Risk-adjusted performance assessment using fitted average non-linear relationship	176
7.7	Application of notional risk/return line to risk-adjusted performance assessment	180
7.8	Indifference curves of risk-averse investors and Markowitz frontier of efficient investments	180
7.9	Various combinations of riskless asset and market portfolio	180
8.1	Jensen's α in terms of the regression to estimate it	196
8.2	Jensen's α in terms of the SML	196
8.3	Treynor's risk-adjusted measure of performance	196
8.4	Sharpe's risk-adjusted measure of performance	196
8.5	CML with different borrowing and lending rates	203
8.6	CML with investors of different credit ratings	203
8.7	CML with transaction costs	203
8.8	CML with no riskless asset	203
8.9	Fama's CAPM decompostion of total excess return	214
8.10	Additive decomposition system with model fund primary reference point	214
8.11	Decomposition of performance using index simulation with an unspecified risk/return relationship	224
8.12	Graphical representation according to CAPM theory of the risk-adjusted measure E of this study	224

FIGURE	TITLE	PAGE
9.1	F.T.A. British government securities all-stocks price index and composite P & D index	238
9.2	F.T.A. British government securities all-stock income index and composite P&D income index	239
10.1	Over-view of Fox's performance measurement system	252
10.2	Over-view of the calculation system recommended by the B.A.I.	254
10.3	Over-view of system design of this study	256,257
10.4	Over-view of system design giving file and subroutine names	258,259
10.5	Format of a market data file	267
10.6	Format of a model type file	268
10.7	Format of a fund data file	269
10.8	Fund data file with NO POLICY option	274
10.9	Fund data file with default new money details option	274
10.10	Fund data file with SOME repaid new money option	277
10.11	Fund data file for batch run of 3 funds	281
10.12	Fund data file for review period of one month	282
10.13	Fund data file for review period of two months	282
10.14	Fund data file for one year	283
10.15	Selected error messages	285
10.16	Fund data file with "capital value only" option	292
10.17	Fund data file with NOTIONAL option	292
10.18	Fund data file with GRAND TOTAL option	294
10.19	Fund data file with MONTHLY TOTALS option	294
10.20	Fund data file with SECTOR TOTALS option	295
10.21	Fund data file with PARTIAL option	295
10.22	PARTIAL and GRAND TOTAL options	298
10.23	PARTIAL and MONTHLY TOTAL options	298
10.24	PARTIAL and SECTOR TOTALS options	299
10.25	PARTIAL and GRAND TOTAL option (3 sectors)	299
11.1	Flow chart of SIA's simulation method	303
11.2	Flow chart of simulation method of this study	309,310
11.3	Actual and assumed commission rates for equities	312
11.4	Actual and assumed commission rates for gilts	312
11.5	Schematic representation of ROR of total fund, non-cash sector and cash sector	326
11.6	Format of model history file	332
11.7	Format of fund history file	337
11.8	Variation of estimates of risk relative to the market as number of observation grows	345

FIGURE	TITLE	PAGE
12.1	Example of a complete Fund Performance Report	349-360
12.2	Components of performance of Fund C in terms of CAPM theory	365
12.3	Timing measures with sharp market movement	368
12.4	Data files associated with Figure 12.3	369
12.5	Components of overseas performance with adverse exchange rate movements	374
12.6	Performance of funds A to E in risk/return space	384
12.7	Components of performance of Fund E	384
12.8	Components of performance of Fund B	387
12.9	Cumulative ROR tables when fund and model patterns of accumulation differ	392
12.10	Fund data file for SIA example	395
12.11	Fund data file for Kingston's example	395
12.12	Fund Performance Report for SIA example	396,397
12.13	Fund Performance Report for Kingston's example	398,399
12.14	Fund Performance Report for artificial test for bias	404
13.1	Over-view of design of program REPORT	406
13.2	Format of Parameters file	407
13.3	Format of Reference file	407
13.4	Example of a Fund Comparison Report	411-414
13.5	Risk-adjusted performance over two successive periods of a fund which adjusts its risk	420

LIST OF NOTATION

The following notation may be taken as standard throughout this thesis unless the surrounding text indicates otherwise.

THE REVIEW PERIOD IN GENERAL

n = Length of the review period in terms of number of sub-periods.

$t(i)$ = Time of the ith event (eg i^{th} new money flow).

$l(i) = t(i) - t(i-1)$ is length of time between the ith and $(i-1)^{th}$ events.

SUBSCRIPTS

t denotes at time t during the review period, which may be measured in sub-period (eg. I_t)

$t(i)$ denotes as at time of ith event (eg $C_{t(i)}$)

m denotes either model fund or market (eg π_m or R_m)

p denotes either trustee policy fund (eg π_p) or "of the portfolio" (eg. R_p)

b denotes beginning, or initial, fund (eg π_b)

a denotes actual fund (e.g. π_a)

SUPERSCRIPTS

s denotes a sector of the fund, or the market, in general This may have special values of

c = cash sector

os = overseas sector

A tilde $\sim$ denotes a random variable (eg. $\tilde{R}_p$)

A bar $-$ denotes an average (eg. $\bar{C}$)

RATES OF RETURN

ROR is to be read as "rate of return"

MWR is to be read as "money-weighted rate of return"

TWR is to be read as "time-weighted rate of return"

r = A rate of return in general

R = A rate of return in the market

a = An annualised rate of return

THE MARKET

R_m = Rate of return in the market over the review period

E_t^p = Premium rate of exchange (price of £1) at time t

E_t^o = Ordinary rate of exchange at time t

E_t^e = Effective (penalised) rate of exchange at time t after allowance for premium surrender rule

α = Percentage of the premium which must be surrendered

W = A weight in general which is derived from market data

THE FUND

S = Number of sectors in which the fund is invested

MV_t = Market value of the fund at time t (eg. MV_o)

MV'_t = Market value of the initial fund at time t (as if it was frozen and unchanged)

C = Volume of new money

m = Number of new money flows during the review period

P = Net purchases by the fund

I = Income earned by the fund, possibly net of tax

GI = Gross Income earned by the fund

R = Income repaid by the fund to the trustees, possibly net of tax

GR = Gross income repaid by the fund to the trustees

GRT = Total gross income which was repaid to either trustees or as tax.

INDEX QUANTITIES

X_t^s = Index value as at time t of sth sector

IX_t^s = Income index value as at time t of sth sector

XH_t^s = Number of index units held of the sth sector as at time t

CX_t^s = New money during t^{th} sub-period which was invested in sector s in terms of number of index units of that sector

NI_t^s = Notional income earned from the holding of index units of the sth sector during the tth sub-period

z_s = Commission charge for transactions in the sth sector (allowing for different rates for buying and selling)

Z = Total simulated dealing cost for a portfolio realignment

NOTIONAL FUNDS

π = A matrix of profile proportions, the first column of which gives the initial distribution of the notional fund between sectors. Subsequent columns give the profiles with which new money flows during the period are to be notionally invested between sectors. (eg. π_m)

π^o = A special case of π where all columns but the first are zero. (eg. π_m^o)

$V(\pi)$ = Depending on context, either: Final value as at the end of the review period of a notional portfolio based on profiles π

or : The notional portfolio itself which is based on profiles

$I(\pi)$ = Total gross income earned over the review period by a notional portfolio based on

$r(\pi)$ = ROR on a notional portfolio based on profiles over the review period (usually a money-weighted RWR)

$\beta(\pi)$ = Systematic risk measure of a notional portfolio based on profile

$MWR(\pi)$ = Money-weighted ROR of a notional portfolio based on

$TWR(\pi)$ = Time-weighted ROR of a notional portfolio based on

MWN = Money-weighted rate of return on a notional portfolio based on the profiles π_a of the actual fund and the same amounts of new money and sector switches during the review period

TWN = Time-weighted rate of return on a notional portfolio based on the initial profile of the actual fund but with no new money.

MVN_n = Final market value of a notional portfolio based on the initial profiles of the actual fund and the same amounts of new money and sector switches during the review period

MVN'_n = Final market value of a notional portfolio based on the initial profile of the actual fund but with no new money or sector switches during the period

RISK AND RISK ADJUSTMENT

α_p or α_i = Jensen's risk-adjusted performance measure

T = Treynor's risk-adjusted performance measure

RV = Sharpe's risk-adjusted performance measure

σ = Total risk of a portfolio

β = Systematic risk of a portfolio

λ = Risk premium in the market = $\dfrac{R_m - R_f}{\sigma_m^2}$

R_f = Risk-free rate of return

ρ = Correlation co-efficient

CAPM = Capital asset pricing model

SML = Securities market line

CML = Capital market line

SD = Standard deviation

SSD = Semi-standard deviation

MAD = Mean absolute deviation

FILES

Certain data fields in files are indicated by an alphanumeric code. The alphabetic part indicates which file, while the number refers to the field in this file. (eg. F6)

M denotes Market data file

T denotes Model Type file

F denotes Fund data file

MH denotes Model History file

FH denotes Fund History file

P denotes Parameters file (for program REPORT)

R denotes Reference file (for program REPORT)

MISCELLANEOUS

p = Premium rate of return relative to some standard

w = A weight in general, usually based on fund data

Y_t or y_t = Income yield as at time t

BAI = Bank Administration Institute

SIA = Society of Investment Analysts

PART A

PERFORMANCE MEASUREMENT

CHAPTER ONE

INTRODUCTION

This chapter aims to give some essential perspective to the rest of this thesis by outlining the reasons for the importance of the assessment of pension fund performance and by describing the background to this study. Although this thesis concentrates exclusively on performance appraisal, it must always be borne in mind that the conduct of any investment activity is usually more important than its measurement, and that the latter only derives its importance from the extent to which it can assist the former.

> "The mere act of performance measurement is not, of itself, going to improve results, but it must focus attention on the important decisions, and therein lies the hope of getting better results."[1]

I. PENSION FUNDS AS INSTITUTIONAL INVESTORS

Pensions funds have as their main objective the ensurance that money saved during the working lifetimes of members is used to provide sufficient funds upon their retirement to enable the payment of pensions which have adequate purchasing power throughout their retirement. The "savings" typically come from both employees (as deductions from salaries) and employers (as appropriations from profits). Exactly how and by whom a pension plan should be funded is a matter of growing

---

1: M.G. Hall in Holbrook(41,p70)

controversy and is beyond the limits of this study. However, there is little controversy about what the objective of investing the pension fund should be. A practising investment manager of a pension fund expresses this as follows (37,p245).

> "Having regard to the nature of the liabilities, the objective should be to maximise the rate of return by investments which involve an acceptable level of risk."

Hence the investment of pension funds has always been a chief concern of pension plan management.

There are usually 4 main areas of management of a pension plan. These are as follows:-

1. The Trustees

   This is a governing body of persons whose general responsibility is to see that the plan is run efficiently and meets its objectives.

2. The Administration, which deals with the generation of the plan (distribution of benefits etc.).

3. The Fund Manager

   The Management of the fund's investments, because of its complexity, is usually delegated to an outside firm of investment managers who specialise in the management of large investment portfolios.

4. The Actuary

   Another complex task, delegated to an actuary, is to assess the degree to which current provisions (i.e., contributions) match expected future liabilities. (i.e., pension benefits).

This study aims to deal with one of the problems connected with the investment area. This is the provision of information on how successfully a fund manager has invested the funds with which he has been entrusted.

II. WHY MEASURE PERFORMANCE?

The need to measure performance is simply analogous to the need for any kind of management information. These needs are as follows:-

1. The sheer size of pension funds

   Section III below will mention some statistics on the large volume of pension fund money which is currently being invested in the U.K. economy (and overseas). The responsibility of looking after such large volumes automatically implies an obligation to monitor as accuractely as possible its growth and how well it is being managed.

2. To enhance the accountability of investment personnel.

   "Public" declaration of investment results will not only act as an incentive to a fund manager, but also to the trustees, to improve the fund's performance. Callan(9) argues that improvement in the performance of fund managers inevitably follows the introduction of performance assessment.

3. To provide feedback to the fund manager

   Investment is today so complex and the markets so volatile that gone are the days when a manager could rely on an intuitive appreciation of how good performance was, or the reasons for good or bad performance. Although it can be argued that it is difficult to learn from the past in the art of investment, an analysis of the causes of past performance can nevertheless help to pinpoint consistently weak or strong practices.

4. To provide feedback to the trustees

Trustees delegate investment responsibilities to a manager to a degree which varies greatly from fund to fund. An objective quantification of how a policy restriction has affected investment performance is a very effective way for a fund manager to persuade the trustees that restrictions should be relaxed.

5. To aid communication between trustees and manager.

6. To provide feedback to the plan's actuary

To extrapolate the future value of the pension fund in order to see how well it matches expected future liabilities, the actuary must assume a future rate of return to be earned on the existing reserve of funds. An accurate record of past performance assists the formation of a more reliable assumption.

7. To increase knowledge at industry level

Holbrook(41) shows that the analysis of performance data for a large number of funds can demolish traditional beliefs which were offered by trustees and managers alike as explanations of otherwise apparently inexplicable results.

III. INCREASING INTEREST IN PERFORMANCE MEASUREMENT

Superfically, the concept and measurement of investment performance are simple matters. Indeed, this was the case just a few decades ago. Since then however many factors have complicated the concept of investment portfolio performance to the extent that today there are as many ways of measuring performance as there are of defining it. Such an increase in complexity (some would say "obscurity") is rarely justified

without a corresponding purpose, and performance measurement is no exception. The rapidly increased supply of measurement techniques has been in response to a growing demand for feedback on investment performance which not only copes with a more difficult investment environment but provides greater analysis of the reasons for performance, rather than just a purely descriptive rate of return statement.

The traditional approach to pension fund investment used to centre on the principle of matching assets to liabilities. In more stable times than today, the maturity structure of a pension plan's liabilities could be matched by the maturity structure of its assets by simply investing in gilts and insurance annuities, which would be guaranteed to yield a real rate of return. The measurement of investment performance was also a relatively simple matter. The annual yield on book values sufficed as an accurate measure of rate of return and the causes of good or bad performance were easily identified by looking at the (relatively stable) gilt market alone.

Several factors began to appear from the late 1950s onwards which gradually rendered this investment approach obsolete. These factors have been the basic causes of the growing interest in performance measurement since then (particularly in the recent decade), and are as follows:-

1. Growth in the size of pension funds

The total market value of pension funds in the U.K. as at the end of 1977 was around £20,000 million, investing around £750 million per quarter.[1] Institutional investors, of which pension funds are major members, collectively own over 50% of the U.K. equity market,[2] and there are predictions (39) that

---

1: U.K. Government Statistics(8)

2: The Observer(60)

they could eventually hold nearly all equity capital. Some writers (41, 15) argue that the pension fund's predominance implies that they determine their own fate in the equity sector. The Wilson Committee presently looking into the operation of City financial institutions is known to be concerned at this remarkable growth of pension fund money.

2. Growth of inflation

Inflation has been the primary enemy of pension funds, whose liabilities grow with inflation but whose assets lose value with it. The appearance of this potentially chronic deficit has forced the management of pension plans to be of a more critical, aggressive and efficient style. Generally speaking, pension plans have responded to inflation on the investment side in three main ways:-

(i) Diversification from gilts alone into equities, overseas investments and property

(ii) They have concentrated on market values, rather than book values, in recognition of the need to boost return via capital appreciation as well as higher income.

(iii) Some funds actively manage their gilt portfolio, a practice which was rare twenty years ago.

(iv) Closer scrutiny of the success or otherwise of current investment policies.

It is through the last point that interest in performance measurement has grown as a result of inflation.

3. Growing volatilities of markets

This has increased the importance of timing decisions in determining investment return. Good timing decisions require frequent information flows of an analytical nature.

4. Demands by fund managers for greater power of discretion.

With increasing pressure to perform, fund managers have demanded the ability to take advantage of more opportunities through greater flexibility and speed of action, instead of lengthy and often costly delays incurred as a result of the need to consult trustees. Trustees have accordingly delegated more freedom to their managers on the one hand but on the other have demanded a closer monitoring of investment performance in order to see that this greater freedom is not misused.

5. Greater government legislation

Recent developments in both the U.K. (new state pension scheme) and the U.S.A. (the Employment Retirement Income Security Act - ERISA (1974)) have meant that the management of pension plans has come under closer legal scrutiny. British employers who have contracted out of the state scheme now have an even greater incentive to closely monitor performance in order to see whether it might be cheaper to not contract out after all.

6. Pensions have become a greater part of the cost of labour

As benefits have been increasingly financed by the employer, the cost as a labour expense has risen

to the extent that some pension funds are treated as profit centres in a business, being charged with the opportunity cost of not using contributions elsewhere inside the business. Great emphasis is placed on the rate of return achieved on invested funds, since it has been estimated (15) that a 1% rise in rate of return can reduce the cost of employer contributions by 10 to 15%. Employers are therefore extremely interested in tracking the investment progress of their fund.

IV. PREVIOUS WORK

A booklet (87) produced by a New York consulting firm in the early 1960s illustrates the general approach to performance measurement which existed before the first major work to change this approach appeared. The booklet described how the internal rate of return (i.e., the discounted cash flow return) should be used to measure fund performance, using either book values, market values or some combination of these two. It states that when comparing the results of different funds, one must subjectively allow for the effect of differences in timing of cash flows and the differing proportions of the funds invested in bonds and equities.

P.O. Dietz(16) drastically reduced the need for such large subjective adjustment when he published his ideas for a method of performance measurement exclusively designed for pension funds. This 1966 publication represented a turning point in the field, and the late 1960s and early 1970s saw a number of articles which improved Dietz's approach. Most of these articles suggested ways in which the usefulness of Dietz's approach could be increased by an analytical decomposition of performance into various components.

With the growth of pension funds and the intense competition which existed in the USA between investment management firms (mostly banks) for clients, the Bank Administration Institute (BAI) (1) in 1968 attempted to derive a uniform standard method for the measurement of pension fund performance.

This method was basically that of Dietz(16). At about the same time however, the first report of a computerised performance measurement system using market indices as a standard of performance appeared (Fox(33)).

The BAI recommendations did not prove popular in the U.K. however[1] and in 1972 the British Society of Investment Analysts (SIA) published a report in an attempt to recommend a standard method of performance assessment. Their report, while supporting the general principles of the BAI report, recommends an approach (based on Fox(33)) which differs completely in detail from the American recommended method.

As if this duplicity of general approaches was not enough, more recent articles have appeared suggesting alternative approaches to that of both the BAI and the SIA. Hence the situation confronting anyone who wishes to measure investment portfolio performance today is that there exists a number of alternative methods, each with their own unique advantages and disadvantages, but none being clearly superior to all of the others:

> "The number of procedures of portfolio performance analyses that have been suggested in the literature seems to be almost as large as the number of contributors to the discussion."[2]

> "Monitoring services range from the calculation of returns for the portfolio to elaborate computer systems which audit all transactions, calculate returns and evaluate the impact of transactions."[3]

> "Thus, anyone interested in measuring investment results is faced with an almost infinite set of academic approaches to the subject and a plethora of commercial services."[4]

The above has not mentioned the parallel development of the measurement of portfolio risk which has independently

---

1: See SIA(76,p4)
2: Cocks(14,p7)
3: Christiansen(11,p26)
4: Dietz(16,p4)

taken place in academic journals over the same period. This will be discussed in Chapter 7.

V. AIMS AND ORGANISATION OF THIS STUDY

With so much prior work on the subject, there was little opportunity for complete originality. There was room however for a contribution to the field in two ways. The first way was to survey and compare on an overall basis all these different approaches to performance measurement. No such survey exists in the literature. The second way was to draw together the two seperate strands of development in performance measurement, represented by the analysis of performance using components and the measurement of risk. The former has developed amongst practisioners in professional journals, while the latter has been largely confined to the academic world. This study draws the two together to show that they have much in common in connection with the adjustment of portfolio performance for risk.

The organisation of this thesis is as follows. The next chapter outlines the technical problems of the measurement of the performance of pension funds, in order to set the stage for the rest of the thesis, which examines various techniques which can either partly or completely overcome these problems. The rest of Part A considers the available measures of the rate of return on a pension fund portfolio, from both the points of view of their theoretical properties (chapter 3) and their practical estimation (chapter 4).

Part B considers the much wider issue of how to analyse the performance of a portfolio. Chapter 5 conducts a survey of all the existing methods of analysis known to the author, classifying them into types according to their basic techniques. Chapter 6 applies the general principles established in the previous chapter to assess the merit of the thirteen British existing measurement systems about which the author could obtain information.

Part C examines the relatively vague question of risk, briefly outlining the academic work on the subject in Chapter 7. The application of the academic theory (namely the Capital Asset Pricing Model, or "CAPM" for short) to the adjustment of portfolio performance for risk is considered in Chapter 8. It is in this chapter that measures based on the CAPM are rejected in favour of a measure which is obtained by simply linking the two seperate strands of performance measurement theory as explained previously.

Finally, Part D describes the applied side of this study in the form of the set of computer programs which were written to embody those techniques of analysis which were chosen in previous chapters as the best of all the alternatives from an overall (practical) point of view. The results of the application of the software to 5 pension funds are used to illustrate the usefulness and interpretation of the performance measurement system's output.

As two final introductory notes, the rest of this chapter gives some background to the origin of the data which was used to prove the software developed, and lastly notes briefly the relevance of this work to the measurement of the performance of portfolios other than pension funds.

VI. SOURCE OF DATA

This study was done with the co-operation of a City merchant bank, one of whose specialist services is the management of pension fund portfolios. The bank employs 6 full-time fund managers, each of whom manages about 5 to 8 funds. They manage between them about £1,000 million of funds. The organisation of the office is similar to that described by Draper(20). The one fund manager is wholly responsible for the funds under his control. Thus there is little specialisation by market sector, but a portfolio is managed in a coherent and responsive manner. Although the managers have different styles (e.g., some relying on security analysis more than others, some trading more than others), there is

usually some uniformity of opinion regarding future market trends, on which formal meetings are held occasionally.

The bank was interested in this study because of its lack of any consistent method of performance measurement of the portfolios under its management. Each is presently measured by an independent body (usually a commerical service) in order to provide the trustees with unbiased feedback on the progress of their portfolios (for which the trustees pay). The problems of this arrangement are as follows:-

1. There is no consistent basis for the comparison of fund performances.

   Each measurement service uses either a different measure of performance or the same measure but estimated in a different way. Thus the performance results of one fund cannot be directly compared to another.

2. There is no consistent method of internal control.

   The measurement services, if they quantify the performance of the fund manager at all, do so in different ways which consequently hinder direct comparisons.

3. The bank does not have the ability to analyse in detail its own performance, either in aggregate or for all the funds of the one manager.

   The feedback from such an analysis can be a valuable management tool for both self-evaluation and management by objectives.

4. Reliance on commercial measurement services is expensive over the long run.

   The option of measuring 30 to 40 funds all on the one system is expensive, either in terms of fees, or in terms of the re-direction of broking business.

VII. PERFORMANCE MEASUREMENT OF OTHER TYPES OF PORTFOLIOS

Dietz(16,Preface) lists some factors which distinguish pension funds from other types of portfolios. He implies that these differences mean that performance measurement methods applicable to pension funds may not be so for other types of portfolios, and that direct comparisons across the two classes would be invalid. These factors are as follows:-

1. Different investment objectives of pension funds. Mature pension funds can be constrained by a need for liquidity whereas a unit trust may wish to be as fully invested as possible, or an income-oriented unit trust may wish to avoid the property sector.

2. Uneven size and timing of cash flows.

   Chapter 3 will explain that these not only effect the technical properties of rate of return measures, but can also influence the strategy with which a fund is managed. Portfolios which receive a steady stream of new money are thus not directly comparable cases.

3. Different legal restrictions for pension funds.

4. Tax exempt status of pension funds.

   This not only alters the technical calculation of performance measures but can affect investment policy also.

All these factors imply that while some aspects of a measurement system for pension funds are equally applicable to other types of portfolios, many are not. No attempt has been made however in this study to identify compatible features of the measures discussed from the point of view of portfolios other than pension funds.

CHAPTER 2

CONCEPTUAL PROBLEMS OF PERFORMANCE MEASUREMENT

The simplest approach to pension fund performance measurement would be to be able to apply standard discounted cash flow techniques to measure fund performance, to directly compare the performance of different funds, and to equate the performance of a manager with that of his fund. In reality none of these operations can be successfully undertaken because of the many conceptual problems which invalidate these approaches. This chapter aims to outline these problems. The severity of the problems is indicated by the following comment, made by Holbrook(41,p25):

> "Practical work on performance analysis is largely concerned with clearing away the misconceptions which arise from the natural desire for simple solutions to complex problems."

I. MEASURING FUND PERFORMANCE

The following are problems of a conceptual nature which have been encountered by attempts to simply measure (let alone analyse) the performance of a pension fund, (as distinct from managerial performance).

1. Validation of the fund's assets

   Probably the most crucial element in the measurement of performance, the method of valuing a fund's net worth is considered in section III of this chapter.

2. Use of an appropriate ROR measure

   There are a multiplicity of approaches, depending on the interest rate at which income is

assumed to be reinvested and the frequency with which it is assumed to be reinvested. The choices have important consequences on the degree to which a ROR reflects fund performance independently of new money or not.

3. Choice of an appropriate time horizon over which performance should be judged.

Many studies[1] show that fund performance is notoriously variable from year to year, with very few funds performing consistently over time. It is only over longer periods that a consistent pattern can be identified, on the basis of which overall performance can be reliably judged.

4. Allowance for the risk taken in achieving a given rate of return.

The question of risk is a very abstract one and is taken up by Chapters 7 and 8.

5. The usefulness of performance results is ultimately determined by their implications for the future. Holbrook (41, Discussion) argues that:

> ".....it is far more important for the trustees to learn how the portfolio is <u>likely</u> to perform than how it <u>did</u> perform."

Holbrook, as a practising actuary, agrees in a sense with many academics. Both are saying that the real use for performance figures lies in what they tell of the future. Academics have expressed this in terms of the need to adjust for risk, which is itself a concept of the future.

II. MEASURING FUND MANAGER PERFORMANCE

Complexity immediately arises concerning this objective because of the basic fact that the performance of a fund and

---

1: See IV.1, Ch.12.

the performance of a fund manager are two very different things. This is so because the manager often does not have complete discretionary control over all aspects of the fund. This implies that certain components of performance will be a direct result of decisions made by the manager, yet other components will be completely beyond his control. Restrictions imposed by trustees on investment policy are the most obvious example. To take an extreme case, if the trustees of a fund specify that their fund is to be invested in gilts only, the performance of that fund is likely to be very poor relative to that of other funds which are heavily invested in the higher yielding equity market. However, the manager of the restricted fund could have done very well by extracting from his gilt investments a very high return, relative to the market rate of return for gilts. The fact that other funds easily achieved a higher rate of return from equities, even if they were not too well managed, makes a superficial comparison of fund rates of return a very unfair measure of the skill and performance of the manager of a restricted fund.

A complete list of the main difficulties in identifying fund manager performance appears below.

1. Heterogeneity of trustee-imposed restrictions.

   A simple comparison of the performance of different funds is rendered meaningless given the variety of possible restrictions which may may be constraining them.

2. Allowance for the effect of trustee-imposed restrictions.

   The heterogeneity of these restrictions amongst funds may be avoided by comparing fund performance to a "benchmark" which is independent of other funds. Even then, any and all restrictions on the fund manager must be allowed for if his true performance is to be assessed. As Chapter 5 will mention, this involves either an adjustment of fund performance to counter-act the inhibiting effect of restrictions, or an adjustment of the benchmark to simulate its value when it is exposed

to the same restrictions as were placed on the fund under review.

3. Heterogeneous sizes and timing of cash flows.

A fund manager usually has no control whatsoever on how much new money the fund will receive from the trustees at any given time, or when he will receive this money. Yet these two factors can substantially effect fund performance though three effects:

(i) They render a discounted cash flow rate of return useless for the purpose of fund manager performance measurement.

(ii) They determine the manager's ability to realise current investment opportunities.

(iii) They determine, for large funds, the degree to which sector switches can be made without loss.

The effect of new money on the discounted cash flow (DCF) rate of return will be considered in the next chapter. It suffices to comment here that because the size and timing of new money flows can materially influence a DCF rate of return, the latter is an inadequate measure of fund manager performance.

The other two effects have as their basic cause the problem of non-marketability which plagues some large funds. The desire to alter the balance of a portfolio is often inhibited by the need to sell investments in such large quantities as to drive the selling price against the vendor. If this desire coincides with the fortuitous arrival of large amounts of new money, the judicious investment of that new money can often assist, or even complete, the achievement

of the desired realignment without the need to sell such large amounts of existing assets.

4. Time horizon for assessment.

The same problem as was described in section I above exists for the assessment of fund managers.

5. Adjustment for risk.

The manager who increases the risk of a portfolio in order to earn a high return may be, in the short term, doing no more of a better job than another manager who is deliberately creating a low-risk portfolio but sacrificing some return in doing so.

6. Adjustment for other external factors.

The performance of a fund can be enhanced by fortuitous events beyond the manager's control in addition to new money. In this context, Chapter 5 will show how the effect of exchange rate changes can be isolated to quantify the performance of the overseas sector of a fund net of the exchange rate factor.

III. VALUATION OF ASSETS

III.1 DESIRABLE CHARACTERISTICS OF A METHOD

Tutt and Tutt(82,p156) quote the following as the most desirable attributes of a valuation method. It should:

1. Produce values which are stable from year to year.

2. Produce realistic values, which are acceptable to both accountants and actuaries in an unmodified form.

3. Be cheap to apply and easy to comprehend.

4. Not either directly or indirectly influence the investment strategy of the fund manger.

5. Include a margin for safety which rises and falls to offset temporary fluctuations in market value.

Regarding the fourth point, a valuation method must fairly reflect the return on assets whether that return is earned via income or capital gain, and whether the assets concerned were bought, sold or simply held throughout the review period. If the method is biased in any way, a cunning investment manager will learn that his measured performance can be increased by slanting his investment strategy towards acts which capitalise on this bias. This was the case when book values were used to value assets. Very often a manager would be reluctant to sell old bonds in times of rising interest rates for fear of large book losses, yet to do so may have produced more profit in the long run. He would also be tempted to sell much of his appreciated stock just before a performance review in order that any capital gain could be realised into book value and so counted.

The fifth point above is the basis for the many methods which exist for combining book and market values together according to a specified formula to produce some sort of weighted average value. The general strategy is to capture the long run appreciation of assets produced by rising market value, but at the same time to prevent the valuation from being radically affected by any short term fluctuations in market value.

It has already been mentioned that book values are not satisfactory in today's more volatile investment climate. The following sub-sections discuss the pros and cons of other valuation methods which have been proposed in the literature.

III. 2. PRESENT VALUE OF INCOME EARNINGS

From a theoretical point of view, the value of an asset to its owner is the discounted present value of all future income streams to be derived from that asset. The practical application of this principle to the valuation of assets has many difficulties however. These are as follows:

1. One must estimate future income streams, which are obviously uncertain.

2. One must assume a long run discount rate.

3. The method is not readily understood by laymen.

4. The method is not very robust to changes in the estimated incomes and discount rate.

5. The method could affect investment strategy if a manager was to learn of, and act on, any biases in the estimation methods.

For these reasons, a present value approach is not a practical valuation method.

III. 3. MARKET VALUE

This is the most popular valuation method, even though it is generally recognised that the method has inherent weaknesses. The advantages of market values have been listed by various authors(16,41,82) as follows:

1. Market values, either rightly or wrongly have been accepted by most people as being objective.

2. They constitute a simple and readily understood method of asset valuation.

3. Values are easily and relatively cheaply obtained.

4. Market values can be regarded as the best available independent estimate of the discounted present

value of all future income streams of an asset.

Under this thesis, the short run volatility of market values is a natural reflection of the varying degree of uncertainty about future income streams as the implications of the most recent information are absorbed by the market. Hence Dietz(16,p49)refers to a market value as a "true economic value".

5. As the market values automatically reflects capital appreciation, no arbitrary rules exist which can tempt a manager to bias his strategy one way or another.

Market values therefore satisfy the third and fourth desirable criteria listed in II.1. Because of the following disadvantages of market values as a valuation method, it is sometimes argued that their use is not valid however:

1. Use of market values implies perfect marketability of assets.

   Quoted prices, particularly regarding equities, refer to marginal sales and purchases. Pension funds typically hold such large blocks of a security that it would be unrealistic to expect the market to absorb a sale of all of the holding at the price quoted, even if the sale is conducted over a period of time. Thus the market value of a large holding of an asset is not its true realisable value, especially at the time of termination of a pension plan.

2. Market values are not a real concensus of opinion, since at any one time there will always be traders who regard a given price as either too dear or too cheap.

3. Dennis(15,p248) argues that market values are becoming less and less of a reflection of discounted present value because of recent developments in the

U.K. market concerning the taxation system and the increasing concentration of the market as institutional investors crowd out private investors.

4. Market values are unrealistic measures of economic value since they are subject to so much short term fluctuation. The rate of return can, in certain market conditions, depend critically on the beginning and end points of time of the review period over which performance is assessed.

The above disadvantages have been answered by the same authors. A truly objective appraisal must admit however that some answers are pure rationalisations in the face of a lack of any better alternatives. The two most serious drawbacks are short run volatility and the assumption of perfect marketability.

Short run volatility is, unfortunately, a fact which must be tolerated if the advantage of simplicity and objectivity are to be retained. Tutt and Tutt(82) argue that at least at an overall level, this volatility may be reduced for a complete portfolio due to the characteristic counter-cyclical fluctuation of gilts and equities, one sector compensating for the other. This pattern has not been evident in recent periods of "stagflation" however. Most proponents of market values point out that the effects of short run fluctuations cancel out as the period over which performance is assessed lengthens. Hence they emphasise that performance statistics over short periods based on market values need to be interpreted with care.

Marketability has become much more of a serious issue in recent years with the rise to predominance of the institutional investor (refer the previous chapter). There are no strong arguments to detract from the seriousness of this problem. Most answers seem to be rationalisations. Dietz(16) regards non-marketability as not so much a valuation problem as it is a type of risk which is taken to capitalise on market values. Holbrook(41, Discussion) points out that any artificial adjustment for the marketability of shares held could lead a manager to bias his strategy to invest

in more marketable, but less profitable, shares.

Finally, there is even debate about whether unrealised capital gain should be included at all in performance figures. Mulligan(58) distinguishes between permanent and temporary capital gains in an attempt to attack the problem of short run volatility. The arguments for including unrealised gain are not decisive. The one main advantage is that it allows the simple and straightforward use of market values. To answer the charge that unrealised gains are not certain, Dietz(16,Ch.4) argues that the manager could realise them if he wished to - if he got his timing right of course. Taylor(78) maintains that higher income potential is often reflected in permanently higher market values. Skelton(74) points out that accountants and trustees are quick to become alarmed about capital losses based on declining market values, so they should be equally quick to recognise capital gains also.

All these doubts prompt many actuaries to rely only on book values and income data in valuing assets.[1] It must be remembered however that their valuation objectives are different from those of performance measurement. They are concerned with the absolute level of resources accumulated in the fund. They want to be certain that this absolute level can be drawn upon to pay future liabilities. Performance measurement is, on the other hand, mostly concerned with the <u>relative</u> change in the level of resources over time, wishing to compare it with the relative change in the market. It may be that for the measurement of such relative changes it is not critical that the levels concerned are not 100% assured.

Hence market values, if they are the most satisfactory compromise between accuracy and practicality for measurement purposes, may be suitable for investment performance analysis but less so for the actuarial side of pension plan management. One can place the onus of establishing just

---

1: See, for example, Skelton(74).

what is certain value and what is not on the actuary. This leaves performance analysis free to concentrate on the extent to which a manager caused his fund to match the market in overall gain, however uncertain some of that gain may be.

III. 4. ADJUSTMENT MARKET VALUES

Any adjustment of market values must be subjective to some degree since it must rely on a basic assumption to distinguish perceived permanent capital gain from temporary short run volatility. Even the long run that trend extracted from past data involves the assumption that trend will continue into the future. Thus although stable values and a margin of safety would be achieved, the valuation method will not be cheap, realistic or completely unbiased.[1]

III. 5. METHOD USED IN THIS STUDY

Market values were used in this study for the reasons discussed in II.3 above. This immediately meant that the presentation of performance figures had to be a careful one, emphasising in each report the long term pattern of results.

While market values can be used carefully in this manner at the moment, this may not always be the case. For as existing pension plans grow to maturity at more or less a uniform rate as the age structure and size of workforce changes, liquidity will become a more important investment objective. At this point, fund valuation for performance assessment purposes may have to assume some of the responsibilities of actuarial measures. The scenario where most plans reach maturity at the same time and all have to start selling large blocks of assets in a market dominated by themselves is a not unlikely one. Marketability will become such a serious issue in this event that it may prevent the use of market values.

1: For a summary of the various techniques, see Kass(44).

CHAPTER THREE

RATE OF RETURN MEASURES

This chapter aims to briefly outline the theory of the two main rate of return (ROR) measures in the literature, the money-weighted rate of return (MWR) and the time-weighted rate of return (TWR).

I. CONTINUOUS VERSUS DISCRETE COMPOUNDING

The Bank Administration Institute (BAI) (1) in their monumental study advocate continuous compounding on the grounds that any other interval is arbitrary and is open to misuse. Sharpe(71,p43) however admits that, while continuous compounding is preferred for its greater mathematical tractability, "the use of continuous compounding in practice is, however, both recent and still relatively rare".

This study has used in its calculations, and wherever possible in its theoretical accounts, discrete compounding. The reasons were simply those of simplicity and fairness. Non-specialists including some fund managers, find it difficult to understand the principle, let alone the relevance, of continuous compounding. Rate of return estimates based on continuous compounding are less than those based on a discrete compounding interval, so that on a superficial level, continuously compounded rates of return can appear to understate performance.

The software package outlined in Part D calculates holding period returns assuming income is reinvested monthly[1]. A monthly compounding period was chosen because, while income is received continuously by a fund, it is usually aggregated on a monthly basis for accounting purposes. Where income is not received directly by a manager, he is usually informed of it on a monthly basis by the trustees.

1: In fact the length of the sub-period can be varied from a month with few changes to the coding. See Chapter 11.

II. IDEAL PROPERTIES OF A ROR MEASURE

Mills(55) was the first to specify criteria which a ROR measure should ideally fulfill. His three principles are as follows:

1. Principle of Equivalent Cash Flow
   Two funds with identical initial and final market values plus identically sized and timed cash flows should have exactly the same ROR.

2. Principle of Equivalent Appreciation
   If the assets of two funds appreciate at identical rates in every sub-period, their performance measures should be identical.

3. Principle of Ordinary Return
   If a fund has no cash flows, then the ROR measure should be that compound interest which accumulates the initial value of the fund to its final value.

The first principle simply means that the ROR measure should be independent of the market environment during the time period over which performance has been measured. That is, it should not be affected by how a final value was achieved (e.g., how many bull and bear markets there were). The second principle requires the ROR measure to be independent of any cash flows into the fund, a most necessary property for its use a means of comparison between funds. Finally the third principle requires a ROR measure to fulfill the normal definition of compound interest.

Mills' paper was an important contribution to performance measurement theory for its clever proof that no single measure can hope to fulfill all three principles. It is a mathematical impossibility.

A more recent work (Cocks(13)) adds a fourth principle in the requirement of a ROR to be disaggregable. If an

overall ROR on a portfolio is to be useful as an analytical tool as well as a descriptive one, Cocks maintains that it must be able to be disaggregated into components in order to explain analytically why performance was at the level it was. Cocks himself explains that this requirement (called here the "Principle of Disaggregation") cannot be satisfied by any ROR measure in the presence of new money, which of course exists in most realistic situations.

The remainder of this chapter is concerned with specifying what ROR measure(s) is least imperfect in terms of Mills' criteria.

III. MONEY-WEIGHTED RATE OF RETURN

The most familiar ROR is variously known as the "internal ROR", "yield to maturity", "discounted ROR", "DCF return", "average compounded ROR" and also "money-weighted ROR" (abbreviated here as MWR).

Let a portfolio be initially valued at MV_o and valued n sub-periods later at MV_n. Then assuming no new money enters or leaves the portfolio during the whole period (consisting of n sub-periods), the money-weighted ROR, r, is given by solution of the standard DCF (discounted cash flow) equation

$$MV_n = (1 + r)^n \, MV_o \qquad - (3.1)$$

or

$$MV_o = (1 + r)^{-n} \, MV_n \qquad - (3.2)$$

If continuous compounding is used, the equation analogous to (3.2) is

$$MV_o = e^{-rn} \, MV_n \qquad - (3.3)$$

The fundamental cause of all technical difficulty concerning the accurate measurement (and indeed analysis also) of performance is the usual occurrence on new money, either in the form of additions to the portfolio or the withdrawal of

funds. If $C_{t(i)}$ is the ith of a total of m net new money flows, the MWR is given by the solution of the more difficult but standard DCF relation

$$MV_o + \sum_{i=1}^{m} \frac{C_{t(i)}}{(1+r)^{t(i)}} = \frac{MV_n}{(1+r)^n} \qquad - (3.4)$$

Using continuous compounding, (3.4) is equivalent to

$$MV_o + \sum_{i=1}^{m} C_{t(i)} e^{-rt(i)} = MV_n e^{-rn} \qquad - (3.5)$$

Both of the above equations indicate that the MWR is an average ROR per unit of currency invested. That is:

1. It is the <u>constant</u> ROR, r, which leads to the capital growth of MV_o to MV_n.

   The same ROR is used to discount the new money flows as is assumed to affect the initial portfolio of size MV_o over the whole period. Hence the MWR is the <u>average</u> appreciation of every pound in the portfolio, including new money.

2. An implicit mathematical assumption is that all income generated during the n sub-periods is reinvested at the same (constant) MWR r.

IV. TIME-WEIGHTED RATE OF RETURN

IV.1 DEFINITION

Dietz's(16) major contribution to performance measurement was his recognition that the MWR is influenced by the size and timing of cash flows (i.e., new money flows), leading to unfair assessments of fund managers as indicated in Chapter 2.

The time-weighted rate of return (TWR) may be concepually regarded as the average of different MWRs, each calculated over a sub-period bounded by successive cash flows into or out of the portfolio. This average is time-weighted (hence its name) in the sense that each MWR is weighted by the length of the sub-period over which it was earned. Let the MWR earned over the ith sub-period (bounded in general by cash flows $C_{t(i-1)}$ and $C_{t(i)}$) be denoted by r_i such that

$$\left[MV_{t(i-1)} + C_{t(i)}\right] (1 + r_i) = MV_{t(i)} \qquad - (3.6)$$

(using (3.1))

$$\text{or} \quad (1 + r_i) = \frac{MV_{t(i)}}{MV_{t(i-1)} + C_{t(i)}} \qquad - (3.7)$$

Then the total ROR factor over n successive such sub-periods will be

$$1 + TWR = \prod_{i-1}^{n} (1 + r_i) \qquad - (3.8)$$

$$= \prod_{i=1}^{n} \frac{MV_{t(i)}}{MV_{t(i-1)} + C_{t(i)}} \qquad - (3.9)$$

The fact that the TWR is a time-weighted geometric average is implicit in (3.9) and may be more clearly seen[1] by expressing each MWR r_i as an annual ROR a_i. Thus

$$(1 + r_i) = (1 + a_i)^{l(i)} \qquad - (3.10)$$

Where $l(i) = t(i) - t(i-1)$ is the length of the ith sub-period

If (3.10) is substituted into (3.8) and the result itself annualised, the annualised TWR factor becomes

---

1: This part of the exposition is adapted from Weaver(84,p164)

$$1 + TWR_{an.} = \prod_{i=1}^{n} (1 + a_i)^{l_i / \sum_{i=1}^{n} l_i} \qquad - (3.11)$$

where the exponent is a weight by time.

With continuous compounding, the TWR becomes a time-weighted arithmetic average of the natural logarithums of the sub-period MWRs.

That is,

$$r_i = \ln \frac{MV_{t(i)}}{MV_{t(i-1)} + {}_{t(i)}} \qquad - (3.12)$$

corresponding to (3.7)

so that

$$TWR = \sum_{i=1}^{n} r_i \qquad - (3.13)$$

corresponding to (3.9)

On an annualised basis,

$$r_i = l(i) \ln a_i \qquad - (3.14)$$

corresponding to (3.10)

so that

$$TWR = \sum_{i=1}^{n} \frac{l(i)}{\sum l(i)} \ln a_i \qquad - (3.15)$$

corresponding to (3.11)

The BAI(1) quote a more obscure definition of the TWR. Its derivation from (3.9) is given in Appendix 3-I.

IV.2 DIFFERENCE TO MONEY-WEIGHTED ROR

The reason for the independence of the TWR from cash flows is simply that all cash flows occur between sub-periods. In correspondence with the two points made in II about the MWR, this implies that:

1. Each cash flow is discounted by only those RORs which occurred after the cash flow's appearance.

This is in contrast to the MWR's assumption of a constant discount rate, r.

2. Income is assumed to be reinvested at the RORs occurring in the sub-periods after that in which it was earned.

Because the constant discount rate r used by the MWR is influenced by the size and timing of the new money flows $C_{t(i)}$ in (3.4), the MWR is affected by new money flows. The above two points illustrate that the TWR has no such property. The Bal study (1 , App. IV) showed that the MWR is in fact a weighted average of sub-period MWRs, where the weight for the ith sub-period is approximately the product of the length of the sub-period (l(i)) and the volume of new money $C_{t(i)}$ which occurred during the sub-period. Hence the MWR is really a "money-and-time-weighted ROR".

An intuitive appreciation of the difference between the two measures may be obtained by reference to an analogy from agriculture. Imagine that two farmers cultivate two adjacent areas of land of equal size and productivity. They each plant the same amount of winter crop, after which a particularly hard winter follows and both farmers' crops suffer to the same extent. At the turn of spring, both farmers are expecting a delivery of the same quantity of summer seed. Farmer A plants all of his delivery but farmer B is unlucky in only receiving half his expected order. Hence he only planted half the amount of seed relative to A. A particularly favourable summer passes, at the end of which farmer A is extremely happy. His average yield for the year, in terms of grain per bag of seed planted, is high due to the fact that he made up in the summer for what he lost in the winter. Farmer B on the other hand has a lower yield for the year. He realises the hard way that the reason why his annual yield is lower is that he did not have the same opportunity to make up for his winter losses because he had only half the summer seed to plant. The greater yield offered by the summer season

acted on a smaller absolute number of seeds and this depressed his average yield for the year appreciably relative to A's.

In a similar vein, the fund which receives more new money (seeds) just before the market appreciates rapidly (a summer season) will enjoy a greater MWR, simply because its MWR is the average return (yield) per unit of currency (bag of seed) in the fund. Continuing the analogy, if the farmers work for the same company, it would be unfair for farmer B's employer to reprimand him for his lower average yield if it was entirely the company's fault that only half of his summer seed was delivered. If the company looked at the yield over winter and summer separately (i.e., the two sub-periods between cash flows) they would realise that B produced in each season the same percentage yield as A.

V. COMPARISON OF MWR AND TWR

V.1 MATHEMATICAL DIFFERENCES

The two measures are so different that they are almost complementary. Table 3.1 indicates this fact. With reference to some of the points in the table:

1. Exact calculation of the TWR would require valuing a fund every two days if that is how frequently it had cash flows.

2. The MWR is more difficult to calculate exactly (given that complete data is available) because (3.4) may have multiple roots for r if cash flows $C_{t(i)}$ oscillate at all in sign (as they can and do for some funds).

3. The MWR's inability to satisfy the Principle of Appreciation is well documented in the literature (see(21),(56) or(71)). Table 3.2(a). quotes the example given by (76,p7). Fund B's extra

TABLE 3.1

Conceptual comparison of TWR and MWR

Characteristic	MWR	TWR	More desirable measure on this characteristic
Basic ROR assumptions	Constant throughout period	Varies between cash flows	TWR
Data requirements for exact calculation	Low (cash flows, MV_o, MV_n)	High (valuation at every cash flow)	MWR
Ease of exact calculation	Difficult (requires iterative process)	Easy (simple ratios)	TWR
Ease of satisfactory approximation	Easy (assume no interest on interest)	Difficult (requires MV estimates)	MWR
Principle of Equivalent cash flow	Satisfies	Does not satisfy	MWR
Principle of Equivalent Appreciation	Does not satisfy	Satisfies	TWR
Principle of Ordinary Return	Satisfies	Satisfies	Either
Principle of Disaggregation	Does not satisfy	Does not satisfy	Neither
Increased difficulty of use for sector RORs	Low (just harder to evaluate)	High (may be undefined)	MWR

TABLE 3.2

Examples of the difference between the MWR and TWR

(a) PRINCIPLE OF EQUIVALENT APPRECIATION

	FUND A	FUND B
Initial value	£1000	£1000
Return during 1st half of year	6%	6%
New money after half year	Nil	£500
Return during 2nd half of year	10%	10%
Final value	£1166	£1716

$$MWR_A = \frac{\text{Profit}}{\text{Av. capital}} = \frac{1166-1000}{1000} = 16.6\% \text{ p.a.}$$

$$MWR_B = \frac{1716-1000-500}{1000 + 500/2} = 17.6\% \text{ p.a.}$$

$$TWR = (1.06)\ (1.10) - 1 = 16.6\% \text{ p.a.}$$

(1.06 x £1000 x 1.10) (1.06 x £1000 x 1.10 + £500 x 1.10)

(b) PRINCIPLE OF EQUIVALENT CASH FLOW

	FUND C	FUND B
Initial value	£1000	£1000
return during 1st half of year	-15%	6%
New money after half year	£500	£500
Return during 2nd half of year	27.1%	10%
Final value	£1716	£1716

$$TWR_C = (0.85)\ (1.271) - 1 = 8.0\% \text{ p.a.}$$

$$TWR_B = (1.06)\ (1.10) - 1 = 16.6\% \text{ p.a.}$$

$$MWR = \frac{\text{Profit}}{\text{Av. capital}} = \frac{1716-1000-500}{1000 + 500/2} = 17.6\% \text{ p.a.}$$

(1000 x 1.06 x 1.10 + 500 x 1.10)

(£100 x 0.85 x 1.271 + 500 x 1.271)

£500 just before the market rose boosted its overall MWR for the year, yet both funds earned an identical TWR.

4. The TWR's inability to satisfy the Principle of Equivalent cash flow is less well illustrated in the literature. In Table 3.2(b) Fund B is identical to that of the previous example in every respect. Fund C has identical cash flows to B and earns the same MWR, yet its TWR is less. The greater losses of Fund C in the first half of the year were balanced by a greater return in the second half of the year to produce an identical overall MWR.

5. The TWR is more difficult to apply to individual sectors because of the more frequent cash flows (since sector switches become new money flows) and the consequential need for more valuations. In addition, as the BAI (1, App II) points out, the TWR may be theorectically undefined if the sector is completely sold or completely purchased during the review period.

Opinions, and one would therefore assume also experience, differ on how critical these differences are when all is said and done. Cocks(14,p10) writes:

> "In particular we can expect that the time-weighted rate of return will not differ greatly from the real rate of return (i.e., MWR) on most large institutional portfolios."

On the other hand, authoritative papers((1),(16)) have viewed the differences in practice to be sufficient to warrant their recommendation of the use of the TWR instead of MWR as a means of comparison between different funds.

The performance results produced for a small sample of funds in this study indicate that while the two measures may

be very similar from quarter to quarter, the cumulative difference between them over years becomes quite significant (refer Chapter 12).

The difference between the two measures will in fact be greater the greater are the following factors:

1. The size of the cash flows $C_{t(i)}$ relative to the initial size of the fund.

2. The degree of variation of sub-period rates of return r_i

   The greater the variation, the less appropriate is the MWR's assumption of a constant return.

3. The length of the review period

   The extra profit or loss made from new money has longer to compound.

4. The "centrality" of the timing of the cash flows

   The closer a cash flow is to the centre of the review period, the more likely it is that the return earned on it will differ from the return r on the initial portfolio.

Indeed, at the extremes of these four factors (i.e., when there is no new money, or sub-period rates of return are all identical, or the review period length is (trivially) zero, or all cash flows are at the very beginning or very end of the review period), the TWR equals the MWR.

Of course, these factors vary tremendously from fund to fund. The average annual TWR obtained for one fund in this study over 4 years differed from its average annual MWR by as much as $2\frac{1}{2}\%$ p.a. Yet for other funds the difference was $\frac{1}{2}\%$.

When reviewed over one year without any intervening valuations, MWR differed from the estimated TWR by as much as 15% p.a. for some sectors[1]. The apparently small size of these differences must be viewed in the context of performance margins in excess of the market which are themselves quite small. To outperform a representative market index by 2% p.a. is a very good result, and a 4% p.a. margin a rarity.

Writing of the U.S. banks' reaction to the BAI's recommended use of the TWR, Berin(5 ,p62) comments:

> 'Observed over a period of years, time-weighted rates of return seem to hover about the dollar weighted rates of return sometimes slightly above, sometimes slightly below:, but there are occasional aberrations in which the time-weighted rates are clearly higher or lower."

Thus the TWR is worth considering, especially when its interpretation can give added dimension to that of a MWR. This is discussed below.

V.2 DIFFERENCES IN INTERPRETATION

Mills(55) pinpointed the main difference in the proper use of these two measures when he wrote that they measure two completely different things. MWR measures the performance of the <u>fund</u>, whereas TWR measures the performance of the fund <u>manager</u>. On the basis of this argument, there would seem to be little use for the MWR except for actuarial purposes. However, various writers have indicated that the TWR is not the universal answer to all the objectives of performance measurement, for the following reasons:

1. MWR is more useful where a standard for comparison is desired
   Holbrook(41 ,p88) comments:

1: These figures are derived from estimates of the TWR

"In presenting results, a statement that the time-weighted return on the equity portfolio was -50.9% in 1974 and +156.4% in 1975 is surely less informative than a statement that the portfolio out-performed the All Share Index by 2% in each year."

In other words, absolute performance measures are of less interest than measures relative to some standard, be it the performance of other funds or the performance of an index.

The TWR is useful for the comparison of the results of different funds because of its independence of the effect of differing cash flows. However, there are other problems in such a comparison, as outlined in Chapter 2. As these problems can rarely be overcome, comparison to an artificial or "notional" standard is popular. When the notional standard is a market index, calculation of the TWR for both the index and the fund is virtually equivalent to calculating the MWR on both, being careful to simulate all cash flows of the fund with hypothetical purchases and sales of index units[2].

2. TWR is an inappropriate ROR measure for decomposition of performance on a sector-by-sector basis.

Both Eadie(21) and Minto(56,p10) warn that the TWR should only be used where new money flows are genuinely beyond the control of managers.

"It is therefore unsound to use the time-weighted rate of return for a component (i.e., sector) of a fund, unless the cash flows into that component are separately determined. If it is used for a component, the effect of timing of investment in that component is completely lost."[1]

The importance of capturing timing effects as a component of performance is explored in XII.2, Ch. 5. Suffice it to say for the moment that the TWR

1: Eadie(21,p13)
2: Refer II. 6, Ch.4

ignores them. For example, a brilliant move by a manager to sell gilts now and invest the proceeds in equities (constituting "new money" from the equity sector's point of view) instead of later, when the equity market has peaked at very high prices, should be reflected in the equity performance measurement of that manager. Cocks(13,p9-10) argues back that there is no such difficulty with the TWR. However his argument concentrates on the TWR for the total fund and ignores the insensitivity of individual sector TWRs.

3. TWR can yield results which may be difficult for trustees to comprehend.

It is conceivable that a fund can have a MWR of 0.0% yet its TWR is either positive or negative. In this situation, laymen may misconstrue the TWR to mean that a profit or loss has been made on the fund while the actuary and commonsense will tell them that the fund has made no progress whatsoever.

4. The TWR does not <u>completely</u> compensate for the effects of new money on fund performance.

Fama(28,p566) comments that new money, when it is received, usually necessitates decisions which have some effect on the performance of the fund and which are not netted out by the TWR. For example, the receipt of a large amount of new money may force a manager to review his investment strategy in view of the important effect which he knows the way in which he invests it will have on the funds' final performance. One fund receiving new money more frequently than another may benefit from more frequent reviews of this nature. Taking Fama's argument further, an immature pension plan will be affected in this manner by new money flows far less

than a mature plan[1]. The fund manager for a very mature fund has liquidity as a major investment objective. If he knows that he can expect a regular flow of new money, he is likely to adopt a near-completely invested position, reaping the usually higher returns from doing so. A mature fund with less certain new money flows cannot afford to adopt such a fully invested position, with a consequential tendency for it to earn a lower rate of return. While the TWR cannot detect such an effect, the use of the MWR in conjunction with an analysis of performance along the lines outlined in ch. 5 can detect it[2]. Thus the TWR constitutes only an arithmetic adjustment and cannot compensate for any indirect effects of new money which are of a behavioural nature.

VI. ROR MEASURES USED IN THIS STUDY

The TWR's ability to at least mathematically compensate for new money flows and so form the basis for inter-fund comparisons within the one office made it a valuable inclusion in the performance measurement system developed in this study. The previous section indicated that the inclusion of the MWR also has many advantages. The MWR was also included in the software written in this study in order to capitalise on its complementary nature as far as its interpretation goes, and in order to form the basis for the analysis of performance. The latter point will become clearer in Chapter 5.

1: "Maturity" refers to the balance of contributions to a plan and the benefits being paid. An immature plan's contributions far exceed its current liability for benefits.

2: Via the Strategy and Policy components of performance, as incorporated into the software of this study.

CHAPTER FOUR

ESTIMATION OF RATES OF RETURN

The estimation of RORs constitutes a different topic from their theoretical properties because their theoretical values are sometimes difficult to quantify exactly in practice. The TWR is by far the more difficult of the two to estimate, causing this chapter to survey the alternative methods of estimating the TWR and eventually identify those methods which are the more preferable on both practical and theoretical grounds.

I. ESTIMATION OF THE MONEY-WEIGHTED ROR

It has already been observed that the MWR is more difficult to calculate exactly than the TWR given complete information, but is easier to approximate given incomplete information.

The solution of (3.4) for the MWR must be an iterative one, either by trial and error or by a suitably convergent algorithum such as the Newtonian procedure suggested by Fisher(31). Weaver(84, p163) has demonstrated an approximation method which, for short review periods, leads to estimates with a tolerable degree of error. (3.4) may be re-written as

$$MV_o\ (1 + r)^n + \sum_{i=1}^{m} C_{t(i)}\ (1 + r)^{n-t(i)} = MV_n \qquad - (4.1)$$

by multiplying (3.4) by $(1 + r)^n$. Let the whole review period be measured as one arbitrary unit of time (so that n=1) and sub-periods measured as fractions of this (so that $t(i) < 1 \forall i$).

Then (4.1) becomes

$$MV_o\ (1 + r) + \sum_{i=1}^{m} C_{t(i)}\ (1 + r)^{1-t(i)} = MV_n \qquad - (4.2)$$

By using the Binomial Series

$$(1 + r)^k = 1 + {}^kC_1 r + {}^kC_2 \frac{r^2}{2!} + {}^kC_3 \frac{r^3}{3!} + \ldots \quad - (4.3)$$

which is convergent for $|r|<1$, the terms

$C_{t(i)} (1 + r)^{1-t(i)}$ in (4.2) may be approximated by

$$C_{t(i)} \left[1 + (1 - t(i)) r\right] \quad - (4.4)$$

Hence (4.2) becomes

$$MV_o(1+r) + \sum_{i=1}^{m} C_{t(i)} + r \sum C_{t(i)} (1-t(i)) = MV_n \quad - (4.5)$$

leading to a solution for MWR as

$$r = \frac{MV_n - MV_o - C}{MV_o + \bar{C}} \quad - (4.6)$$

where $C = \sum_{i=1}^{m} C_{t(i)}$ is the total net new money entering the portfolio during the review period

$$\bar{C} = \sum_{i=1}^{m} (1-t(i)) C_{t(i)} \quad - (4.7)$$

is the average amount of net new money into the fund, each flow being weighted by the time for which it contributed to the total ROR.

Hence the MWR is reduced to the ratio of net profit, including income[1], to average capital employed.

1: The above exposition assumes that all income remains in the fund. The modifactions needed to cater for repaid income and other complications are discussed in Ch. 11.

Various other approximations exist for the MWR, most of which are less accurate than (4.6). These are shown in Table 4.1.

The foundation for the above approximation is the assumption that there is no interest-on-interest effect. That is, only the income on new money, $r\sum C_{t(i)}\ (1-t(i))$ and on the initial portfolio, $r\ MV_o$, is considered. Further income generated by the subsequent reinvestment of this income during the review period is ignored. The allowance for interest-on-interest leads to a far more complex estimate, as Table 4.1 and Appendix 4-I show.

The software of this study uses a modified form of (4.6) to estimate MWRs for three reasons. It is simple yet reasonably accurate, and, most importantly, it is disaggregable. Appendix 4-I shows the sort of magnitude of error involved for some realistic parameters. The critical factors are the length of the review period and the size of the MWR. Both of these determine the absolute size of the interest-on-interest which is ignored. Provided returns are calculated on a quarterly basis, the estimates should not be in signicant error.

The most important quality of the estimate (4.6) is that it can be exactly decomposed linearly into a set of performance components. These components can even be further disaggregated on a sector-by-sector basis. It will be shown in Chapter 5 that (4.6) forms the basis for a system of performance analysis which is most attractive for its relative simplicity.

II. ESTIMATION OF TIME-WEIGHTED ROR

II.1 NEED FOR ESTIMATION

The difficulty of exact calculation lies in the associated tremendous data requirements, which are:

TABLE 4.1

Various approximations to MWR

1. $$\frac{MV_o + \bar{C} \pm \sqrt{(MV_o + \bar{C})^2 - \left[2 \sum t(i)\ (1-t(i))\ C_{t(i)}\right]\left[MV_n - MV_o - C\right]}}{\sum t(i)\ (1-t(i))\ C_{t(i)}}$$

   Based on allowance for interest-on-interest (i.e., taking (4.3) to second order terms - refer App. 4-I)

2. $$\frac{MV_n - MV_o - C}{MV_o + C}$$

   No allowance for interest-on-interest (i.e., taking (4.3) to first order terms only).

3. $$\frac{MV_n - MV_o - C}{MV_o + C/2}$$

   As for #2 but further assume that new money is symmetrically distributed around mid-point of the review period (so that $\bar{C} = C/2$)

4. $$\frac{MV_n - C/2}{MV_o + C/2}$$

   As for #3: $1 + MWR = \dfrac{MV_n - MV_o - C + MV_o + C/2}{MV_o + C/2}$

5. $$\frac{MV_n - MV_o - C}{MV_o}$$

   No allowance for interest (i.e., taking (4.3) to not even first order terms). Sometimes known as the "simple interest" formula.

6. Various additions to the above may be made for repaid income, for which refer to Ch. 11.

1. Exact dates for cash flows

2. A valuation of the portfolio as at each of these dates.

It is rarely the case, unless the accounting system is fully computerised, that the exact dates of all individual cash flows are known. It was certainly not the case with the bank involved in this study, where new money is usually aggregated to a fortnightly or monthly total. Even if these dates were known, it would be prohibitively expensive for a financial institution to obtain valuations for each date for all of 20 to 100 funds under its management. In addition, once sector RORs are contemplated, the number of valuations would be on a daily basis and would be clearly totally impractical. Hence the TWR must be approximated to some degree.

While most authorities agree on the superiority of the TWR as a measure of fund manager performance, the literature is less unaminous, even inconclusive, on the method with which the TWR should be estimated. There have been five suggested methods, as follows:

1. Adoption of a unit accounting system
2. Linked internal ROR method
3. Constant portfolio method
4. Regression method
5. Index simulation method

Each of these methods is outlined in the following sub-sections, after which their relative merits are considered.

II.2 USE OF A UNIT ACCOUNTING SYSTEM

Berin(5 ,p62) heroically proposed that financial institutions could alter their accounting systems to one which reports fund values and trasactions in both dollars and units (similar to Unit Trust Shares). This would facilitate the simple estimation of TWRs since the TWR can be viewed as the increase in value of one unit of a fund.

As financial institutions are unlikely to want to dismantle existing accounting systems just to produce more accurate TWR estimates, this method can be safely ignored.

II.3 LINKED INTERNAL ROR METHOD

Expressed at its simplest level, this method involves valuing the portfolio as frequently as possible, calculating the MWR between valuation and hoping that the combination, or linkage, of these returns yields an overall estimate which is not too inaccurate.

Dietz(16) first proposed the method, after which the BAI(1) generalised it slightly to the following procedure:

1. Divide the review period into n arbitrary sub-periods whose boundaries occur at times t(i), i = 1 to n. They need not be of equal length, l(i).

2. Obtain market valuations $MV_{t(i)}$ at times t(i), i = 1 to n.

3. Identify the exact dates of all cash flows during the period.

4. For each of the n sub-periods, calculate the MWR (called by this method the "internal ROR") earned over that sub-period. Let this be r_i, estimated in any of the ways discussed in section I of this chapter.

5. Estimate the TWR over the whole review period by taking a weighted average of the sub-period internal RORs r_i, where the weights are the lengths of the sub-periods.

Thus the TWR estimate is TWR in

$$1 + TWR = \prod_{i=1}^{n} (1 + r_i) \qquad - (4.8)$$

which can be regarded as a weighted average in the same way as (3.11) is related to (3.8).

II.3.1 ADVANTAGES AND DISADVANTAGES

The main advantage of this technique over these alternatives is that it is relatively simple. The main disadvantages are twofold:

1. It may not be very accurate if the sub-periods used are as long as one quarter.

   The BAI study (, ch 2) showed that the quarterly TWR of a fund with a "moderate" amount of new money (not specified but probably meaning less than 10% of initial fund size) could be estimated with an average absolute error of 0.5% p.a. This is of course quite satisfactory, but ignores the following issues:

   (i) Error when new money is not so moderate
   (ii) Error in the estimation of sector TWRs, where new money can be up to 50% of the sector's initial size in large sector switches.

   In recognition of these factors, the BAI concluded that for quickly growing funds, the errors involved with the linked internal ROR method grew quickly in excess of those of the regression method (explained below).

2. Holbrook(41) has indicated that because the linked internal ROR method takes no account of dealing expenses, it produces a TWR estimate which is in fact

not independent of cash flows.

For the ith sub-period, the ROR earned is r_i where

$$MV_{t(i)} = (1+r_i)\ MV_{t(i-1)} + (1+r_i)\ C_{t(i)} \qquad - (3.7)$$

re-arranged

Holbrook rightly points out that the assumption of (3.7) is that the same ROR is earned on new money as on the initial amount $MV_{t(i-1)}$. In the U.K. this will not be so since dealing costs act to lower the effective rate on $C_{t(i)}$, which is the gross amount of money invested. Hence two funds with different cash flows may possess different TWR estimates due to different trading expenses.

II.4 CONSTANT PORTFOLIO METHOD

Proposed by Cocks(14), this method is similar to the linked internal ROR method in the sense that it links successive MWRs, each estimated over a sub-period of the total review period. The major difference is that the MWR is calculated for only that part of the portfolio which has remained constant during the review period. That is, the calculation ignores for the duration of the sub-period those securities which have been either purchased or sold, either with new money or concerning the reinvestment of income or just the result of switches.

The procedure is identical to that of the linked internal ROR method except that the sub-period MWRs r_i are calculated according to (3.7), where the market valuations refer to the constant portfolio. Its basic assumption is that new money flows occur <u>between</u> sub-periods and not during them. It achieves this by ignoring portfolio changes until the end of a sub-period, when they are assumed to have all occurred at once.

II.4.1 ADVANTAGES AND DISADVANTAGES

The main advantages are as follows:

1. It is relatively simple
2. It is the only ROR estimate which satisfies the Principle of Disaggregation (refer previous chapter)

Cocks cleverly perceived that because the portfolio has remained constant, the calculated TWR will be the weighted average of the TWR on all securities in the portfolio, where the weight is the proportion of the fund's initial market value, $MV_{t(i-1)}$, made up by a security. Hence the TWR estimate may be decomposed into sector contributions and into securities' contributions in order to indicate the sources of the return and possible reasons for the observed level of performance. This is a considerable advantage.

The chief disadvantages of the method are many however:

1. It is almost certainly less accurate than the linked internal ROR and other methods, given a constant sub-period length.

   The estimation error of the constant portfolio method stems from the ignorance of the appreciation of, and income earned by, new money from the time it entered the portfolio until the end of the relevant sub-period. This is an error of total omission, whereas the error with other methods is only through the difference between the actual return earned on new money and the assumed return. For example, the linked internal ROR method assumes new money earns the same overall return as that earned on the portfolio as a whole. Intuitively therefore, one would expect errors to be greater with a constant portfolio approach, given sub-period length and actual returns.

2. It requires frequent valuations in order to maintain accuracy.

Cocks(14,p9-10) writes:

> "The accuracy of the constant portfolio approximation may be controlled by restricting the length of the time periods for which it is used to ensure that the constant portfolio always represents a sufficiently large proportion of the total portfolio. This would imply that for most large institutional portfolios, portfolio performance analysis should be conducted quarterly or monthly."

It is quite likely in view of the first point above that monthly calculations would be needed. One London consultancy[1] which uses this measure recommends that the portfolio must be valued every time more than 5% of it is turned over. For an active portfolio, this may imply regular monthly valuation.

3. It may lead to very small component factors of TWR.

The small length of a sub-period implies that unless market movements are sharp, overall return will be small and some components of return even smaller, leading to spurious results in some cases. This is not much of a problem however, as if components are calculated in a certain way[2], results may be accumulated over successive sub-periods.

4. The method ignores switches which are executed and then reversed in the same sub-period.

Purely "technical switches" such as these are becoming rarer these days and would present only a small drawback.

5. The method is an impractical measure for individual sectors.

1: Consultancy F (see Ch. 6)

2: Namely by use of multiplicative components. See Ch. 5.

Eadie(21,p7) writes:

> " ..... any attempt to analyse performance without considering portfolio changes can easily lead to error. Although a large institutional portfolio may have a relatively low turnover, it is quite likely to have a major turnover within individual sectors."

Even if one restricted a sub-period to the 5% turnover rule, if all the 5% of changes took place in a sector constituting 10% by value of the portfolio, the TWR estimate for that sector would ignore 50% of the investments in the sector, leading to very large error. This is probably the most serious disadvantage of the constant portfolio method.

5. If used when only turnover exceeds a threshold level, its use can lead to uneven review period lengths. Procedures for using RORs based on uneven review period lengths to derive risk estimates[1] are unpublished and untested.

II.7 REGRESSION METHOD

Developed and recommended along with the linked internal ROR by the BAI(1), its basic strategy is to use information about the historical relationship between the market value of the fund and the level of the market to estimate the missing valuations of the fund as at each cash flow date. The procedure is an iterative one, although the BAI maintained that more than one iteration is not necessary. The full algebraic derivation of the technique is given in (1). A simpler outline of the procedure from a practical point of view is given below as a series of steps:

STEP 1 Propose the following relationship between the fund's TWR, r, and that of the market, r_m:

1: Refer Ch. 7. Risk estimates are functions of past RORs usually.

$$r = a + br_m + \varepsilon \qquad - (4.9)$$

where ε is the error involved by using the relationship to estimate the fund's TWR for any one sub-period.

STEP 2 Estimate the parameters a and b of (4.9) from past returns of the fund and use the resulting equation to give an estimate, $\hat{r}_i$, of the ROR earned on the fund from the time of the ith cash flow, $C_{t(i)}$.

$$\hat{r}_i = \hat{a} + \hat{b}\, r_m^i \qquad - (4.10)$$

where r_m^i is the ROR in the market in the ith sub-period.

STEP 3 Use the estimated returns $\hat{r}_i$ to discount the associated cash flows $C_{t(i)}$ to the beginning of the period.

STEP 4 Use (4.9) to estimate the return earned by the fund over the whole review period to discount the fund's final value, MV_n, to the beginning of the period. Call the return so used $\hat{r}$.

STEP 5 Use discounted values of the previous two steps to calculate the MWR of the fund over the whole period. Call this estimate $\hat{MWR}$. It is virtually unaffected by the timing of new money, as these flows were discounted in Step 3 at the estimated actual return $\hat{r}_i$ earned on them.

STEP 6 Obtain the "best estimate available" of the actual TWR earned by the fund over the whole review period. This could be, for example, the known MWR for the fund. Call it $\hat{TWR}$.

STEP 7 Assume that for each cash flow, the difference between the actual ROR earned on it (r_i) and the estimated return ($\hat{r}_i$) is constant for all sub-periods (i.e., ε in (4.9) is constant).

STEP 8 Find the difference, d, between the best estimate of the actual TWR earned by the fund over the whole review period (Step 6) and the rate estimated from the regression relationship to discount MV_n (Step 5)

$$d = \hat{TWR} - \hat{MWR} \qquad - (4.11)$$

STEP 9 The estimated TWR over the whole period is then obtained as the sum of the rate used to discount the final value of the fund ($\hat{r}$ in Step 4) and this difference:

$$TWR = \hat{r} + d \qquad - (4.12)$$

STEP 10 If greater accuracy is required, repeat the algorithum starting at Step 6 using (4.12) as the "best available" estimate $\hat{TWR}$.

A clearer picture of the basic strategy of the method can be obtained by assuming only one iteration and the use of the actual known MWR on the fund as the best available estimate in Step 6. In this case, d in (4.11) is simply the error involved in using the regression (4.9) to estimate the MWR of the fund. The TWR estimate is simply formed by assuming that the same error was incurred by using the relationship's estimate $\hat{r}$ to estimate the fund's TWR. (4.12) represents a "correction" for this error.

II.5.1 ADVANTAGES AND DISADVANTAGES

The advantages were seen by the BAI as follows:

1. It makes more efficient use of the available data than do other techniques.

   All TWR estimation methods implicitly estimate the value of a fund at the time of a cash flow if that value is unknown. The linked internal ROR method does so by assuming a constant rate of return from the beginning of the sub-period to the date of the cash flow for example. A more efficient estimate

of the unknown market values is obtained by the use of the past history of the fund as well as its present record.

2. It tends to be more accurate than the linked internal ROR method.

The BAI(1 ,Ch. 2) showed that smaller estimation errors result when new money ceased to be a relatively moderate fraction of the initial portfolio (i.e., greater than 10%). They concluded that this greater accuracy would allow the use of the regression method with quarterly valuations with the knowledge that accuracy would tend to be about the same level as that obtained with the use of the linked internal ROR method with monthly valuations[1].

3. It may be able to be applied at little marginal cost, since the regression is basic to the measurement of risk also (being the funds beta measure of systematic risk, as outlined in Ch. 7).

The disadvantages of the regression method are, in the view of this writer, serious however:

1. The technique is much more complex than the others.

The need to estimate a regression every time a review is done increases all of the programming effort, program run time and input data requirements.

2. The argument that it produces more efficient estimates assumes that the regression relationship is a reasonable "fit" to past data.

There is conflicting evidence about how well a linear relationship like (4.9) can explain the variation of a fund's ROR[2]. In addition, at least

---

1: Assuming in both cases that valuations of the fund are made every time new money exceeds 10% of the initial portfolio.
2: III, Ch.8 mentions some of the evidence.

30 observations need to be accumulated before (4.9) can be estimated with any confidence. Even with monthly valuations, that is a $2\frac{1}{2}$ year lead time.

3. The method cannot easily cope with sector TWRs. The estimation of six different regressions for six sectors of a fund for each review period is not a practical proposition from a computing or data input point of view.

4. It cannot cope adequately with funds spread between many different sectors.

r_m in (4.9) would have to be a composite index of sector market returns, introducing added complexity. The alternative of doing a seperate regression for each sector has already been ruled out. The fit of (4.9) where r_m is not a suitable composite may be poor.

II.6 INDEX SIMULATION METHOD

Rejecting the above two American methods of approximation, the British Society of Investment Analysts (76) (SIA) developed an approximation method which in this study will be called the "index simulation" method. The technique at its simplest is to mirror the actual portfolio and all its transactions in a hypothetical, or "notional", portfolio which is invested in market indices. By so doing, information on current market movements, as they affected the fund <u>with</u> its new money, may be obtained which can then fruitfully be used to provide an estimate of the fund's TWR which, like the regression method, is more efficient than just using the MWR alone.

The central element of the method is the following approximation:

$$\frac{1 + TWR}{1 + TWN} = \frac{1 + MWR}{1 + MWN} \qquad - (4.13)$$

where TWR = the true, but unknown, TWR of the actual fund

TWN = the TWR in the market, as measured by a notional fund which is invested in the same proportions between sectors as the actual fund but which has no new money.

MWR = the MWR of the actual fund, assumed known.

MWN = the MWR of a second notional fund which once again is invested in the same proportions between sectors as the actual fund but which also has identical cash flows to those of the actual fund.

No proof of this relationship is published by the SIA or elsewhere in the literature. An algebraic proof appears in the next sub-section. Of more direct interest for the moment is the intuitive explanation of (4.13). Central to this explanation is the idea of premium return. If two funds both commence with market value MV_o and enjoy returns r_1 and r_2 respectively, the premium return, p, earned by the first fund over the second is defined as:

$$1 + p = \frac{1 + r_1}{1 + r_2} \qquad - (4.14)$$

p is simply the fraction by which the first fund's final value exceeds that of the former, since

$$p = \frac{MV_n^{\,1} - MV_n^{\,2}}{MV_n^{\,2}} = \frac{(1+r_1)\ MV_o - (1+r_2)\ MV_o}{(1+r_2)\ MV_o}$$

$$= \frac{r_1 - r_2}{1+r_2}$$

so that 1 + p is given by (4.14)

The SIA's approximation (4.13) merely states that the premium by which a fund's TWR exceeds the market ROR is approximately equal to the premium by which the same fund's MWR exceeds the market's MWR when it too is exposed to the same new money flows as the actual fund. That is, while the fund's TWR and MWR may differ in absolute value, their relation to their market analogies remains relatively fixed[1].

The TWR estimate follows from (4.13) as

$$1 + TWR = \frac{1 + MWR}{1 + MWN} \times (1 + TWN) \qquad - (4.16)$$

Recalling (4.6),

$$1 + MWR = \frac{MV_n - (C - \bar{C})}{MV_o + C} \qquad - (4.17)$$

and by analogy,

$$1 + MWN = \frac{MVN_n - (C - \bar{C})}{MV_o + C} \qquad - (4.18)$$

so that the estimate reduces[2] to

$$TWR = \frac{MV_n - (C - \bar{C})}{MVN_n - (C - \bar{C})} \times (1+TWN) - 1 \qquad - (4.19)$$

1: An alternative view is obtained by re-arranging (4.13) to

$$\frac{1 + TWR}{1 + MWR} = \frac{1 + TWN}{1 + MWN} \qquad - (4.15)$$

This implies that the premium between the two measures for the actual fund is the same as the premium between the two measures for the market.

2: This reduction relies on the satisfactory approximation of the MWR in both market and fund by the first order equation (4.6). As Cocks(14) points out, the TWR estimate (4.16) may be equally well, if not better, made by calculating the MWRs exactly.

II.6.1 GENERATING THE NOTIONAL FUND

The basic procedure is as follows[1].

STEP 1 Obtain information on the values over the review period of market indices which describe the market movement of each of the sectors in which the fund concerned is invested. Let the level of the index for the sth sector at the time of the ith cash flow by $X^s_{t(i)}$.

STEP 2 Invest the initial market value of each sector, MV^s_o, in the associated index to produce a hypothetical holding of units in the sth sector of[2]

$$XH^s_o = \frac{MV^s_o}{X^s_o} \qquad - (4.20)$$

STEP 3 Invest each cash flow $C_{t(i)}$ in the indices in the proportions between sectors in which it was actually split. The index holding of each sector will be increased at time t(i) by

$$CX^s_{t(i)} = C^s_{t(i)} / X^s_{t(i)} \qquad - (4.21)$$

STEP 4 Generate the notional income from the notional index units held. This is achieved through the use of an income index associated with each sector price index X^s_t.

STEP 5 At the end of the review period, translate the total number of index units held in each sector back into market values as

$$MVN^s = XH^s_n \times X^s_n \qquad - (4.22)$$

1: See Chapter 11 for a more detailed account than this

2: In practice, trading expenses would be allowed for. This and other complications have been ignored in the above but are discussed in Ch. 11.

giving a total simulated final market value of

$$MVN_n = \sum_s MVN_n^s \qquad - (4.23)$$

STEP 6 Carry out a similar simulation of another notional fund which is identical in every respect except that all new money flows are zero (i.e., $C_{t(i)} = 0$ in steps 2 to 5 above). Let the simulated final value of this fund be MVN_n'.

STEP 7 Compute the ROR of the notional fund in step 6 as

$$TWN = \frac{MVN_n'}{MV_o} - 1 \qquad - (4.24)$$

STEP 8 Apply formula (4.19).

II.6.2 PROOF OF THE S.I.A.'s TWR ESTIMATE

Consider the simplest situation possible where there is only one new money flow, C, in the whole review period, represented diagramatically as Figure 4.1. Using the notation of this figure, the final market value of the fund in terms of the rates of return actually earned on the fund's assets is

$$MV_n = \left[(1+r_1)\ MV_o + C\right]\ (1+r_2) \qquad - (4.25)$$

If the market were exposed to the same cash flow at the same date, it would have a final market value of

$$MVN_n = \left[(1+R_1)\ MV_o + C\right]\ (1+R_2) \qquad - (4.26)$$

assuming that MV_o was notionally invested in the market at the beginning of the review period.

Using (3.8), the TWR of the actual fund is

$$TWR = (1+r_1)\ (1+r_2) \qquad - (4.27)$$

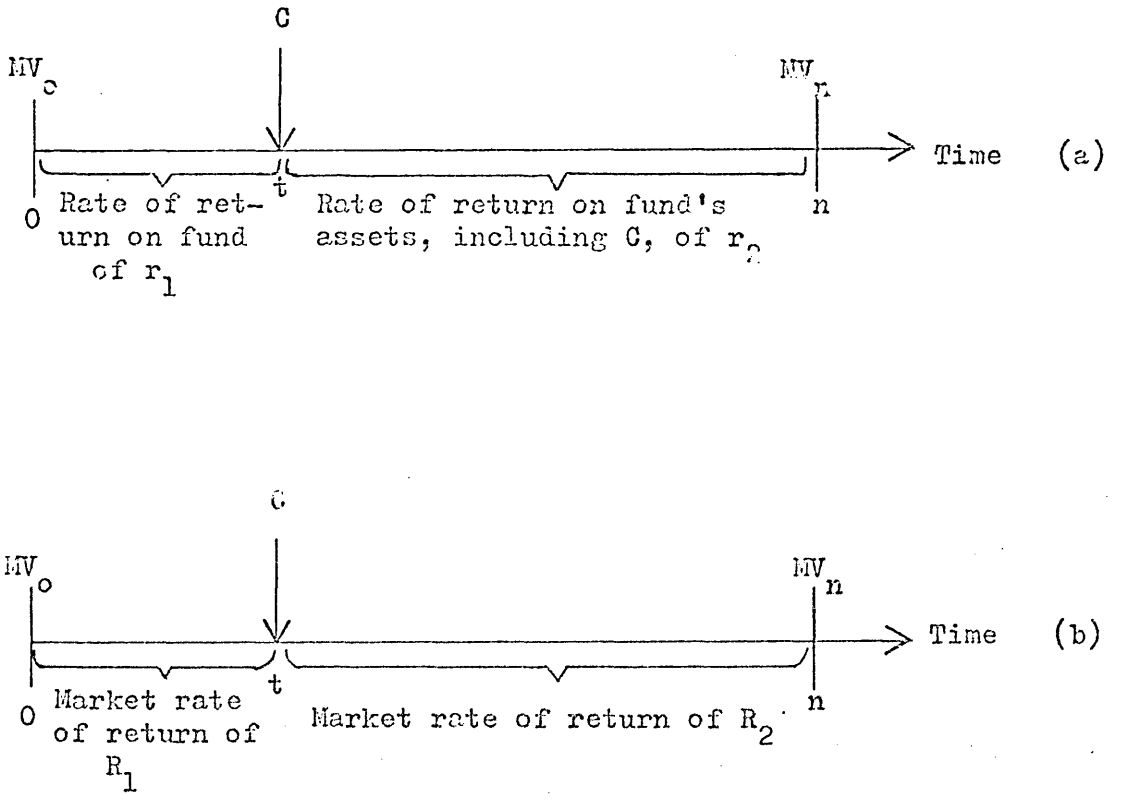


FIGURE 4.1

Schematic representation of (a) actual fund and (b) market, during review period with one new money flow.

The difficulty of course is that the fund's RORs r_i between cash flows are unknown. Noting that average new money is

$$\bar{C} = w_t C \quad \text{where } w_t = (1 - \frac{t}{n}) \qquad - (4.28)$$

$$MV_n - (C - \bar{C}) = MV_o\ (1+r_1)\ (1+r_2) + C\ (1+r_2) - (C - w_t C)$$

$$= MV_o\ (1+r_1)\ (1+r_2) + C\ (r_2 + w_t) \qquad - (4.29)$$

Similarly, for the market

$$MVN_n - (C - \bar{C}) = MV_o\ (1+R_1)\ (1+R_2) + C\ (R_2 + w_t) \qquad - (4.30)$$

Thus

$$\frac{MV_n - (C - \bar{C})}{MVN_n - (C - \bar{C})} = \frac{MV_o\ (1+r_1)\ (1+r_2) + C\ (r_2 + w_t)}{MV_o\ (1+R_1)\ (1+R_2) + C\ (R_2 + w_t)} \qquad - (4.31)$$

Now, using (3.8)

$$\frac{1 + TWR}{1 + TWN} = \frac{(1+r_1)\ (1+r_2)}{(1+R_1)\ (1+R_2)} \qquad - (4.32)$$

Note that (4.32) is similar to (4.31), leading to the hypothesis

that $$\frac{MV_n - (C - \bar{C})}{MVN_n - (C - \bar{C})} = \frac{1 + TWR}{1 + TWN} + e \qquad - (4.33)$$

Substituting (4.32) and (4.31) it can be shown that the error term reduces to

$$e = \frac{C}{MV_o} \quad \frac{(r_2 + w_t) - \dfrac{(R_2 + w_t)}{1 + TWN}}{(1 + TWN) + \dfrac{C}{MV_o}\ (R_2 + w_t)} \qquad - (4.34)$$

Thus the estimation error is a function of new money as a proportion of the fund, of actual and market rates of return and of how early in the period the cash flow occurs (w_t). It is significant that these are the same factors which lead the TWR to differ from the MWR in the first place (refer V.1, Ch. 3). An analysis of (4.34) will conclude that the estimation error decreases as

1. The new money is a smaller proportion of the initial fund.

2. The actual rate of return, r_2, on the fund's assets (including C) <u>after</u> the new money flow is smaller.

II.6.3 ADVANTAGES AND DISADVANTAGES

The advantages of this method may be listed as follows:

1. Probable greater accuracy than the linked internal ROR or constant portfolio approaches.

   Just as the regression method made more efficient use of <u>past</u> information, the index simulation method makes more efficient use of <u>current</u> market information.

2. More easily comprehended by investment personnel.

   Notional investment in an index is more familiar to them than regression.

3. It produces estimates of sector TWRs with little extra effort.

   TWRs for individual sectors are almost produced as a by-product. (4.19) can be applied equally well to sectors with the simulation of only one extra notional portfolio which mirrors sector switches as well as the cash flows $C_{t(i)}$[1].

1: The need for this extra simulation is not mentioned in SIA's report (76) but is demonstrated in III, this chapter.

4. Notional funds may be needed for the analysis of performance, implying that TWR estimates could be generated at little extra effort.

Chapter 5 will show that one method of analysing performance is to use notional funds, two of which would be identical to those needed by (4.19).

The disadvantages of the index simulation method are as follows:

1. It is not as simple and readily comprehensible as the linked internal ROR and constant portfolio approaches.

2. It requires more data input than the linked internal ROR and constant portfolio methods.

3. It requires much more input than any other method if only the ROR on the whole fund is desired to be measured.

   Because the notional funds must be built up on a sector-by-sector basis, all input must be disaggregated to this level.

4. Suitable indices may not always be available.

   Just as the regression method will contribute little if the statistical fit is poor, the index simulation method will be less accurate if the index used to represent a sector is not fully representative of the market with which the fund's assets tend to vary in value. Fortunately there exist high quality indices for the two sectors which constitute the main investments of British funds. Chapter 9 will argue that equities and gilts are well-represented, while the cash and overseas sectors are satisfactorily covered under certain usually acceptable assumptions.

III. RELATIVE MERITS OF THE APPROXIMATIONS

III.1 ACCURACY OF THE METHODS

Comparisons of the accuracy of any of these four techniques are rare in the literature. Only three comparisons have been published, as follows:-

1. The BAI study (1) compared the linked internal ROR method with the regression method to conclude that a choice on accuracy alone was impossible between use of the former on a monthly valuation basis and use of the latter on a quarterly valuation basis. The equality applies only if the fund was valued (while using either method) on occasions when new money exceeded 10% of the fund.

2. The SIA(76) compared their index simulation technique with the linked internal ROR method.

   The comparison is, however, not meaningful because each study used different assumptions to generate their error statistics. The BAI used actual fund data, compounded returns to an annual basis before comparing estimates and made no tests with new money consistently at a high level (only a mixture of moderate plus heavy growth). The SIA on the other hand appears to have used simulated data under the controlled conditions of market versus actual return and consistently high cash flows of 25% of initial fund size. Comparisons were made on the basis of quarterly (not annual) returns. To worsen the comparability further, some of the more important error rates quoted by the BAI appear to be based on daily dating of cash flows, whereas the SIA assumed monthly aggregation of cash flows. The BAI results show that this can have some small effect on the estimation error.

3. Kingston(45) took one hypothetical fund over a hypothetical review period of one quarter and examined how three estimation methods fared under the assumptions of severe cash flow and market movement during the quarter.

   Kingston himself admits that it is impossible to generalise from the one example. In any case, his use of the BAI's method is a weakened form of that described in II.5 above (he assumes that b = 1 in (4.9)) and he deviates in some important ways from the SIA's recommended method also (refer VI.1, Ch.12).

It is therefore apparent that in the absence of any detailed comparisons of accuracy under controlled conditions, no firm choice between the four alternative methods can be made on the basis of accuracy alone. Such a detailed simulation study was contemplated as part of this study but was rejected as probably not being a fruitful expenditure of effort. The reason for this will become apparent in the following sections.

What can probably be safely concluded from the scant evidence available is that the choice is between the regression method and the index simulation technique, these two "dominating" the other two simpler methods in terms of average accuracy. The following pages will argue that although these two techniques have not been linked in the literature, they are remarkably similar, being based on the same numerical strategy. This similarity suggests that the regression method's proven superiority over the linked internal ROR method probably is also shared with the index simulation method. The argument will then take two directions, depending on how much reliability one is willing to place on the above conclusion.

If it is not questioned, the most which can be said is that the index simulation method is a clear choice after practical factors are considered. If the above conclusion is questioned, the most that can be said is that there is a trade-

off between accuracy and effort when faced with the two remaining feasible approaches of the linked internal ROR and index simulation methods.

III.2 SIMILARITY OF THE REGRESSION AND INDEX SIMULATION METHODS

The BAI study (1 ,p83) shows that the estimate central to the regression method (r in Step 4 of II.5) is calculated from the equation[1]:

$$\frac{MV_o}{(X_o)^b} + \sum_{i=1}^{n} \frac{C_{t(i)}}{(X_{t(i)})^b} e^{-\hat{r}t(i)} = \frac{MV_n}{(X_n)^b} e^{-\hat{r}n} \qquad - (4.35)$$

where $(X_{t(i)})^b$ is the value of the index used to represent the market, and from which the return r_m in (4.9) is calculated, raised to the power b, where b is the regression parameter in (4.9).

The BAI's TWR estimate is then, in the continuous compounding terms of its derivation,

$$\hat{TWR} = \hat{r} + b \frac{1}{\sum l(i)} \ln \left[\frac{Xn+1}{X_o}\right] \qquad - (4.36)$$

corresponding to Step 9 in II.5.

The above procedure has some striking similarities to the other method of estimation of the TWR. The BAI report itself recognises that if b is set to zero (so that no regression relationship (4.9) is hypothesised to exist), (4.35) reduces to

$$MV_o + \sum_{i=1}^{n} C_{t(i)} e^{-\hat{r}t(i)} = MV_n e^{-\hat{r}n} \qquad - (4.37)$$

1: (4.35) is the re-expression of BAI's equation 15 on page 83 in the notation of this thesis.

whose similarity to (3.5) implies that $\hat{r}$ is simply the MWR for the fund calculated on the basis of continuous compounding. $\hat{TWR}$ as given by (4.36) becomes $\hat{r}$, so the estimate when b = 0 is effectively the linked internal ROR.

What the BAI did not recognise (it could not have done so at the time it was written) and what no-one else has realised is that if b is set to unity, one has a TWR estimate almost identical to that yielded by the index simulation method. b = 1 in (4.35) produces the standard DCF formula for a MWR of a fund which has been notionally invested in index X to the value of MV_o at the beginning of the review period, and whose new money has been notionally invested at index levels $X_{t(i)}$ and whose final holdings of index units is the holding obtained by the notional investment of the actual final value of the fund, MV_n, at the index level as at the end of the review period. This is almost identical to MWN in (4.13). The only difference is that the actual final value of the fund is used in (4.35), whereas MWN used MVN_n as defined by (4.23).

The similarity continues with (4.36). This combines $\hat{r}$ with the market ROR r_m (calculated on a continuously compounded basis) in an <u>additive</u> manner, whereas the SIA's method combines its version of $\hat{r}$ (MWN) with market ROR in a <u>multiplicative</u> manner. The analogy may be more clearly seen by comparing (4.12) with (4.13). As explained in II.5, the regression method's basic strategy is to assume that the absolute difference between the fund's true MWR and that estimated from market return (via the regression) is the same as the absolute difference between the fund's true TWR and that estimated from market return via the regression. This is a remarkable parallel with the index simulation's strategy of assuming that there is an identical premium return between the same two sets of fund and market returns. (refer II.6).

III.3 RELATIVE MERIT BASED ON ACCURACY

Given the similarity between the above two techniques, it is reasonable to assume that the superiority of the regression method over the linked internal ROR technique can also be attributed to the index simulation technique, although it must be stated that this point is not proven.

Section II.4.1 above argued that on a-priori grounds the constant portfolio technique is less accurate than the linked internal ROR. The same section also indicated that there are clear practical difficulties with a constant portfolio approach. An additional difficulty arises if this method is applied to the many funds of a financial institution. The multiple number of funds not only increases the cost of more frequent reviews, but may lead to an administratively difficult performance measurement system. There are bound to be some funds which turn over more rapidly than others, implying that either some effort must be wasted in reviewing all funds with the frequency required by the most active fund, or that different funds are to be reviewed at different times. The latter practice may be difficult to administer. Who, for example, would ensure that measurement takes place as frequently as necessary? Problems of comparability between funds' results would be rife if RORs were regularly measured over different intervals of time (refer Chapter 13).

For these practical reasons and that of inferior accuracy on a-priori grounds, the constant portfolio estimation of the TWR was not considered by this study as a feasible approach.

III.3.1 MERITS ON PRACTICAL GROUNDS

Section II.5.1 raised a number of practical difficulties of use of the regression method to estimate the TWRs of a portfolio and its individual sectors. Its most severe drawbacks are its large data requirement and large computational load.

Dietz(18,p5) concludes:

> "Whether (the SIA) method is actually simpler than the BAI method depends on the ease with which the concept of a notional fund is accepted".

He also observes

> "Although used by some of the larger bank trust departments in the USA, (the regression) method appears to be too cumbersome for most purposes".

In addition, the regression method has no real advantages over index simulation. Its simultaneous provision of an estimate of the beta of a portfolio is of little value, as the theory on which this measure of risk is based is argued in Chapter 8 to be too untested to be of practical benefit.

Hence it appears that the main choice of a TWR estimation method is between the linked internal ROR and index simulation approaches. If one has faith in the close connection between the latter and the regression method, the choice is clear. Failing this, a choice must balance the increased effort involved in the index simulation method with its likely greater accuracy.

In fact, the above choice cannot be effectively made in isolation of the choice of a method of analysis of performance. The relevance of the latter lies with the possibility of overlap between the calculations necessary for analysis and those necessary for measurement of performance.

III.3.2 COMPLEXITY IN COMMON WITH PERFORMANCE ANALYSIS

Chapters 5 and 8 cover the methods used to analyse performance and to measure risk in the software of this study. These chapters recommend that analysis is best done with the aid of several notional funds, while Chapter 8 concludes that the calculation of a beta value is not a worthwhile endeavour. These two findings jointly point to two major conclusions. The first is that the index simulation method will produce TWR estimates at little marginal cost, whereas the regression method would require many calculations which have no use other than as intermediate stages of a TWR estimate. The second is that the balance of extra effort versus accuracy is slightly tipped in favour of index simulation, since the extra effort over that involved with the linked internal ROR is to a large extent shared with the cost of analysis. The next section will indicate that the index simulation method was, for the above reasons, incorporated into the software developed in this study. As a final point however, some perspective is given to the question of accuracy by the following paragraphs.

III.3.3 VALUE OF ACCURACY

Opinions about accuracy for its own sake vary widely. Kingston(45,p6) writes:

> "Both the BAI and SIA were anxious to get as near to the theorectically correct answer as was practicable. Most people assessing performance would be prepared to depart further than this to sacrifice some accuracy for ease of calculation. In many cases, this is unnecessary as the use of computers makes monthly valuations comparatively easy ... "

While the latter part of his opinion ignores the expense of frequent valuations, even if it is by computer, it is certainly true that ease of calculation is a matter of prime importance for most practising investment personnel. For performance measurement must be considered in the perspective of people who carry the burden of <u>doing</u> the activity which is the subject of measurement.

Accuracy in estimation may be a moot point however just as the mean square error of sampling estimators in statistics often pale into insignificance compared to non-sampling errors. Corresponding to the latter type of error, one has in performance measurement the following sources of inaccuracy.

1. Jobber's spread on market prices

   The BAI(1,Ch.2) suggest that this leads to error in ROR estimation which is at least as large as the mean absolute error for the various TWR estimators.

2. Inaccurate dating of transactions

   A transaction can be dated at settlement date (when the cash changes hands), the date it is actually carried out, or the date at which it is first set up. The most preferable is the latter but it is not always recorded, especially if the manager

is anticipating a future cash flow. Hence the date at which a transaction is ordered is usually taken as a second best.

The extent to which the second factor causes error is unknown. With reference to the first point, one of the five funds studied here was on one occasion valued in two different ways. A valuation at middle market prices yielded an equity sector value of £13,431m while a valuation using Stock Exchange Prices Official List yielded £13,323m, a difference approaching 1%. Errors in valuations probably have the greatest effect of all possible data errors (as opposed to errors in cash flows or income etc.)[1]

IV. TWR ESTIMATION METHOD USED IN THIS STUDY

In the view of this writer, Section III points to the index simulation as the most feasible of the five alternative methods of TWR estimation. All TWR estimates in the software developed in this study are based on this technique, but with some changes relative to the SIA's recommended method. The SIA, while they give no general algebraic proofs or guidelines for their method, do give an excellent detailed example of its use in practice (76, App.1) Kingston(45 ,App.) also quotes a worked example.

IV.1 MODIFICATIONS TO THE S.I.A.'s METHOD

The SIA's method was programmed and tried on data from funds available to the present study. The method was found to be lacking in a few ways which when compounded together can lead to appreciable error. Hence certain modifications were made to the SIA's method. Because they centre mainly on the simulation of notional funds, the changes are discussed in more detail in Chapter 11. In so far as they are relevant to TWR estimation they are as follows:

1: See BAI (1 ,p144)

1. A more realistic notional investment of excess notional income.

The SIA's method, though leading to correct results when all income is assumed to be fully repaid to trustees (as it was in their example), leads to unrealistic results when some income is retained in the fund for immediate reinvestment.

2. The use of a different notional fund for the estimation of the TWR of the total fund.

The SIA use a notional fund modelled on the desired split between sectors on the part of the trustees. To do this as a general procedure would be quite incorrect. It is not made clear that what is needed is a notional fund which mirrors the actual fund[1], not that desired by the trustees which potentially can be very different, although it was not in the example given by the SIA.

3. The use of a different notional fund for the calculation of sector TWRs on the one hand, and total ROR on the other.

No details are offered by the SIA on how to use their method to estimate the TWR of an individual sector. A warning needs to be given that the direct application of the same technique as that for estimating the TWR of the total fund as a whole is incorrect. Two things differ:

(i) A different notional fund is required to produce the sector's MVN_n (or, equivalently MWN^s) in (4.16). The guiding principle here is that the notional fund should simulate the market ROR when exposed to the same cash flow as the actual fund. For an individual sector, cash flows include any

1: To yield estimates of MWA and MVN_n in (4.16) and (4.19)

inter-sector switches which were made independently of the investment of new money. Hence the appropriate notional fund is one which simulates <u>all</u> actual transactions during the period, including sector switches[1].

(ii) (4.19) is in fact a simplified estimate of the TVR of the total fund, let alone for an individual sector. There are more injections and withdrawals into and out of a sector than simply its new money, which for a sector is the actual net purchases in that sector. Chapter 11, VI.3 gives the necessary modifications to adapt (4.19) to more realistic circumstances.

4. Subtraction of dealing costs involved in the realignment of notional portfolios between review periods.

5. Cessation of the simulation of a sector after all of that sector has been sold during the review period.

These modifications and others are discussed in detail in Chapter 11.

1: That is, for an individual sector, nVN_n should be the sector's final value in the SIA's "Partly Restrained Fund", and not its "Fully Restrained Fund" as defined in (76,App.1).

PART B

ANALYSIS OF PERFORMANCE

CHAPTER FIVE

GENERAL PRINCIPLES OF ANALYSIS SYSTEMS

Just as the previous chapters resulted in a choice of rate of return measure based on their relative merits, this chapter aims to survey in a similar manner all the various methods of performance analysis. The discussion will be confined to the consideration of broad principles in order to eventually make a choice of a general approach. Despite the many published studies which propose various methods, there appears to be no work on the difference between methods or their relative merits from an overall point of view. It will be shown that such a general approach is justified because the principles of construction of a performance analysis system so revealed can then be used as a framework with which to logically compare existing systems, as well as to suggest previously unpublished component structures.

Chapter 6 will go on to describe existing performance analysis systems in terms of this general framework.

I. NEED FOR PERFORMANCE ANALYSIS

Various writers[1] have expounded the virtues of analysis as follows:

1. Analysis provides a relative measure as well as an absolute one.

1: Cocks(12), Dietz(18), Eadie(21), Fama(28), Holbrook(41).

Draper(20,p96) comments

"Considerable attention is paid by the investment managers to some of the indices. ..... It is considered important to know how well a fund manager's performance compares with his objectives and with the performance of the other fund managers".

The accurate conduct of such comparisons requires some degree of analysis.

2. Inferior or superior performance should be explained.

Opinions differ on whether performance analysis is needed to provide the explanation however. Ross-Jackson(67) regards it as an essential feature of any performance analysis system, whereas Dietz (18,p7) comments that

" ..... analysis is hardly necessary for the majority of funds being evaluated. Analysis would, however, be useful in confirming or denying whether particular results were random or not".

The position seems to be that for fluctuations of return in line with the market, analysis is not needed. The fund managers interviewed in the course of this study maintained that intuition and memory sufficed in these cases. However, fluctuations in excess of the market represent a problem. The discussion text after Holbrooks' paper(41,p76) revealed one opinion that

" ..... funds never deviate far from the average, and when they do deviate, managers often do not really understand why they have done so".

Because it is not only wasteful but also damaging to the usefulness of performance measurement to produce unwanted statistics, the detailed performance analysis required to identify reasons for inferior or superior performance has been made optional in the computer programs developed in this study.

3. Fund managers would benefit from feedback on the success of the investment philosophies and practices followed over the review period.

Cocks(12,p3) writes:

"A thorough, logical analysis of a managers' performance may help produce a more articulate voice of experience to guide the manager in his future decisions and so improve his future performance."

The managers interviewed in this study maintained that detailed feedback was not very useful because every market situation is "unique", implying that what was correct yesterday will not necessarily be so tomorrow. While this viewpoint may be valid at the detailed level of selection of individual securities, it is less true at the more general levels of sector selection and timing decisions. (That is, decisions relating to how much of the fund to allocate to bonds, equities, property, cash etc.) For this reason, the performance measurement system used in this study analyses the effect of only the major decisions about which it is believed feedback is almost always useful[1].

4. Holbrook(41) and Nursaw(59) imply that trustees are more or less obliged to probe the weakness of a fund with the intention of correcting them.

In addition, managers sometimes need to convince trustees of the adverse effects of their imposed restrictions on his freedom of action. Data to back up a manager's argument would be useful.

5. Trustees need to be able to assess the performance of their managers.

1: III, Chapter 10 will explain the reasons for this in greater detail.

Chapter one has already described the increased demands in this area. Analysis is a means of quantifying various aspects of a managers' performance.

6. Analysis can help to identify areas of potential risk in a portfolio.

By identifying the sources of good or bad performances, analysis can reveal the likely effect on portfolio return given that past trends continue or alternatively do not continue. On a more theoretical level, Chapter 8 will show that the component system used in the software of this study is intimately related to the adjustment of portfolio return for risk. It is also shown that the risk-adjusted performance measure so provided is more general and probably more robust than those provided by conventional capital asset pricing theory.

II. CLASSIFICATION OF PERFORMANCE ANALYSIS METHODS

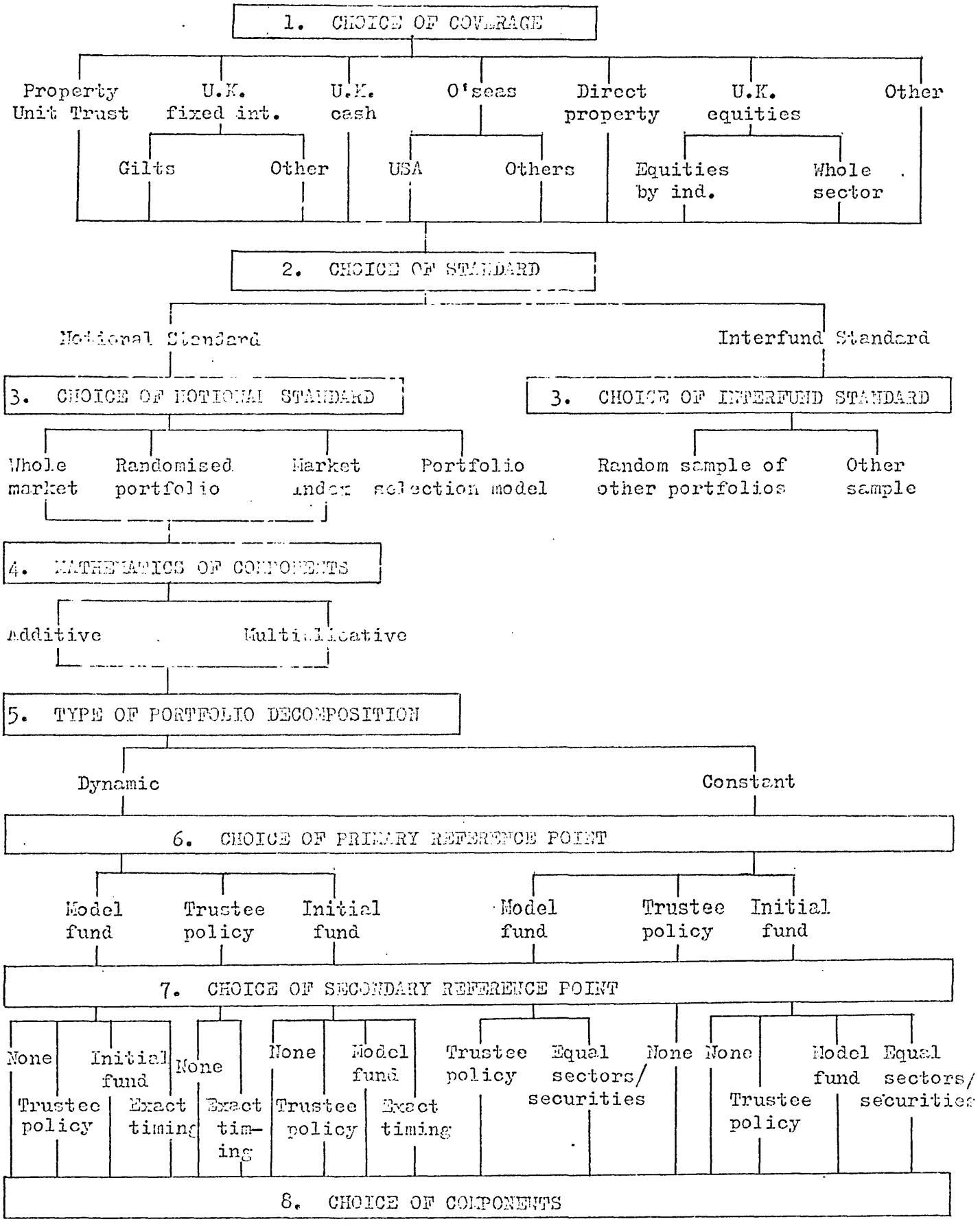
This writer could identify eight distinct levels at which an important decision can be made in the choice of a performance analysis system. The various methods which have been proposed in the literature represent various combinations of outcomes down this heirarchy of eight decision levels.

The eight levels are shown in Figure 5.1. Some of these decisions are relevant only for certain choices at previous levels, as indicated by the heirarchical structure. This may be a little misleading to the extent that some decisions need not necessarily be made in the strict order implied by the heirarchy. For example, the coverage of the system could be one of the last choices without necessarily affecting choices concerning the other seven levels.

The remainder of this section is devoted to descriptions of the alternatives at each level and their relative merits in isolation of decisions at other levels. The choice made at each level by this study is also indicated.

FIGURE 5.1

Decisions in the creation of a performance measurement system



III. CHOICE OF COVERAGE

Almost all commercially available performance measurement services evaluate the performance of U.K. equities, U.K. fixed interest stocks (but some cater for gilts only) and cash invested within the U.K. Overseas investments and Property Unit Trusts are covered by some services also. No services sighted by this writer evaluated the performance of direct holdings in property, works of art or commodities (except perhaps by use of trustees' estimates of market value).

The degree to which a sector is covered is almost solely determined by the ease with which the assets of that sector can be valued. Hence direct holdings in property are never incorporated into regular performance reviews for example.

The availability of indices for each of these sectors is discussed in Chapter 9.

IV. NOTIONAL VERSUS INTER-FUND STANDARD OF COMPARISON

A standard of performance, if it is regarded as a "fair" return on investment without any undue effort, can enable the performance of the fund and its management to be assessed in terms of the deviation of actual performance from this standard. Cocks(14,p11) in a brief survey of possible standards writes:

> "The standards against which it has been suggested that portfolio performance may be compared have varied considerably, but the underlying philosophy has shown little variation. It is either believed that the performance of a portfolio should be compared with the performance of other similar portfolios, or that the performance of a portfolio should be compared with that of a naive, unmanaged portfolio. The former approach provides a measure of the performance of the investment philosophy of a portfolio manager relative to the performance of his peers. The latter approach provides an absolute measure of the performance of the investment philosophy of a portfolio manager."

The comparison of performance with that of other portfolios has been termed here as "inter-fund comparison." An unmanaged or naive portfolio provides a "notional" standard of comparison. The following two sub-sections discuss each type of standard in detail.

IV.1 INTER-FUND COMPARISON

Many commercial services exist which calculate the return on the portfolio of a number of subscribers to the service and then provide for each client a comparison of his return with those of the other subscribers (who usually remain anonymous). The comparison usually involves ranking funds on their TWR.

IV.1.1 ADVANTAGES

The approach has a number of advantages over the use of a notional standard:

1. It has a greater intuitive appeal as a standard of performance than any artificial notional standard.

2. It provides a standard of performance which incorporates the effect on performance of active management.

   Pilch and Wood(64) argue that an artificial notional fund, because it simulates a completely <u>un</u>managed fund, is a lenient benchmark by which to assess managerial performance, since it assumes absolutely no active trading is conducted - whereas a client would normally <u>expect</u> active management by his manager.

3. An inter-fund standard of performance has a more potent motivating effect on fund managers

   Because managers regard it as a more realistic benchmark, and because they believe that a notional

standard is "inhuman", success in inter-fund terms is more enthusiastically persued (or failure enthusiastically feared) by managers than is success relative to any artificial index.

4. The statistical significance of inter-fund comparison results is more easily assessed than the significance of the performance of a fund relative to a notional standard.

To test the statistical significance a deviation of a fund's results from a norm provided by a sample of results of other funds, one need only compare the size of the observed deviation with the amount of general deviation in the sample. It is a simple "t-test" situation (providing the sample mean is accepted as a constant). Testing the significance of the performance of a fund relative to its notional standard involves analysis of the fund's past deviations from the standard, which may not always be available in sufficient quantity to provide a reliable conclusion.

IV.1.2 DISADVANTAGES

Off-setting these advantages are the severe drawbacks of an inter-fund standard, as follows:

1. Funds are too heterogeneous to allow valid comparisons to be made.

"Even within different classes of portfolios, such as pension funds, life insurance, company portfolios, investment trusts and unit trusts, few portfolios are truly comparable. The managers of apparently similar portfolios may be subject to vastly different restraints and there may be considerable differences between the amount of freedom with which the portfolio managers may operate within the given restraints."[1]

1: Cocks(14,p13)

Recalling the example given in I, Ch.2, restrictions imposed by trustees on a manager can inhibit performance of a fund to the extent of completely negating the beneficial effect of good management. These effects are not allowed for in any way by a simple ranking of funds by ROR.

Other causes of heterogeneity amongst pension funds are administrative differences between funds and differing liquidity requirements. The speed with which a manager can implement changes in strategy can sometimes affect performance, especially in quickly changing markets. The effect of different liquidity requirements according to the maturity of the associated pension plan was described in V.2, Ch.3.

Both Holbrook(41) and Bail( ) argue that the effects of some of these factors can be reduced by a suitable classification of funds into more homogeneous groups. The difficulty with this idea is of course that the size of the sample with which performance is then compared may be too small to draw any firm conclusions.

2. It gives little indication of the reasons for good or bad relative performance.

Some clues may be gained from seperate rankings according to the return on individual sectors, but the approach still fails to quantify the costs or benefits from past investment decisions of a timing nature or decisions relating to selection of securities.

3. It gives no guide to the <u>absolute</u> merit of performance.

This is due to two factors. Firstly, the sample of funds on which the inter-fund standard of average

return is based may not be representative. Samples are never random. Secondly, the results bear no relation to the market. Even if the sample were representative, it is still possible that, because most funds are following the same malpractice, most funds are under-performing the market. This means that a fund could compare quite favourably with the performance of other funds but nevertheless be under-performing the market.

An example of such a malpractice has been a point of sharp controversy in the U.S.A. since Sharpe(70) first indicated that mutual funds were under-performing the equity market (on a risk-adjusted basis) by a margin which was approximately equal to their dealing expenses. In other words, if active management of a fund tends not to produce enough extra gain to pay for transaction costs, over-all return will be lower than what it would have otherwise been. If most funds are active, an inter-fund standard will yield a standard of performance which is not net of the adverse effect of this mal-practice. In contrast comparison to a market rate of return would highlight the adverse effect.

4. There is no consideration of risk.

Many of these disadvantages could be minimised if the comparison service used surveyed a large number of funds, as in America where the Becker measurement service has achieved good penetration amongst pension funds and so is able to make more meaningful comparisons. The situation in Britain is different however. Writing in the early 1970's, Kingston (45 ,p3) observed

> "There are at least three such services for pension funds in the U.K. but the penetration is nothing like as great yet as in the U.S. where something like 5,000 pension funds are involved. No-one appears to have a sample greater than 100."

The writer's own survey of services commercially available in 1977/78 also produced three comparison services[1], each with around 100 funds or less.

IV.2 NOTIONAL FUNDS AS STANDARDS OF COMPARISON

Rutter(68) explains that a notional standard is usually designed to reflect the performance of an alternative investment which is both

1. Similar in some sense
2. Either an average investment in the same market, or a direct alternative investment.

The index is taken to be representative of the market and so represent an average, or market, return for the sector it represents. An example of comparison with a directly alternative investment would be if overseas equity investments were compared with U.K. equities.

IV.2.1 ADVANTAGES

The advantages of a notional standard are equivalent to solutions to all the disadvantages of inter-fund comparison. Briefly, these are as follows:

1. It overcomes, at least partly, the problem of heterogeneity amongst funds by making specific numerical adjustments to incorporate into the standard of performance allowances for the particular restrictions imposed on a fund manager. For example, if a manager is forbidden to invest in equities, the notional standard would not incorporate an index of equity values.

2. It quantifies the various levels of decisions which led to good or bad performance.

   These are termed componenets of performance.

1: Consultancies A, B and D in the terms of Ch.6.

3. It quantifies the absolute merit of the achieved level of performance.

Market return is regarded as a "fair" return and, as will be argued in XI of this chapter, can also be regarded as the weighted average return of all U.K. pension funds.

4. It enables the quantification of risk-adjusted performance.

Chapter 8 will demonstrate that under certain reasonable assumptions, components of performance can be used to assess the merit of performance after adjustment for the risk of a fund relative to the market.

5. It enables the quantification of management's contribution to overall performance, net of any policy restrictions

Inter-fund comparisons provide only an ordinal measure (via the ranks) which is not net of any trustee restrictions. Since market return can be interpreted as one which could be derived from the passive management of a well-diversified portfolio, the deviation from market return is also a measure of the benefit from active management.

IV.2.2 DISADVANTAGES

The above advantages are not acquired without some associated drawbacks:

1. A notional standard is not perfectly comparable with an actively managed portfolio.

Smith(75,p254) comments:

"Both the market and random (notional) standards reflect a buy-and-hold strategy over time, while a typical portfolio being evaluated would be revised at periodic intervals. Assuming that portfolio revision enhances the ex-post yield of a portfolio, it can be argued that market and random (notional) comparison standards should represent a lower bound on performance."

This line of thinking probably led Pilch and Wood(64) and Plymen to argue that an unmanaged index is not a stringent enough standard of performance.

"Managers and analysts advising trustees are merely not justifying themselves unless they consistently produce significantly better results than from an unmanaged index."[1]

In the software developed in this study however, notional funds are realigned between review periods and are charged the simulated trading expenses of doing so.[2]

2. A notional standard is more complex than an inter-fund one, and is consequently less comprehensible.

3. It is a less potent motivating force than an inter-fund standard, as outline in IV.1.1 above.

4. It gives no guide to performance relative to other funds.

In direct contrast to inter-fund standards, notional standards by themselves give no guide to performance relative to other funds but a good guide to absolute performance. It may be that most funds have out-performed the market by a margin which is larger than that of the fund which is of interest.

1: Plymen in (41,p69)

2: Although these are insignificant on a quarterly basis, they can accrue to material amounts in the long term, as Ch.11, II.1.2 will show.

5. It is difficult to construct reliable notional funds.

The difficulty stems from two sources:

(i) There are no generally accepted indices for some sectors of the market (e.g., property)

(ii) There is no generally accepted standard composition of a fund as a whole.

Even if a satisfactory index can be found for each sector, the weights with which the indices should be combined into a representation of a whole standard fund are not well defined.

6. The benefits from switches and dealing do not always emerge in the short term.

Nursaw(59,p139) raises this objection on the grounds that if trading is to appear as profitable relative to an unmanaged index, its benefits must appear quickly enough to cover transaction costs before performance is measured.

7. It affects investment strategy

It is human nature for a conservative manager to be encouraged to model a portfolio on an index if he knows the performance of that portfolio is to be measured against that index.

8. Statistical significance is harder to assess using a notional standard, as outlined in IV.1.1 above

IV.3 TYPE OF STANDARD USED IN THIS STUDY

Cocks(14,p12) writes:

" ..... it would be an advantage if a procedure of portfolio performance analysis could be developed which .... may be used to provide both absolute and relative measures of the performance of a portfolio .."

Following this suggestion, such a procedure was implemented in this study. A notional standard was used as the main standard of performance against which the performance of funds in the office of the bank concerned would be measured. Despite the advantages of a notional standard however, it was recognised that for purposes of internal control and the direct comparison of managers, an inter-fund comparison standard was of more direct practical benefit. The comparison was designed to be a more cautious one than a simple ranking on the basis of TWR alone. Excess performance over the notional standard was also used as a basis for rankings. Because the notional standard used for each fund partly reflected the effect of legal restrictions on that fund, these rankings could compensate to some degree for heterogeneity from this source[1].

A notional standard was used as the main benchmark of performance because of its considerable advantages and because of its reported disadvantages, upon closer inspection, are not that serious:

1. The argument that an unmanaged index is not a stringent enough standard is dependent upon the assumption that active management is beneficial to performance. There is evidence, both in the academic and professional literature, to deny that this is the case[2]. Given this evidence, it is up to management to prove, by successful trading activity, that it can in fact out-perform an unmanaged index.

2. Although no <u>direct</u> indication of performance relative to other funds is given by a notional

---

1: This is explained in greater detail in Chs.9 and 13

2: The evidence centres on the work of Sharpe(70), Jensen(42) and on surveys within the investment industry such as Pension World(62) and Ellis(23).. These studies show that the great majority of funds have not been able to out-perform the market over periods varying from the last 5 years to the last 15 years. Controversy over the results mainly centres on the question of risk-adjustment and the fact that the studies have focused on periods of relatively static market movement only.

standard, it will be argued in XI of this chapter that the performance of a notional fund which is based on figures for the average commitment of U.K. pension funds to the various sectors is an acceptable proxy for the average performance of all U.K. pension funds. This implies that such a notional standard can provide an indirect indication of relative performance, and also a common denominator on which funds may be compared if so wished anyway.

3. Good indices are available for the two sectors in which most funds are mainly invested and acceptable indices are available for other sectors.

4. Nursaw's criticism that the benefits of switches are not fairly judged is more a criticism of the review period length than of notional standards themselves.

5. Modelling a fund's holdings on a sector index may actually be advisable.

Recalling the evidence mentioned in point 1 above, one consequence of that research in the USA has been the promotion of 'index funds' as a more productive way in which to invest pension fund money (or at least part of it). The idea is to capitalise on the evidence and simply invest money in a spread across the equity market in line with an equity index and only manage the investment of the extent of occasional realignment[1].

In addition, it is a practical reality of the equity market that most large funds, being worried about non-marketability, are forced to invest in much the same collection and weightings of stocks as those contained in an index anyway.

1: See, for example, Sinquefield(73) or Ehrbar(22).

The only real disadvantage of a notional standard is its greater complexity relative to an inter-fund approach. For this and other reasons, an inter-fund comparison standard based on all the funds in the one office was also included in the software.

V. CHOICE OF INTERNAL STANDARD

The choice relevant to the use of an inter-fund standard does not in reality exist. A random sample of funds is both impractical (since performance results are sometimes closely guarded secrets) and expensive. As already mentioned, all comparisons are done on a non-random sample of subscribing clients to a service.

Turning to notional standards, there have been five types proposed in the literature[1]. These may be divided into two distinct classes:

1. Direct representations of the market
2. Analytical models of the market

Remembering that the "market" here refers to individual sectors taken in isolation (methods of combining the sectors are discussed in sections XI), the following two sub-section discuss each class[2].

V.1 DIRECT REPRESENTATIONS OF THE MARKET

Cocks(13,p12) explains how all alternative methods within this class pursue the same philosophy:

> "In constructing a portfolio, a portfolio manager is essentially taking a sample of securities from a population of securities, which is usually referred to as the market. It is not a random sample. The securities are chosen from the market with the intention of forming

---

1: For example, see Smith(75)

2: In fact, Lindey(49) has suggested a third class, which although theoretically pleasing, is impossible to represent on a practical basis. It is the appreciation of an asset which automatically matches the pension fund's liabilities independently of interest rate movements.

a sample which is superior to the market from which it is drawn. To judge the success of the portfolio manager in this regard, one may compare the sample with the population; one may compare the portfolio with the market."

Discussions of how to represent the "market" (for a sector) in the literature are usually confined to the equity sector, but the same principles can be applied to other sectors. The three ways of representing the market are as follows:

1. Simulation of the entire market.

   This involves calculating the return which could be achieved from investment in every security in the market. While the weightings to be applied to individual securities are debatable, it is the most accurate method of representing the market, but of course also the most complex[1].

2. Random portfolios

   While this would reduce the expense of the above procedure, it has the complication of introducing sampling effects into excess performance figures.

3. Market indices

   The key feature of an index is the inclusion of those securities which have the greatest market capitalisation and hence have the greatest impact on the total value of the market. The advantages of an index are therefore as follows:

   (i) It is an agreeable compromise between accuracy and expense. There is an initial overhead expense of devising the index, after which calculations are relatively cheap. Its accuracy is derived from

---

1: Fisher and Lorie(32) have done this for the New York Stock Exchange

exploitation of the Pareto principle of a small number of shares accounting for a large amount of the total value of the market.

(ii) Pursuing Cocks' analogy, an index may be regarded as the structure of an average sample of securities one would obtain from an infinite number of replications of a sample of given size which is picked with probability proportional to size (by value).

The trade-off of a little accuracy for a large reduction in expense is a most attractive one and is sufficient to make the index approach a clear choice. A further advantage which previous writers have not mentioned is that it is a more realistic standard from a fund's point of view. Referring to Fisher and Lorie's(32) simulation of the entire New York Stock Exchange, Smith(75,p239) comments:

> "Fisher and Lorie provided performance data for the entire market, a portfolio that cannot, of course, be duplicated by any individual or institutional investor."

A market index on the other hand can be duplicated in miniature by an institutional investor, since non-marketability is minimised as a constraint by the index's inclusion of only the larger shares. Market indices were used by this study to provide its notional standards of performance.

V.2 ANALYTICAL MODELS OF THE MARKET

A model may be used to analyse the various choices which exist in the market and to choose from them that subset which, by the analysis, is identified to be "best" in some sense. This approach differs radically from that of the previous section where the aim was to derive a measure of "average", not "best" performance.

There are two types of analyses: mean-variance theory and other methods. The former type of method (as first developed by Markowitz(53) and extended by Sharpe(69)) includes any portfolio selection model based on Markowitz's efficient frontier strategy, in which mean return on a security is weighed against its risk, as measured by the standard deviation (or equivalently, variance) of return. Related to this mean-variance standard is the standard of performance provided by the Capital Asset Pricing Model (CAPM), which is a modern derivative of Markowitz's work. This CAPM theory is quite important in the provision of standards of performance which specifically adjust for the risk of a portfolio. For this reason, it is discussed in Chapter 7.

Wright(88) shows how a linear programming model can be used in the assessment of fund performance. An objective function can be formulated according to any number of subjectively chosen criteria (e.g., price-earnings ratio etc.) and a hypothetical portfolio constructed so as to maximise this objective within constraints imposed by the supply of funds, marketability of securities and trustee-imposed restrictions. Achieved performance may then be assessed against the "best possible" portfolio provided by the model. Furthermore, Wright shows how both ex-ante and ex-poste "best" standards of performance can be derived from the model according to whether the information input to the analysis is that available at the beginning of the review period or that available at the end of the period respectively.

The great advantage of any analytically derived performance standard is the indication of how close to "perfection" achieved results were. Most of the literature[1] agrees however that the use of these standards is impractical and even perhaps misleading. The reasons cited are as follows:

1: For example see Cocks(14), Holbrook(41), Fama(28).

1. Doubtful validity

III, Ch.8 will show that the evidence for the validity of CAPM theory is mixed and inconclusive.

2. Even if the theory were validated, not all managers would agree that the standard represents the "best possible" performance.

Whereas managers tend to select securities on expectations about their future, almost all analytical models use past properties of securities as direct estimates of future properties.

3. Greater abstraction and complexity than other standards.

VI. COMPONENTS OF PERFORMANCE

Various writers have proposed different components of performance which aim to measure the effect of various types of investment decisions and to which different names have been given. Most proposed schemes are related to a central heirarchy of components as follows:

1. Gain from trustees' policy regarding approved investments in certain sectors (Policy).

2. Gain from the fund manager's decisions regarding deviations from the trustees' policy (Strategy)

3. Gain from the fund manager's skill at the selection of individual securities (Security Selection).

The above components are as proposed by Holbrook(41) and constitute an extension of the two recommended by the SIA (76). The names quoted in parentheses above are those used by (41) and will be used here also.

Opinions have differed on the validity of any such heirarchy of components, as well as on whether these and not other components should be measured. The first point of controversy is considered in VII.2 below, while a discussion of other components is deferred until the three components mentioned above have been fully explained.

VI.1.. RATIONALE OF COMPONENTS

Starting from the bottom of the heirarchy, selection measures the contribution to the total return of the portfolio made by the manager's ability to select securities within the various sectors which earn a return which is above average for their respective sectors. For example, if the F.T.A. all-share index yielded a total of 6% over the past year, while the equity section of a portfolio yielded 8%, that portfolio would possess a positive share selection component of performance. The same concept can be applied at a sub-sector level also, so that one can talk about good or bad selection within the Consumer Durables sector of the equity market.

Strategy refers to the more general investment decision about where and by how much to invest the available funds. Strategic decisions are reflected in the proportion of the fund which is invested in various sectors. Hence a portfolio which is 90% invested in equities and 5% in gilts and 5% in cash is pursuing a strategy which is heavily oriented towards the equity market. A portfolio invested in equities to the extent of only 30% reflects a different strategy, one which would have a greater pay-off if the fixed interest and other sectors of the market yielded more than equities generally.

Opinions about the appropriate investment strategy differ, for example, between trustees and fund managers. Trustees may hold the view that a 90% equity strategy is the appropriate one in the context of future market movements in the long-term. If the manager disagrees with this view, the trustees can either bow to his opinion or enforce their wishes upon him.

The degree to which trustees do impose such specific restrictions differs considerably from fund to fund. However, where they are imposed, they can have a drastic effect on fund performance (as Chapter 2 illustrated). In these cases, it would be inappropriate to measure the performance of the manager by a direct comparison to market return, since he may have been prevented from pursuing his own strategy. In these cases, two adjustments must be made.

1. The contribution to total return of the manager's strategic moves must be measured not against the market, but against what fund performance would have been had trustee policy been followed.

2. That part of fund performance which is due to trustee policy must be isolated in order that the remainder can be attributed to management effect alone. This component of performance is termed here as Policy.

VI.2 REALISM OF PERFORMANCE COMPONENTS AS REFLECTIONS OF INVESTMENT DECISIONS

Dennis(15,p245) claims that:

> "Most funds, either consciously or unconsciously, differentiate between basic portfolio split or policy, strategy and tactics."

Other writers admit that these three components of performance are conceptual only:

> "In practice, the dividing lines between the decision levels and the elements of decision are not clear cut ..... Nevertheless the decisions do exist, however implicitly, in any investment decision making process"[1]

1: Eadie(21,p14)

The main artificiality of the components stems from the fact that while they do exist, they are not always independent decisions[1]. Draper, in a study of the investment practices of one City institution, confirms that his institution practised sector selection within the equity market. He concludes (20,p22):

> "The distinction between tactical and strategic decisions is not always clear. For example, the sale of a large line of stock that has been held for sometime may, or may not, involve a substantial change in emphasis in a portfolio. Accordingly, classification as a strategic or tactical decision varies."

In other words, a manager's decision to purchase a large block of shares may be because he either wishes to move into equities to a greater extent than he is at present (i.e., change his strategy) or because he believes the security purchased to be of superior earning power (i.e., aim to improve his selection). An analysis of performance will interpret the transaction as a bit of both, but will never be able to identify the original motive.

Strategy and selection components are therefore valid concepts, even if a little abstract. Each is a means of attempting to out-perform the market[2], and is therfore relevant to performance assessment.

The realism of the Policy component is a more controversial matter, in unison with the degree to which trustees participate in strategic investment decisions. Most authorities agree (e.g., Mulligan(58)) that it is the trustees' duty to formulate an overall investment policy for the fund.

1: In an analogy with statistics, the components are not orthogonal as would be the case in Factor Analysis for example.

2: This is meant here in a general sense of earning a return which exceeds market return. In the more academic sense of out-performance after adjustment for risk, only Selection is a means of beating the market. This will be discussed in Ch. 8.

The area of disagreement is by how much they exercise opinion independently of the advice given by their fund managers. Over the last decade, trustees have been increasingly willing to delegate discretionary powers to their fund managers. It seems to be the position today that few trustees impose restrictions, although most like to participate in the formulation of policy[1]. Hence the need to cater for policy restrictions may not be common. Nevertheless, an allowance for just such an effect has been incorporated into the system developed in this study (as an option) for two reasons:

1. When they do exist, the effects of restrictions can be so significant that they cannot be ignored.

2. When performance analysis is used for the purpose of internal control, it may be wished to compare individual managers' performance against that of an agreed "office philosophy" regarding what strategy should have been followed over a particular period. If the trustees' desired policy proportions in the analysis are replaced by proportions conforming to this philosophy, the various managers will be assessed against office philosophy as a standard. Hence the provision of a facility for a Policy component may have dual benefits.

VII. SYMBOLIC REPRESENTATION OF COMPONENT ANALYSIS

It is convenient to study the differences between component structures by using an algebraic approach. In general, the progress of a notional portfolio may be expressed in terms of its market value at time t. Given as fixed parameters the indices which are to be used as representations of the various sectors of the market, market value will be a function of three types of parameters:

1: A survey in (41) showed that trustees participated at least jointly with managers in the formulation of policy in 76 out of 93 funds surveyed.

1. Initial sector proportions, describing the split of the notional fund between sectors at the very beginning of the review period.

2. New money sector proportions, describing the way in which the various new money flows during the review period are to be split between sectors. These may be, by default, the same as the initial sector proportions but they need not be.

3. Timing of the notional investment of new money.

New money can be notionally invested at index levels which are either:-

(i) As at the specific date on which the new money was received by the actual portfolio.

(ii) As at the date which is the mid-point of the sub-period being simulated (e.g., mid-month).

(iii) Averages taken over the relevant sub-period being simulated (e.g., monthly average).

To express the market value of a notional fund as a function of these three factors, the following notation will be used. Given that the performance analysis is to be concerned with at most 6 vectors, let $\underset{\sim}{P}_b$ and $\underset{\sim}{P}_f$ be (6 x 1) vectors giving the initial and final split of the actual fund being analysed as at the beginning and end of the review period respectively. In general their ith element will be

$$\frac{MV_o^s}{MV_o} \quad \text{and} \quad \frac{MV_n^s}{MV_n} \quad \text{respectively} \qquad - (5.1)$$

Denote by π a matrix of proportions whose first column is $\underset{\sim}{P}_b$ and whose subsequent columns refer to the notional investment of new money. If m new money flows are to be simulated,

π will be of dimension 6 x (m + 1), where the $(j + 1)^{th}$ column will be the proportions in which the jth new money flow will be notionally invested between sectors (j = 1 to m). Define as special cases of this matrix the following parameters:

1. Let π_a consist of $\underset{\sim}{P}_b$ and the splits between sectors in which new money flows were actually invested.

2. Let π_m denote the initial and new money proportions of some hypothetical model of the market, designed to reflect the manner in which a fund <u>should</u> have been managed during the review period.

3. Let π_p denote the initial and new money proportions of a notional fund designed to reflect the way the fund should have been split if trustees wishes had been followed during the period.

4. Let π_b consist of m + 1 columns each equal to $\underset{\sim}{P}_b$. If specifies a notional fund which is to maintain the initial profile of the actual fund by investing all new money in the same split as the initial profile of the actual fund.

VII.1 EXAMPLE OF AN ADDITIVE COMPONENT SYSTEM

The example in Table 5.1 is intended to illustrate the basic logic behind the formation of components of performance. The example is taken from the SIA's report (76), whose own terminology is given in the lower half of the table for comparison purposes. The three components isolate different aspects of performance in the following ways:

1. Strategy

   Both $V(\pi_a)$ and $V(\pi_p)$ are based on index returns for individual sectors. Suppose that a fund manager was wise enough to hold a large proportion of the actual fund in higher yielding sectors, while

TABLE 5.1

SOCIETY OF INVESTMENT ANALYST'S (ADDITIVE) COMPONENT SYSTEM

In notation of this study	MV_n	−	$V(\pi_p)$	=	$V(\pi_a)$	−	$V(\pi_p)$	+	MV_n	−	$V(\pi_a)$
	1		2		3		4		5		6
	Final value of actual portfolio	−	Final value of notional portfolio reflecting Trustee investment policy	=	Final value of notional portfolio reflecting actual investment but market RORs	−	Final value of notional portfolio reflecting Trustee investment policy	+	As for 1	−	As for 3
Names of components used in this study	Excess return			=	Strategy			+	Selection		
Names of components used in SIA report	Performance			=	Selection of Sectors				Selection of Stocks		
Verbal explanation as given in SIA report	Final value of actual portfolio	−	Fully restrained fund	=	Partly restrained fund	−	Fully restrained fund	+	As for 1	−	As for 3

the trustees recommended putting most of the fund in what turned out to be the lower yielding sectors over the review period. Then the total final value $V(\pi_a)$ will exceed $V(\pi_p)$, since both started with the same initial value, MV_o, and experienced the same amounts of new money. The difference $V(\pi_a) - V(\pi_p)$ is extra profit[1] where the adjective "extra" is understood to refer to the reference point of that profit which would have resulted if trustee policy had been followed to the letter.

2. Selection

$V(\pi_a)$ is generated by assuming that the associated notional portfolio based on π_a is identical to the actual portfolio in every respect except that each sector earned a market (i.e., index) ROR for that sector instead of the actual ROR earned by the actual fund in that sector. Hence the difference $MV_n - V(\pi_a)$ measures the increment in the final value of the fund due to the fund's sectors appreciating (including re-invested income) faster than the rate earned by the same sectors in the market.

To briefly see how analysis can aid interpretation even with this simple system, suppose achieved return over the review period far exceeded trustees' expectations. The trustees and/or manager may like to know whether this superiority was due to the manager's breach of the trustee's wishes to keep within their policy. If this was in fact the case, Strategy would be positive and the manager would have a better case to argue for a change of the trustees' policy and greater freedom of action.

1: If $V(\pi_a) = MV_o + C + P_a$ where P_a = profit of actual fund

$V(\pi_p) = MV_o + C + P_p$ where P_p = profit of policy fund

then

$$V(\pi_a) - V(\pi_p) = P_a - P_p \qquad - (5.2)$$

If on the other hand the surprisingly high return was due to Selection being so positive that it more than balanced a negative Strategy component, the trustees would have a better case to insist that the manager move the fund back into line with their wishes[1].

Other component systems can be more complex than this one but are nevertheless all based on the same fundamental logic. Armed with the benefit of this illustration, the following sections investigate these other systems.

VIII. CHOICE OF MATHEMATICAL STRUCTURE

Total performance may be expressed as the sum of various (additive) components or the product of various (multiplicative) components.

VIII.1 ADDITIVE STRUCTURES

Additive structures are obtained by decomposition of the approximation (4.6) of the fund's MWR over a given review period. Recalling that this is simply the ratio of total profit to average capital employed, the previous section's decomposition of excess profit may be transformed into a decomposition of achieved excess MWR by simply dividing each component by the average capital employed figure, $MV_o + \bar{C}$.

Generally, if the super-script "*" refers to some standard of performance (like trustee policy in the previous section), an additive decomposition has the general form

$$MWR - MWR^* = \frac{P - P^*}{MV_o + \bar{C}} \qquad - (5.3)$$

$$= \frac{P - P_1}{MV_o + \bar{C}} + \frac{P_1 - P_2}{MV_o + \bar{C}} + \ldots + \frac{P_{g-1} - P_g}{MV_o + \bar{C}} + \frac{P_g - P^*}{MV_o + \bar{C}}$$

1: This rather simple example assumes the review period length is long enough to facilitate reliable conclusions. In reality, results over several review periods are needed in order to draw conclusions like these

where MWR = return onthe actual fund

P = Profit on the actual fund

P^* = Profit from the notional fund acting as the standard of performance

P_j = Profit from the notional fund associated with the jth and $(j + 1)^{th}$ component

g + 1 = Total number of components into which excess return is split (g = 1 in table 5.1)

VIII.2 MULTIPLICATIVE STRUCTURES

A multiplicative structure rests on the idea of premium return (as discussed in II.6, Ch. 4). The general form of a multiplicative system is:-

$$\frac{1 + MWR}{1 + MWR^*} = \frac{1 + MWR}{1 + MWR_1} \times \frac{1 + MWR_1}{1 + MWR_2} \times \ldots \times \frac{1 + MWR_{g-1}}{1 + MWR_g} \times \frac{1 + MWR_g}{1 + MWR^*} \qquad - (5.4)$$

where MWR^* = Return earned on that notional portfolio serving as the standard of performance.

MWR_j = Return on the notional portfolio associated with the jth and $(j + 1)^{th}$ components.

The SIA's additive system (refer Table 5.1) appears in Table 5.2 as a multiplicative system as an illustration of (5.4).

VIII.3 EQUIVALENCE OF ADDITIVE AND MULTIPLICATIVE STRUCTURES

Although the literature does not explicitly recognise it, any additive system may also be expressed as a multiplicative system of components. To see that each is an equivalent form of the other, note that the total premium return factor in Table 5.2 may be re-expressed as

TABLE 5.2

S.I.A.'s SYSTEM OF COMPONENTS EXPRESSED WITH A MULTIPLICATIVE STRUCTURE

$\dfrac{1 + MWR}{1 + MWR(\pi_p)}$	=	$\dfrac{1 + MWR}{1 + MWR(\pi_a)}$	x	$\dfrac{1 + MWR(\pi_a)}{1 + MWR(\pi_p)}$
Premium return of actual compared to policy notional fund	=	Premium return of actual compared to simulated actual portfolio	x	Premium return of simulated actual compared to policy notional portfolio
Total premium return	=	Selection factor	x	Strategic factor

where $MWR(\pi_p) = \dfrac{V(\pi_p) - MV_o - C}{MV_o + \bar{C}}$ and $MWR(\pi_a) = \dfrac{V(\pi_a) - MV_o - C}{MV_o + \bar{C}}$

$$\frac{1 + MWR}{1 + MWR(\pi_p)} - 1 = \frac{MWR - MWR(\pi_p)}{1 + MWR(\pi_p)} \qquad - (5.5)$$

without affecting the relative rankings of funds according to this statistic.

The numerator of (5.5) may be decomposed as

$$MWR - MWR(\pi_p) = MWR - MWR(\pi_a) + MWR(\pi_a) - MWR(\pi_p)$$

$$= \frac{MV_n - MV_o - C}{MV_o + \bar{C}} - \frac{V(\pi_a) - MV_o - C}{MV_o + \bar{C}}$$

$$+ \frac{V(\pi_a) - MV_o - C}{MV_o + \bar{C}} - \frac{V(\pi_p) - MV_o - C}{MV_o + \bar{C}} \quad \text{using (4.6)}$$

$$= \frac{1}{MV_o + \bar{C}} \left[MV_n - V(\pi_a) + V(\pi_a) - V(\pi_p) \right] \qquad - (5.6)$$

(5.6) may be recognised as the additive system represented in Table 5.1.

VIII.4 COMPARISON OF ADDITIVE VERSUS MULTIPLICATIVE STRUCTURE

To a large degree, the advantages of one are the disadvantages of the other. They are complementary in their strengths.

VIII.4.1 ADVANTAGES OF MULTIPLICATIVE SYSTEMS

1. Greater accuracy

The addivity of (5.3) depends on the simple nature of the approximation (4.6) to MWR. In contrast the MWRs used in

a multiplicative system may be calculated exactly if so desired. In practice however, the error is almost certainly negligible provided (4.6) is used over quarterly review periods or less.

2. Components can be linked over successive review periods.

This is without doubt a major advantage, as it is the longer term picture which tells the most in performance measurement. If performance is reviewed quarterly, multiplicative components can be derived which refer to performance over one or two or more years in the following manner. Let two successive review periods possess components (denoted by "a" and "b") in a two-component system. If R denotes the ROR over the two periods taken together, the total performance factor will be

$$\frac{1 + R}{1 + R^*} = \frac{(1 + a)}{(1 + a^*)} \times \frac{(1 + b)}{(1 + b^*)} = \frac{(1+a_1)(1+a_2)}{(1+a_1^*)(1+a_2^*)} \times \frac{(1+b_1)(1+b_2)}{(1+b_1^*)(1+b_2^*)}$$

$$= \left[\frac{1 + a_1}{1 + a_1^*} \times \frac{1 + a_2}{1 + a_2^*}\right] \cdot \left[\frac{1 + b_1}{1 + b_1^*} \times \frac{1 + b_2}{1 + b_2^*}\right] \quad - (5.7)$$

In general, the performance component for a period consisting of n successive sub-periods is equal to the product of the n individual sub-period components. Additive components cannot be linked in this or any other manner, unless re-expressed in multiplicative terms first.

VIII.4.2 ADVANTAGES OF ADDITIVE STRUCTURES

1. Greater simplicity and therefore greater chance of acceptance by non-specialists.

The greater familiarity of most people with profit promotes a more easily acquired intuitive

understanding of an additive system, which simply decomposes profit. No such familiarity exists with the concept of a premium return, on which multiplicative systems operate[1]. Additive systems have the added flexibility of being able to be considered in terms of either profit or return, whereas a multiplicative system is based on return only. In addition, it is easier for most people to recognise the additive relation between figures rather than a multiplicative one.

2. Additive components can be further decomposed into sector-by-sector figures (and theoretically down to sub-sectors also).

   Multiplicative components do not have this property. A separate decomposition is necessary for each sector.

VIII.4.3 RELATIVE MERITS OF ADDITIVE AND MULTIPLICATIVE SYSTEMS

The choice reduces to a subjective preference for the ability of a components system to be disaggregable either across sectors for the one review period, or across review periods for the total fund. Because disaggregation across sectors is not a material advantage however in an additive system, the essential trade-off is between the latter's simplicity compared to the price of complexity which is paid for a multiplicative structure's ability to be linked over time.

For additive components other than Selection, the identification of which sectors are to blame for an adverse total component figure can in many cases be deduced from an

---

1: Indeed Cocks(13) chooses to omit the interpretation of his system in terms of premium return and instead regard the statistics as pure indices.

inspection of the profiles of the two funds involved in the component, combined with the knowledge of the direction of market movements over the review period[1]. In addition, Selection figures for individual sectors can be derived seperately from a multiplicative system as

$$\frac{1 + MWR^s}{1 + MWR_1^s} \qquad - (5.8)$$

where MWR_1^s is the market return of the sth sector as measured by the notional fund $V(\pi_a)$.

The ability to link components over time is a real advantage of multiplicative systems for which no completely satisfactory substitute is available using an additive system. The best that can be done with an additive system is to either:

1. Sum the excess profits earned over successive review periods and re-percentage the total on the basis of average capital employed over the whole period.

   While this produces a decomposition over the longer term, its accuracy suffers from the inadequacy of $MV_o + \bar{C}$ as an expression of average capital employed over long periods.

2. Take an arithmetic average of past components as a summary of past performance.

1: For example, a negative Strategy component would be concentrated in the equity sector of a portfolio if less of the portfolio were in equities than is the case with the notional portfolio used as a standard, and if also the equity sector enjoyed a boom over the period.

This is analogous to taking a geometric average, $\bar{p}$, of a multiplicative component p as

$$1 + \bar{p} = \left[\prod_{i=1}^{n} (1 + p_i) \right]^{1/n}$$

VIII.4.4 STRUCTURE USED IN THIS STUDY

The components system incorporated into the software developed by this study is an additive one. While the greater theoretical validity of a multiplicative structure was recognised, it was judged that to most people a multiplicative system would be far less comprehensible. A slightly imperfect but easily understood performance analysis would be far more useful than a perfect but frequently puzzling array of figures.

IX. CHOICE OF TYPE OF PORTFOLIO DECOMPOSITION

G. Cocks in a clever article (13) in 1972 made a major contribution to the subject by pointing out that analysis of performance may be organised in one of two ways, which are referred to in this study as the following:-

1. "Top-down" approach

   Artificial adjustments are made to market rates of return so as to make them comparable to the return on the actual portfolio. The market is exposed (via simulation) to the same constraints and new money as the actual funds in order to make the market more comparable to the fund.

2. "Bottom-up" approach.

   With this method, the rates of return on the fund's securities are manipulated (through simulation of a very elementary nature) in order to make them comparable to an unconstrained market. The

effect of new money is removed by simply ignoring it (i.e., by assuming a constant portfolio).

IX.1 TOP-DOWN ANALYSIS - DYNAMIC PORTFOLIO DECOMPOSITION

The market is defined to include as many sectors as is desired, all of them not necessarily present in the fund being analysed. Thus the analysis commences from a "higher level" than the actual fund, in the sense that it can be wider ranging.

Top-down approaches are characterised by a need for dynamic simulation, which simulates the portfolio as it changes through the review period as a result of new money. The systems in Tables 5.1 and 5.2 are of this type.

IX.2 BOTTOM-UP ANALYSIS - CONSTANT PORTFOLIO DECOMPOSITIONS

This approach starts with the securities in the portfolio being analysed and ignores any sectors which are unrepresented. Interest centres on direct comparisons between the rates of return earned on various sections of the portfolio as compared with the rate of return in the market over the same review period on the same sections. Two features characterise this approach, as follows:-

1. A model of the market must be built to match in composition the structure of the fund.

   If, for example, the funds' equity sector consists mainly of building industry shares, an artificial market equity portfolio must be devised which also consists of building industry shares to the same extent. The process is equivalent to creating a notional fund which matches the existing portfolio exactly according to sectors (and sub-sectors also perhaps).

2. The effect of new money and all other changes to the portfolio must be ignored for the purpose of simulation.

That is, the assumption of a constant portfolio throughout the review period must be made. Only the growth of the initial portfolio is simulated.

Bottom-up systems vary in their handling of changes to the portfolio. The effect of such changes can either be ignored completely[1] or quantified as a residual component necessary to make up a total[2]. An example of the latter type is discussed in the next sub-section.

The adjustment of market RORs to make them comparable to the fund constitutes the effective substitution in the fund of actual RORs for market rates. This is analogous to "blowing up" the fund to the level of the market and seeing if the resulting total ROR matches a pre-set standard of performance.

IX.2.1 EXAMPLE OF CONSTANT PORTFOLIO SYSTEM

The simplest example is that published by Chiene(10), an algebraic interpretation of which appears in Table 5.3. The notation is the same as before except that the relevant matrices π^o have all but their first column as zero vectors, since the investment of new money is not simulated. This is indicated by the superscript zero. The valuation MV_n' is what the initial portfolio would have been worth at the end of the review period if no changes had been made to it at all during the period.

By dividing all terms by average capital employed, $MV_o + \bar{C}$, the decomposition of the fund's estimated MWR over the period is obtained. An example of this system can be found in Chiene(10).

1: As in the systems of Cocks(13) and Consultancy F (refer Ch. 6)

2: As in the systems of Chiene(10) and Consultancy A.

IX.3 COMPARISON OF CONSTANT VERSUS DYNAMIC PORTFOLIO DECOMPOSITION

The following paragraphs consider the advantages of the constant portfolio approach relative to the dynamic portfolio method. The advantages which automatically accrue to a components system because it is based on constant portfolio decomposition are as follows:-

1. Provision of greater detail

   Cocks(12) argues that managers are less interested than trustees in the broad statistics provided by the dynamic decomposition approach. To say this however is to deny that a manager is ever interested in how his portfolio might have gone had it been invested in sectors in which it does not at present have any holdings.

2. Provision of Allocation components

   This component is designed to further decompose what would be in a dynamic system the Strategic and Selection components. The use of Allocation components is dependent on the constancy of the simulated portfolio, as will be shown in XII.1, this chapter.

3. The isolation of all dealing effects into one component

   Both the strategic and selection contributions of all changes made to the portfolio during the review period are isolated in a Changes component (as shown in Table 5.3)[1]. Dynamic portfolio methods separate

---

1: Cocks' system does not have a Changes component but one can be built in if the MVR of the complete fund is known over the review period.

TABLE 5.3

EXAMPLE OF AN (ADDITIVE) CONSTANT PORTFOLIO PERFORMANCE ANALYSIS SYSTEM

$$\underbrace{MV_n - MV_o - C}_{\text{Total profit over review period}} = \underbrace{\underset{\substack{\text{Final value of notional portfolio reflecting frozen initial fund}}}{V(\pi_b^o)} - \underset{\substack{\text{Initial value}}}{MV_o}}_{\substack{\text{Strategy} \\ \text{(or "Policy")}}} + \underbrace{\underset{\substack{\text{Actual final value of frozen initial fund}}}{MV_n'} - \underset{\substack{\text{Final value of notional portfolio reflecting frozen initial fund}}}{V(\pi_b^o)}}_{\text{Selection}}$$

$$\underbrace{+ MV_n - MV_n' - C}_{\substack{\text{Increment due to changes in initial portfolio over review period, less new money} \\ \text{Changes}}}$$

the Strategic and Selection effects of changes but do not isolate them. They are compounded with the same effects derived from the initial portfolio (although as XII.3 will show later in this chapter, the strategic effect of changes can be isolated).

The disadvantages are severe however. If portfolio changes are ignored altogether, one has all the disadvantages associated with the constant portfolio method of estimating the TWR, as outlined in II.4.1, Ch.4. Even if a Changes component is incorporated into the system, one still has the major disadvantage of all constant portfolio decompositions. This is that they give no feedback on opportunity losses. Because the technique is bottom-up, it can neglect to indicate whole sectors of the market through which the fund is incurring large opportunity losses because it has no investments in those areas. Dynamic decompositions do cover opportunity losses to the extent that the original notional representation of the market covers sectors which are not represented in the fund.

The relative merits of the two types of analysis depends to a certain extent on the specific components systems of each type which are being compared. The one disadvantage of all existing constant portfolio techniques is their neglect of opportunity losses.

X. CHOICE OF REFERENCE POINT

X.1 IMPORTANCE

The specification of a standard of performance against which performance is to be compared is equivalent to the choice of a "primary reference point" in the terms of this study. For example, the primary reference points of the systems to Tables 5.1 and 5.3 are trustee policy $V(\pi_p)$ and initial fund MV_o respectively. Each component into which total performance is split has associated with it a "secondary reference point". All systems contain a secondary reference point which is the simulated actual portfolio based

on π_a, or π_a^o in the case of a constant portfolio decomposition. This is the basis for the Selection component which all systems possess. Trustee policy acts as a secondary reference point in Table 5.1 (for Strategy) in addition to its role as a primary reference point.

Reference points are important because their selection pre-determines to a certain extent the range of components which can be used to decompose total performance, however it is measured. For example, a Changes component cannot be derived without an initial fund reference point. Similarly, Strategy cannot exist without a trustee policy reference point. The system shown in Table 5.4 illustrates the general principle that virtually any combination of components can be created by the appropriate selection of the relevant reference points. Table 5.4 combines the SIA's system and a constant portfolio approach by using both initial fund and trustee policy secondary reference points. Further previously unpublished combinations such as this are considered in Table 6.4 of Ch. 6.

X.2 TYPES OF REFERENCE POINTS

Apart from the simulated actual fund based on π_a, there are three types of reference point: initial fund, trustee policy and model fund. These are discussed in turn in the following three sub-sections.

X.2.1 INITIAL FUND REFERENCE POINT

An initial fund reference point has four distinct advantages as follows.

1. It is the simplest type of reference point, in terms of both concept and calculation.

2. It leads to the simplest measure of total performance which can be decomposed, namely historical profit.

TABLE 5.4

ADDITIVE SYSTEM WITH BOTH INITIAL FUND AND TRUSTEE POLICY REFERENCE POINTS

$$\underbrace{MV_n - MV_o - C}_{\text{Total profit over review period}} = \underbrace{V(\pi_p^o) - MV_o}_{\text{Policy}} + \underbrace{V(\pi_b^o) - V(\pi_p^o)}_{\text{Strategy}}$$

Policy = Gain from initial fund conforming to trustee policy

Strategy = Additional gain from initial fund's deviation from trustee policy

$$+ \underbrace{MV_n' - V(\pi_b^o)}_{\text{Selection}} + \underbrace{MV_n - MV_n' - C}_{\text{Changes}}$$

Selection = Extra return over market return earned by the initial portfolio

Changes = Gain from changes made to the initial portfolio

where $V(\pi_p^o)$ is the final value of notional portfolio formed by the investment of the initial value of the fund between sectors according to trustee policy and no subsequent investment of new money

All other reference points involve the concept of excess profit or premium return.

3. It facilitates the isolation of all the effects of a manager's changes to the portfolio in the one component (Changes).

This is a direct measure of the benefit of changes to the portfolio made during the review period. It is an imperfect measure of the benefit from active management however as it is dependent on the volume of new money, which is beyond the manager's control. If one manager has no new money while another has some, and neither makes any changes to his portfolio other than for the investment of any new money, the latter manager may possess a positive Changes component, whereas the former manager will have a zero component. Yet the second manager cannot be said to have managed the fund more actively, since his activity was prompted solely by events outside his control. Also note that a Changes component will be positive even though the new money may have earned a return over the period which was far below market return. Hence Changes is not a very satisfactory component of performance with which to assess managerial performance.

X.2.2 TRUSTEE POLICY REFERENCE POINT

This has already been illustrated as the basis for a Strategy component. It leads to some quantification of opportunity losses to the extent that it indicates the cost of a manager's deviation from trustee policy.

X.2.3 MODEL FUND REFERENCE POINT

A model fund reference point is represented by a notional fund which is in some sense either "ideal", "best" or "fair". It is a benchmark of performance which the manager and trustees should at least aim for. For example, statistics on

the average split between sectors of all pension fund money in the U.K. can be used to derive a notional fund which simulates the performance of a fund which is invested in each sector, as a percentage of its total value, to the same extent as all pension funds on average. If the performance of the index used to represent each sector is taken to be the average return earned by funds in that sector, such a notional fund can be viewed as earning a return which is an average return for all pension funds. It constitutes a "model" fund because a fund manager and its trustees should hope that their fund earns at least this average return. There are other ways of constructing a model fund, as discussed in XI.2 to follow.

The main advantage of a model fund reference point is its ability to indicate the full opportunity losses of not only actual investment strategy persued by the manager but also trustee policy[1].

A second advantage is a model fund reference point's ability to indicate the absolute merit of performance as well as the relative merit of performance. Using trustee policy as a primary reference point for example, no information is conveyed about absolute performance since the absolute merit of trustee policy itself is unknown.

XI. MODEL REFERENCE POINTS

XI.1 EXAMPLE OF AN ADDITIVE SYSTEM WITH MODEL REFERENCE POINT

Table 5.5(a) illustrates the SIA's additive system (Table 5.1) with a primary model fund reference point added. Opportunity losses are quantified by a system such as this to

---

1: The opportunity losses are only "fully" identified on the assumption that there is no industry-wide malpractice or error of omission which most funds are practising (so affecting average performance). In a world of competition such errors are not likely to be numerous, although III.2.2, Ch. 9 will illustrate one existing example.

TABLE 5.5

(a) ADDITIVE SYSTEM USING BOTH MODEL AND TRUSTEE REFERENCE POINTS

$$\underbrace{MV_n - V(\pi_m)}_{\text{Excess profit relative to model fund}} = \underbrace{V(\pi_p) - V(\pi_m)}_{\text{Policy}} + \underbrace{V(\pi_p) - V(\pi_a)}_{\text{Strategy}} + \underbrace{MV_n - V(\pi_a)}_{\text{Selection}}$$

Policy = Gain from trustee policy

Strategy = Gain from manager's deviation from policy

Selection = Extra return over market return

(b) SIA's ADDITIVE SYSTEM WITH A TIMING COMPONENT

$$\underbrace{MV_n - V(\pi_p)}_{\text{Excess profit relative to trustee policy}} = \underbrace{V(\pi_a, E) - V(\pi_a)}_{\text{Timing}} + \underbrace{V(\pi_a) - V(\pi_p)}_{\text{Strategy}} + \underbrace{MV_n - V(\pi_a, E)}_{\text{Selection}}$$

Timing = Gain from investment of new money at actual dates compared to passive dates

the extent that the model achieves a return which is in excess of the actual fund. If, for example, trustees insist that a fund not be invested in equities in the long term, and the manager deviates from this policy by placing 10% of the fund in equities, the SIA's system would show Strategy and total performance to be very favourable if equities performed better than other sectors in the review period. However if the model fund is invested 50% in equities, its performance would be even better and the system of Table 5.5 would show total permance in a bad light. The Policy component would show that the trustees incurred a great opportunity loss over the review period in ignoring equities, while Strategy would signal that the manager was wise to deviate from policy.

XI.2 TYPES OF MODEL REFERENCE POINTS

There are various methods by which a model fund can be constructed to reflect that return which a fund should have earned over a review period. The main types of methods are:

1. Unconstrained best possible performance
2. Constrained best possible performance
3. Subjective standard of performance
4. Average standard of performance

XI.2.1 UNCONSTRAINED BEST POSSIBLE PERFORMANCE

The model fund is meant to represent the best return which would have been obtained over the review period. This is simply the investment of the entire notional fund in that sector which enjoyed the greatest return over the review period.

XI.2.2 CONSTRAINED BEST POSSIBLE PERFORMANCE

Few, if any, managers would hope to ever reach a level of performance implied by the unconstrained standard mentioned above. A more realistic model can be derived as that split between sectors which would have resulted in the greatest

overall return on the notional fund given that the necessary transactions to transform the portfolio from its initial profile to this ideal profile are within the constraints of marketability. It is impossible for a fund to switch from a 100% position in gilts just before an equity boom to a 100% equity position.

The calculation of an optimum notional portfolio within the constraints of marketability has not been suggested in the literature. It would involve the use of a linear programming approach to maximise total notional return subject to marketability constraints. For the sth sector, let

p_s^o = Proportion of the actual fund in the sth sector at the beginning of the review period (known)

r_s = Market ROR earned during the review period (known)

ε_s = The maximum volume (in £) of securities in sector s which can be traded within a certain time interval at the beginning of the review period (specified).

p_s = Proportion of the notional model fund which is to be initially invested in the sth sector. (Unknown).

The composition of the model fund is given by the following linear programme.

$$\text{Maximise} \quad \sum_s (1 + r_s) \; p_s$$

subject to

$$\left| p_s - p_s^o \right| < \frac{\varepsilon_s}{MV_o^s} \quad \text{for } s = 1 \text{ to } S$$

$$\sum_s p_s = 1 \qquad - (5.10)$$

$$p_s \geqslant 0 \text{ for } s = 1 \text{ to } S$$

While this sort of model fund is a realistic standard of performance which is best in the sense of (5.10), it has two great disadvantages as follows:

1. Its specification has some arbitrary points.

   The constants ε_s and their associated trading intervals are undefined. No-one really knows how much a particular market can absorb in a given time interval.

2. It leads to a different model fund for different funds.

   The marketability constraints must involve the initial size of the fund, MV_o, since it is easier for a small fund to sell off 20% of its holdings than for a larger fund. Heterogeneity of model funds is inconvenient if many funds are wished to be compared on the basis of a common standard.

XI.2.3 SUBJECTIVE STANDARD OF PERFORMANCE

The rationale for an arbitrary model fund may be any of the following.

1. It can represent an a-priori or naive standard of performance.

   " ..... a useful 'benchmark' to use in measuring timing[1] ability is a model portfolio invested 50% in a broadly based (equity) index ..... and 50% in three-month Treasury bills ..... If one cannot get one's timing to be better than this benchmark, then one should consider using such a simple portfolio structure with considerable administrative savings[2]".

The difficulty is that there will always be another

1: "Timing" used in this context refers to the sector Selection decision.

2: Ross-Jackson(67,p77)

equally naive benchmark which will show relative performance to be good instead of bad, or vice-versa. Hence managers and trustees can easily rationalise away the results.

2. Multiple abitrary model funds can give a more complete picture.

One consultancy[1] uses two arbitrary models, one wholly invested in equities and the other equally split between equities and gilts. It presents components derived from each model side by side. A formula is provided which enables the user to approxmate the measure of total relative performance for his own specific desired combination of the two sectors. This device does not overcome the basic arbitrariness of the whole approach however. The interpolation is only possible on the basis of a two-sector model and in any case does not enable the direct quantification of components according to the user's desired model profile.

3. It allows the trustees to specify their own model fund.

There is a danger with this method that the trustees will model it on their own policy, so weakening the feedback from a Policy component.

XI.2.4 AVERAGE STANDARD OF PERFORMANCE

The use of statistics on U.K. pension funds, as described in X.2.3 above, is entirely logical provided three assumptions can be accepted. These are:

1. That the average proportions should be weighted averages, where the weight attached to a particular fund's split between sectors is the size of the fund.

1: Constultancy D in terms of Ch. 6.

2. That the published statistics, although based on only a sample of pension funds, are accurate enough for the purpose at hand.

3. That the index return on a sector can be regarded as an average return of all pension funds in that sector.

Holbrook(41,p88) has criticised this method of construction of model funds on the basis that large funds tend to "distort" the figures. However this is precisely what one would like to be the case. The fact that a very small fund holds 90% of its assets in modern art should not be as relevant as the fact that the largest fund holds nothing in that sector. Appendix 5-I describes the available statistics and proves that their use is equivalent to taking a weighted average of funds' splits between sectors.

No-one appears to have studied the accuracy of the published figures and so this point must be taken on trust. Stock brokers Phillips and Drew(63) have noted a past error in the figures on one occasion.

The assumption that index returns constitute average sector returns is the most serious theoretical problem of this type of model fund. Academic research[1] indicates that funds on average earn returns which are marginally less than index returns. There is conflicting evidence however. The methodology of the studies has been criticised[2] and most of the work has been done on American mutual funds rather than British pension funds. Popular wisdom certainly equates fund performance in the equity market with that of the index. The argument is that large funds are forced to invest in much the same stocks as the index because of marketability constraints. Holbrook(41,p40) comments:

> "Because of the growing dominance of large institutional investors, their views at any time on the future course of market prices are tending to become self-fulfilling prophecies."

1: See footnote 2 to IV.3, this chapter
2: See for example Mains(52) and Black, Fisher and Scholes(6).

Talking of American mutual funds, Sharpe(70) observed that the margin of under-performance roughly corresponds with dealing costs, implying that if funds were not as active, their performance may be closer to that of the index. If this is the case (it has not been proven beyond doubt), the use of an index return as a proxy for average return would be justified, since it is free of the effects of active management.

Hence the ROR on a model fund of this type is not the average return of all pension funds in its strictest sense. The latter would allow for any average under-performance, however caused, as mentioned above. Rather, it is the ROR on a portfolio which is managed in a passive manner, the only action of the hypothetical management being to ensure that the model fund is aligned between sectors in a profile which is average. Because most investment personnel agree that sector decisions are the major determinants of performance[1], the difference between true average return and that of the model fund should be minimal anyway.

XII. CHOICE OF COMPONENTS AND AUXILLIARY ANALYSES

The literature on peformance measurement contains a liberal sprinkling of suggestions for components other than the three considered in the previous sections. This section aims to examine the relative merits of these suggestions.

XII.1 ALLOCATION AND SELECTION COMPONENTS

These two components are more easily illustrated using a multiplicative system of components, such as that used by Cocks(13). Using lower case letters to represent attributes of the fund and upper case to indicate those of the market, the contribution to total return from the selection of securities in a sector (previously referred to as Selection) may be written as

$$\text{Total Selection} = \frac{1 + r_w}{1 + R_w} \qquad - (5.11)$$

1: See III, Ch. 10.

where r_w is the ROR on the sector in the actual fund (subscript w indicates that it is a weighted return).

R_w is the market ROR (of some model fund for example).

Assuming that the sector consists of N different securities in the market, each with capitalisation

MV_i at the beginning of the review period,

$$1 + R_w = \sum_{i=1}^{N} (1 + R_i) \frac{MV_i}{MV_o} \qquad - (5.12)$$

where R_i = ROR on the ith security over the review period

MV_i = Market capitalisation of the ith security

MV_o = Total market capitalisation of the sector at the beginning of the review period.

Similarly, if the assumption can be made that the portfolio has remained constant throughout the review period,

$$1 + r_w = \sum_{i=1}^{n} (1 + r_i) \frac{mv_i}{mv_o} \qquad - (5.13)$$

Total relative performance of the fund's holdings in this sector (given by (5.11)) will consist of two factors:

1. The fact that the fund's securities earned on average a different return than the average return of all securities in the same sector in the market.

2. The fact that the fund may have held securities of this sector in relative proportions by market value which differ from the holdings implied by the securities' relative market capitalisation.

The first component may be quantified by comparing an unweighted average return of the fund's securities with an unweighted average of the returns of all securities in the

same sector in the market. This yields a pure Selection component

$$\text{Selection} = \frac{1 + r_u}{1 + R_u} \qquad - (5.14)$$

$$\text{where} \quad 1 + r_u = \frac{1}{n} \sum_{i=1}^{n} (1 + R_i) \qquad - (5.15)$$

$$1 + R_u = \frac{1}{N} \sum_{i=1}^{N} (1 + R_i) \qquad - (5.16)$$

The second component is best interpreted as that part of Total Selection which is unaccounted for by Selection. That is,

$$\text{Allocation} = \frac{\text{Total Selection}}{\text{Selection}}$$

$$= \frac{(1 + r_w)/(1 + r_m)}{(1 + R_w)/(1 + R_u)} \qquad - (5.17)$$

If more of the fund is allocated to higher yielding securities than is the market, Allocation will be positive. Note that,

$$\text{Total Selection} = \text{Allocation} \times \text{Selection} \qquad - (5.18)$$

The disadvantages of this decomposition of Total Selection are:

1. Its derivation is dependent on a constant portfolio approach. (already seen to have its own drawbacks)

2. It can lead to voluminous output.

   If the components are output on the basis of individual securites, one can be in the unenviable

position of having a mass of figures with no clear trend.

In addition, it is questionable if information as detailed as this is necessary. Cocks(13,p11) rightly points out that such detail is of interest only to the fund manager. The fund managers involved in this study maintained that given they have an unfavourable Selection figure for a certain sector, they would know which securities to blame and why (i.e., whether it was an unbalanced holding or just a poor return or both). While this claim may be untested, it is a reflection of a fear observed amongst the managers of being swamped by a mass of figures. All wanted a set of clear summary statistics which gave them the overall picture, rather than a large collection of detailed figures, such as those which the proper use of these components would imply. For this reason plus the necessity of a constant portfolio approach, these components were not included in the software of this study.

XII.2 TIMING COMPONENT

Timing may only be measured using dynamic portfolio simulation. The simplest approach is to distinguish between transactions stemming from the investment of new money and those which are independent of the availability of new money. (switches etc.) Assumptions about when each type of transaction would have been passively timed differ because the former type depends on the date of availability of the new money concerned. Section VII of this chapter listed the various alternatives for passive timings, to which must be added such extremes as simulating all transactions as at the middle, or average index value, of the whole review period (e.g., quarter).

As an illustration, suppose passive timing is regarded as the middle of the review period for switches and for new money as at its date of first availability. The notional fund leading to $V(\pi_a)$ would simulate transactions at these dates.

Call the similar situation with exact dates $V(\pi_a, E)$ where the second argument signifies that simulations are done with exact timing. The timing component will appear as shown in Table 5.5(b).

Note that:

1. The component Strategy is independent of the timing of transactions provided that the simulated policy fund $V(\pi_p)$ involves the same technique of passive timing of simulated investments as that assumed by $V(\pi_a)$

2. If no timing component is isolated and transactions are simulated only with passive timing, then timing effects will be embodied in the Selection component, which becomes $MV_n - V(\pi_a)$ (putting $V(\pi_a) = V(\pi_a, E)$ in Table 5.5(b)). This gives the SIA's system of Table 5.1.

XII.2.1 DIFFICULTIES OF MEASURING TIMING

1. It requires exact or at least very detailed information on the actual timing of transactions.

2. It fails to quantify the effect of timing of intra-sector switches.

   These remain hidden in the Selection component.

3. It is frequently difficult to distinguish those transactions which were prompted by new money from those which were pure switches.

In practice it is the burden of the detailed data collection which is the greatest disadvantage. Measurement of timing effects is very difficult from a practical point of view unless the accounting system is computerised. For this reason, timing was measured in this study using an alternative approach, as described in the next sub-section.

XII.2.2 USING TWR AND MWR TO MEASURE TIMING

Recalling from Chapter 4 that the MWR is affected by the timing of new money whereas TWR is not, the difference between these two RORs should provide a measure of timing which does not require the same detailed input as the previous technique. If, for a particular sector, its MWR exceeds its TWR, the purchases and sales of securities in that sector were timed well, since the timing served to inflate the sector's MWR. The same difference for the total fund is no guide to timing performance of a manager however since the timing of new money flows into the fund is usually beyond the manager's control.

This measure is only approximate in practice for three reasons:

1. In practice, the TWR is itself only an estimate.
2. In practice, the TWR, if estimated using index simulation, is based on a notional fund which is passively timed to some degree ($V(\pi_a)$) when it should theoretically be based on exact timings.
3. The difference is also affected by the quantity of new money as well as the timing of new money. Thus "timing" in this context refers also to the decision about how much to invest as well as when to invest.

XII.3 INITIAL AND SUBSEQUENT STRATEGY COMPONENTS

An analogy to the "frozen initial fund" concept as used by constant portfolio decomposition can be incorporated into a dynamic decomposition though the use of a notional fund which invests new money according to the same sector strategy as that embodied in the notional fund. Calling this notional fund $V(\pi_b)$, new money is notionally invested between sectors in the same proportions as those in which the fund was initially split. Thus π_b represents a continuation of the manager's strategy as at the end of the last review period.

Using $V(\pi_b)$ as a secondary reference point leads to a decomposition of Strategy as follows.

$$\underbrace{V(\pi_a) - V(\pi_b)}_{\text{Strategy}} = \underbrace{V(\pi_a) - V(\pi_b)}_{\text{Subsequent Strategy}} + \underbrace{V(\pi_b) - V(\pi_p)}_{\text{Initial Strategy}} \quad -(5.19)$$

The second component indicates the reward from the fact that initial investment strategy differed from trustee policy. Subsequent Strategy quantifies the additonal gain on top of Initial Strategy made from any change in investment strategy during the review period. These particular components have not been published in the literature, although one consultancy uses them in their measurement service[1].

XII.4 EXCLUDED INVESTMENTS

Trustee restrictions of a nature which specifically exclude certain types of securities (e.g., a certain industry) can theoretically be quantified by the construction of a special index which excludes the banned securities. The effect of the policy will then show as the difference in returns on this index and the model fund. In practice, the construction of the index is not a simple task unless the excluded investments happen to coincide with sub-sectors of the FTA All Share index (or whichever index is relevant).

XII.5 REPEATED DECOMPOSITION FOR SUB-SECTORS AND INDIVIDUAL SECURITIES

The performance of each sector can be decomposed using a repetition of the set of components which were used to decompose the performance of the fund as a whole. For example, equity performance can be decomposed into Strategic and Selection components using the various sector indices which comprise the FTA All Share index (Consumer Durables, Capital Goods etc.). The results will in effect be a detailed decomposition of the equity sector's Selection component in the decomposition of total performance. The same can be done with the gilt sector where sectors are regarded as ranges of maturities.

1: Consultancy E in the terms of Ch. 6.

Decompositions can also be done on the return for individual securities. The first analysis system published (Fox(33)) did this and one consultancy concentrates on this level of detail to produce a large amount of statistics[1].

For reasons which will be explained in III, Ch. 10, this study does not consider analysis at the level of individual securities and in addition does not specifically cater for an analysis at sub-sector level, although this can be done using the software developed. To what level of disaggregation an analysis is taken is largely a subjective matter, dependent on the purpose to which the figures are to be put and the technical sophistication of the user.

XII.6 EVALUATION OF BENEFITS OF PURCHASES AND SALES

This is equivalent to an assessment of the merit of the manager's timing but on a very detailed level. Short and Brumwell(72) summarise the approach. Needless to say, the impracticability of collecting the necessary data precludes the conduct of this analysis in most cases.

XII.7 INCOME VERSUS CAPITAL APPRECIATION

> "It is sometimes argued by pension fund managers, that fluctuations in capital value of the assets are only of small significance to them because they are mainly interested in long term growth of income[2]".

Opinions about whether income should be isolated from capital appreciation differ radically in the literature. There are those who consider income to be a prime indicator of the "quality" of an achieved ROR. One American fund manager has put it this way(37,p121).

> "If 90 per cent of your return came in the form of dividends and interest, those are pretty stable and fairly sure sources of return; the other 10 per cent, of course, comes from market fluctuations, which are a highly uncertain sort of thing."

1: Consultancy A in the terms of Ch. 6.

2: Brew(7 ,p127)

Brew(7 ,p125) has proposed that income be treated seperately merely because the indices for simulating market income are less reliable than the price indices. In complete contradiction Weaver(84,p167) suggests that the performance of large funds may be safely measured by ignoring income completely and considering capital appreciation only. Weaver's argument is convincing only in the case of very large portfolios which are well diversified in all sectors of the market.

The fact that income is a certain gain while capital gain may disappear tomorrow cannot be ignored, so the software of this study indicates the "quality" of return as defined above, as well as conducting a seperate performance analysis of the fund's income relative to that of the market.

XII.7.1 COMPONENTS OF INCOME PERFORMANCE

Just as total performance relative to a model fund may be decomposed, relative income performance can also be expressed as components which quantify the income implications of various types of investment decisions. Analogous to the additive system of Table 5.5 is the following decomposition of excess income over the model fund:

$$GI - I(\pi_m) = I(\pi_p) - I(\pi_m) + I(\pi_a) - (\pi_p)$$

Excess income earned — Policy — Strategy

$$+ GI - I(\pi_a) \qquad - (5.19)$$

Selection

where GI = Gross income earned by the actual fund

$I(\pi)$ = Simulated gross income earned by a notional portfolio based on

The components have the same interpretation as given in VIII.1 this chapter except that they relate to income.

Division of (5.20) by average capital employed, $MV_0 + \bar{C}$, will produce a decomposition of the excess income yield of the fund over that of the model fund[1].

XII.8 MARGINAL ANALYSIS

The components of performance which are most easily calculated are based on a marginal analysis which asks what was the increase in return on the fund as a whole due to the fund's investment in the sth sector. This increase is quantified as

Marginal return from s^{th} sector	=	ROR on fund as a whole	-	ROR on fund with s^{th} sector omitted	- (5.4)

Its severe limitations are that it conveys little about opportunity costs, says nothing about the investment of new money and does not isolate any measure of the benefit of management. It is a "bottom-up" analysis, incapable of indicating opportunity losses.

XIII. COMPONENTS OF OVERSEAS SECTOR PERFORMANCE

Unless a fund manager is expected to anticipate changes in exchange rates, the performance of the overseas sector of a fund will not be a true reflection of the skill with which the manager has handled that sector. The effect of currency movements, being an external factor beyond the manager's control, must be isolated to indicate if, for example, an overseas sector is doing well because of good Selection or because of fortuitous exchange rate changes, or both. The interference of the Bank of England's investment currency regulations also leads to a demand for components of performance to quantify how adversely these regulations are affecting performance.

The existence (until recent times) of the 25% premium

1: Refer IX.4, Ch. 11.

surrender rate[1] created great problems for the valuation of overseas assets. Some argue that to be consistent with the general principle of valuing an asset at its realiseable value, overseas assets must be valued after deduction of the 25% penalty. Others argue that to do so is to penalise a manager's apparent performance, recommending that the deduction should not be made until he decides to sell. Because of the uncertainty involved in the latter approach, overseas assets were valued in this study after deduction of the 25% penalty. This study shows (in XIII.3 to follow) that a component can be derived to indicate by how much the penalty affects a return over a review period. In this way any possibility of unfair assessment can be overcome.

Although various writers[2] have called for the development of components to show these effects, the literature contains no details of how this should be done. Such a component analysis was developed as part of the analysis system of this study.

XIII.1 NOTATION

Given the ROR in the overseas market over the period and the actual transactions conducted in this sector, the final value of the overseas sector of a notional portfolio will be a function of two things:

1: The reader is referred to (3) for a detailed outline of the dollar premium regulations. Briefly, they compel a purchaser of overseas currency to pay a higher exchange rate, called the "premium rate" if the overseas currency is to be used for investment purposes. Income on an overseas investment can be remitted back at the ordinary rate, but the proceeds of a sale of overseas assets must be exchanged in the following manner, even if the proceeds are invested in another overseas asset. 75% of the proceeds must be changed at the premium rate, while the remaining 25% must be changed at the ordinary rate. This has the effect of forcing the invester to pay 25% of the premium be originally paid over the ordinary rate to the U.K. government, so reducing the overall ROR on his overseas assets.

2: For example see Holbrook(41,p18) or Dennis(15,p245)

1. The exchange rates at which transactions are conducted and at which the sector is valued at the end of the review period.

2. The premium surrender rule, which affects the effective exchange rate at which some of the transactions are conducted and, even more so, the final value of the sector.

Given the initial value of the overseas sector, MV_o^{os}, the fund value of this sector may be represented as $V(E, \alpha)$ where the two arguments represent the above two factors. The exchange factor E may assume one of two values:

E_o = Exchange rates as they were at the beginning of the review period.

E_a' = Exchange rates as they actually varied over the review period.

The parameter α refers to the percentage of the dollar premium which must be surrendered upon the sale of an overseas asset. This has stood at 25% since its inception until its abolition in January 1978.

XIII.2 COMPONENTS DEVELOPED FOR THIS STUDY

The analysis of the performance of the total fund will have highlighted the overseas sector's performance relative to the market. Of more interest in the analysis of the overseas sector in isolation will be a decomposition of the actual profit made during the review period, using an initial fund reference point. For simplicity, an additive system was developed, as follows:

$$\underbrace{MV_n^{os} - MV_o^{os} - C^{os}}_{\text{Total Profit}} = \underbrace{MV_n^{os} - V(E_a,\alpha_a)}_{\text{Selection}} + \underbrace{V(E_a,\alpha_a) - V(E_a,\alpha_o)}_{\text{Premium Penalty}}$$

$$+ \underbrace{V(E_a,\alpha_o) - V(E_o,\alpha_o)}_{\text{Exchange rate}} + \underbrace{V(E_o,\alpha_o) - MV_o^{os} - C^{os}}_{\text{Strategy}} \quad - (5.22)$$

Dividing (5.22) by the average investment in the sector during the period will produce a decomposition of the MWR earned in this sector over the review period.

"Strategy" is the gain which any investor who put the same amounts of money into the overseas sector as the fund would have made provided either exchange rates or premium penalty changed. The "Exchange Rate" component measures the contribution to total return in this sector made by movements in the exchange rates over the period, assuming the premium penalty remains constant at its initial value, α_o.[1] This "Premium Penalty" component measures the contribution to sector return from any change in the premium penalty over the period. If the penalty changes, it has two modes of effect. The first is in affecting (quite drastically) the final value of the portfolio. The second effect lies in its role in determining the penalised exchange rate at which any transaction during the period involving the sale of overseas assets produces sterling receipts. This component is usually zero. "Selection" is the same figure as that produced by the overseas sector towards Selection in the analysis of total performance. It measures the extra return earned above the market rate, at actual exchange rates and penalty.

XIII.3 OTHER POSSIBLE COMPONENTS

Three other types of components can be devised to aid the analysis of overseas sector performance, none of which were embodied in the software developed in this study.

1. Effect of changes in the dollar premium as distinct from changes in the ordinary exchange rate.

   If $E_a(p_o)$ denotes exchange rates during the period based on actual ordinary rates but a constant premium penalty p_o, while E_a denotes the

---

1: Since the penalty very rarely changes, this qualification is really redundant.

actual exchange rates based on the actual premium penalties thoughout the review period as before, the Exchange Rate component may be further decomposed into

$$\underbrace{V(E_a,\alpha_o) - V(E_a(P_o),\alpha_o)}_{\text{Premium}} + \underbrace{V(E_a(P_o),\alpha_o) - V(E_o,\alpha_o)}_{\text{Ordinary Exchange Rate}} \quad - (5.23)$$

This refinement was not used in the software however, as it makes little difference to a fund whether the premium rate changes due to one cause or another - the net effect is the same.

2. Loss of profit this period due to the existence of the premium penalty.

Strategy as defined in (5.22) can be split into two components, the first of which quantifies the current loss of profit due to the existence of the penalty. The components are

$$\underbrace{V(E_o,\alpha_o) - V(E_o,0)}_{\text{Penalty Loss}} + \underbrace{V(E_o,0) - MV_o^{os} - C^{os}}_{\text{Strategic Gain with no penalty loss}} \quad - (5.24)$$

The first component is that profit which was foregone because the penalty was at a positive level and not 0%. It would be useful in assessing to what extent an initial investment in the overseas sector yields a poor return just because of the penalty effect.

3. Opportunity losses involved in choice of countries

This would involve an analysis similar to that described in XII.5 this chapter. It was not persued

in this study because of the lack of an overall index linking different countries together.

The decomposition (5.22) is discussed in more detail in V, Ch. 11. Examples are given in Chapter 11.

CHAPTER SIX

SURVEY OF EXISTING PERFORMANCE ANALYSIS SYSTEMS AND SOME PROPOSED NEW ONES

This chapter briefly surveys those systems which have been published and/or made commercially available on the British market.[1] Judgements on the 13 systems surveyed are made on the basis of the advantages and disadvantages of the general classes of methods to which they belong, as outlined in the previous chapter. Additional judgements are made on the basis of a list of ideal characteristics of a performance analysis system as gleaned from the literature and as seen by this writer. Finally, the general principles of the previous chapter are used to suggest component schemes which do not appear in existing systems.

The profile of these various systems according to the heirarchy of decisions appearing in Figure 5.1 is shown in Figure 6.1. All commercial services have been termed "consultancies", but in fact may be stockbrokers, computer bureaux or consulting actuaries.

I. ADDITIVE DYNAMIC PORTFOLIO DECOMPOSITIONS

This was the first type of component system to be proposed in the literature (by Fox(33) in the U.S.A. and then the SIA(76) in the U.K.) The method is currently marketed in Britain by at least two consultancies, each being a slight modification of the SIA's method. Table 6.1 specifies these systems using the notation of VII, Ch. 5.

I.1 FOX

Fox applied his decomposition at the level of the individual share in an equity portfolio and also to total

---

1: As far as this author could detect. For ethical reasons the commercial services could not be contacted directly.

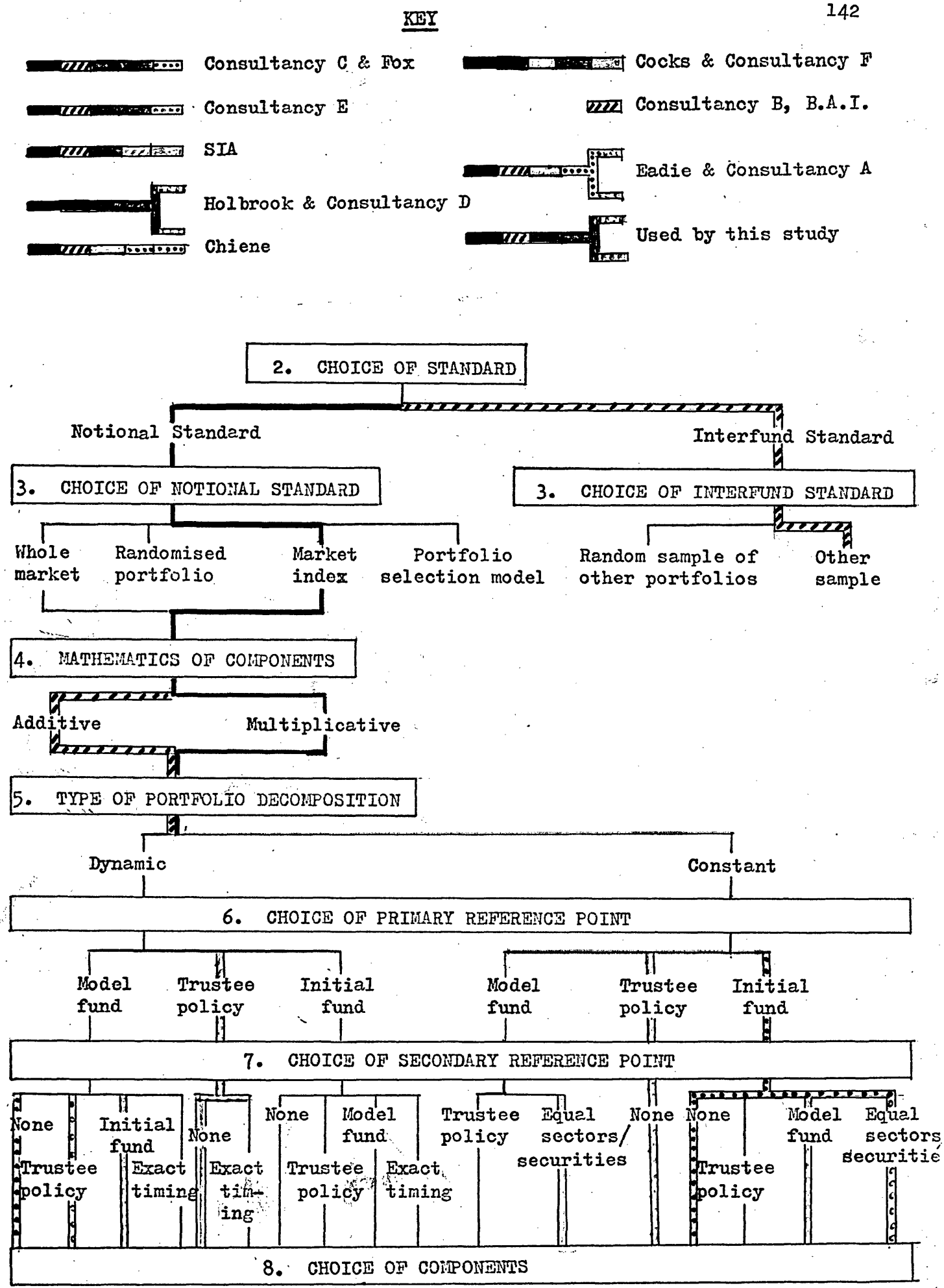


FIGURE 6.1

LOGIC OF 13 EXISTING PERFORMANCE ANALYSIS SYSTEMS, PLUS THAT USED IN THIS STUDY

TABLE 6.1

SPECIFICATION OF PUBLISHED AND/OR MARKETED ADDITIVE DYNAMIC PORTFOLIO PERFORMANCE ANALYSIS SYSTEMS

AUTHOR	SYSTEM						
FOX	$\underbrace{MV_n - V(I)}_{\text{Total excess gain over equity index}}$	=	$\underbrace{MV_n - V(I_s)}_{\text{Selection ("Tactics")}}$	+	$\underbrace{V(I_s) - V(I)}_{\text{Strategy}}$		I is equity index I_s is industry index applied to shares only
S.I.A.	$\underbrace{MV_n - V(\pi_p)}_{\text{Excess gain over trustee policy}}$	=	$\underbrace{MV_n - V(\pi_a)}_{\text{Selection}}$	+	$\underbrace{V(\pi_a) - V(\pi_p)}_{\text{Strategy}}$		
Consultancy C	$\underbrace{MV_n - V(\pi_m)}_{\text{Excess gain over model fund according to a UK fund}}$	=	$\underbrace{MV_n - V(\pi_a)}_{\text{Selection}}$	+	$\underbrace{V(\pi_a) - V(\pi_m)}_{\text{Strategy ("Policy")}}$		If trustee policy exists, substitute π_p for π_m.
Consultancy E	$\underbrace{MV_n - V(\pi_m)}_{\text{Excess gain over model fund aligned arbitrarily}}$	=	$\underbrace{MV_n - V(\pi_a)}_{\text{Selection}}$	+	$\underbrace{V(\pi_a) - V(\pi_b)}_{\text{Subsequent Strategy ("Choice of Sector - Subsequent Transactions")}}$	+ $\underbrace{V(\pi_b) - V(\pi_m)}_{\text{Initial Strategy ("Choice of Sector - Initial Proportions)}}$	

performance at two seperate and different levels:-

1. Sub-sector levels within the equity market
2. Groups of shares according to their classification as growth, cyclical or defensive share types.

He used the Standard and Poors 500 Index (V(I) in Table 6.1) and the sub-sector alternative indices ($V(I_s)$).

I.2 SOCIETY OF INVESTMENT ANALYSIS

The SIA's system amounts to a very great generalisation of Fox's approach without Fox's detail. The logic of the components was outlined in VII.1, Ch. 5.

I.3 CONSULTANCY C

This consultancy adopts the basic structure of the SIA's system but does not use a trustee policy primary reference point unless a clear policy has been specified. In the event of no such clear specification, a model fund primary reference point is used, based on the average profile of all U.K. pension funds. In the latter event, the components system has the great advantage of quantifying opportunity losses. If trustee policy is incorporated however, this advantage is lost.

I.4 CONSULTANCY E

This system makes permanent use of a model fund primary reference point but does not incoporate any trustee policy reference point at all. Thus it cannot satisfactorally handle heavily restricted funds. An additional disadvantage is its use of an artitrarily defined model fund, being either a 100% equity investment or a 50 - 50 split between equities and gilts.

It does have the advantage of incorporating an initial fund reference point $V(\pi_b)$ however, giving feedback on the wisdom of current strategy.

II. MULTIPLICATIVE DYNAMIC PORTFOLIO DECOMPOSITIONS

II.1 HOLBROOK AND CONSULTANCY D

Both Holbrook(41) and this consultancy use the following system of components:

$$1 + p = \frac{1 + r}{1 + r(\pi_m)}$$

Total relative performance

$$= \frac{1 + r}{1 + r(\pi_a)} \times \frac{1 + r(\pi_a)}{1 + r(\pi_p)} \times \frac{1 + r(\pi_p)}{1 + r(\pi_m)} - (6.1)$$

Selection x Strategy x Policy

(6.1) is the direct multiplicative analogy of combining the additive systems of the SIA and Consultancy E (Table 6.1). It has the dual potential advantages of indicating both opportunity losses (Strategy and Policy) and the effect of trustee restrictions if any (Policy).

This system, both as applied by Consultancy D and as recommended by Holbrook, suffers badly in practice from the fact that the model fund used to derive $r(\pi_m)$ is once again an arbitrary one, being either all equities or an even split between equities and gilts.

III. ADDITIVE CONSTANT PORTFOLIO DECOMPOSITIONS

Only one basic components system of this type has been suggested, by Chiene(10). Eadie(21) uses the same basic

structure but provides a more detailed split of one component.

III.1 CHIENE

This system is the constant portfolio analogy to the SIA's dynamic system (refer Table 6.2). The similarity lies in the decomposition of performance into Selection and Strategic components. The difference is that they apply to the performance of the initial portfolio only, while Changes is the only reference to the rest of the portfolio. Chapter 5 (IX.2.1) explained this system in detail.

III.2 EADIE

Eadie(21) adds to Chiene's analysis by the further decomposition of Strategy (i.e., Chiene's "Policy") into two components:

$$V(\pi_b^o) - MV_o = V(\pi_m^o) - MV_o + V(\pi_b^o) - V(\pi_m^o)$$

$$\text{Strategy} = \text{Index} + \text{Loading}$$

The Index component is the gain which could have been made by any investor via the investment of the initial value of the fund, MV_o, in the market, as represented by the model fund. The Loading component is the additional gain, on top of Index gain, due to the fact that sectors were held by the actual fund in relative proportions different to those of the market.

If the actual fund is distributed between sectors in proportions w_s ($s = 1$ to S sectors) and the model fund has sector weights W_s, the loading component for the sth sector will be

$$(w_s - W_s)\ V(\pi_m^o)^s \qquad - (6.2)$$

where $V(\pi_m^o)^s$ is the simulated final value of the sth sector in the model fund.

TABLE 6.2

SPECIFICATION OF PUBLISHED AND/OR MARKETED ADDITIVE CONSTANT PORTFOLIO PERFORMANCE ANALYSIS SYSTEMS

AUTHOR	SYSTEM
Chiene	$\underbrace{MV_n - MV_o - C}_{\text{Gain during review period}} = \underbrace{MV_n - MV_n' - C}_{\text{Changes}} + \underbrace{MV_n' - V(\pi_b^o)}_{\text{Selection}} + \underbrace{V(\pi_b^o) - MV_o}_{\text{Strategy ("Policy")}}$
Eadie	$\underbrace{MV_n - MV_o - C}_{\text{Gain during review period}} = \underbrace{MV_n - MV_n' - C}_{\text{Changes}} + \underbrace{MV_n' - V(\pi_b^o)}_{\text{Selection}} + \underbrace{V(\pi_m^o) - MV_o}_{\text{"Index"}} + \underbrace{V(\pi_b^o) - V(\pi_m^o)}_{\text{"Loading"}}$
Consultancy A	As for Eadie above

The total Loading component is simply

$$\sum_s (w_s - W_s)\ V(\pi_m^o)^s \qquad - (6.3)$$

To see that Loading and Index add to give Strategy, note that $V(\pi_m^o)^s = V(\pi_b^o)^s$, so that the sum is

$$\sum_s (w_s - W_s)\ V(\pi_m^o)^s + V(\pi_m^o) - MV_o$$

$$= \sum_s w_s\ V(\pi_m^o)^s - \sum_s W_s\ V(\pi_m^o)^s + V(\pi_m^o) - MV_o$$

$$= V(\pi_b^o) - V(\pi_m^o) + V(\pi_m^o) - MV_o$$

$$= V(\pi_b^o) - MV_o \text{ or Strategy}$$

Eadie gives no detailed derivation or proofs of his component break-up but presents numerical examples which reflect an approach which differs from the derivation given above. The mathematics behind his examples is not as straightforward as the exposition given here. A full derivation of Eadie's system using his approach is given in Appendix 6-I however, where it is also shown that the simpler method adopted here is in fact equivalent.

Eadie's Loading component may be seen to be very clearly related to Cock's Allocation component in concept, and consequently shares its limited usefulness (refer XII.1, Ch. 5)

III.3 CONSULTANCY A

At the time of writing, this consultancy applies Eadie's system to the equity market alone, although it is understood that other sectors are to be brought into the analysis soon.

The model fund is the F.T.A. All Share index. The decomposition is applied at the three levels of the overall equity portfolio, at sub-sector level and at the level of the individual share. The result is an extremely detailed and voluminous analysis of equity performance.

IV. MULTIPLICATIVE CONSTANT PORTFOLIO DECOMPOSITION METHODS

One components system of this type has been published by Cocks(13) and has been made commercially available by Consultancy F.

IV.1 G. COCKS

Graham Cocks in a series of articles has developed an argument for a system of this type on the grounds that it is the only system capable of providing sufficiently detailed and comprehensive information to meet the demands of a fund manager[1]. His system is complicated, as Table 6.3 shows. The complexity arises not only from the fact that his system is multiplicative, but also because not all of its components can be combined together in the one relationship. Chapter 5 (IX.3.3) has already observed that multiplicative systems are not additive over sectors or securities. Hence the need for a second decomposition of total performance to provide the level of detail desired. Cocks uses titles for his components which differ from the terminology used by other writers and that used here. Cocks' titles appear in quotes in Table 6.3.

Decomposition I of total portfolio performance may become a little clearer if expressed in the notation of notional portfolios as follows:

1: See Cocks(13)

TABLE 6.3

SPECIFICATION OF PUBLISHED AND/OR MARKETED MULTIPLICATIVE CONSTANT PORTFOLIO PERFORMANCE ANALYSIS SYSTEMS

AUTHOR

Cocks

$$1+p = \frac{1+r'_f}{1+R_m} = \frac{\sum_{s=1}^{n} w_s\,(1+r_s)}{\sum_{s=1}^{N} W_s\,(1+R_s)} = \frac{\sum_{s=1}^{n} w_s\,(1+R_s)}{\sum_{s=1}^{N} W_s\,(1+R_s)} \times \frac{\sum_{s=1}^{n} w_s\,(1+r_s)}{\sum_{s=1}^{N} w_s\,(1+R_s)}$$

Decomposition I: (For total portfolio, by sector)

Total relative performance ("Performance Index")

Total Sector Strategy ("Strategic Perf. Index)

Total Security Selection ("Tactical Perf. Index")

Decomposition II: (for individual components)

$$\frac{\frac{1}{n}\sum_{s=1}^{n}(1+R_s)}{\frac{1}{N}\sum_{s=1}^{N}(1+R_s)} \times \frac{\sum_{s=1}^{n} w_s\,(1+R_s)/\frac{1}{n}\sum_{s=1}^{n}(1+R_s)}{\sum_{s=1}^{N} W_s\,(1+R_s)/\frac{1}{N}\sum_{s=1}^{N}(1+R_s)} \times \frac{\sum_{s=1}^{n} w_s\,(1+\frac{1}{n_s}\sum_{i=1}^{n_s} r_{s(i)})}{\sum_{s=1}^{N} w_s\,(1+\frac{1}{N_s}\sum_{i=1}^{N_s} R_{s(i)})} \times \frac{\sum_{s=1}^{n} w_s\,(1+r_s)/\sum_{s=1}^{n} w_s\,(1+\frac{1}{n_s}\sum_{i=1}^{n_s} r_{s(i)})}{\sum_{s=1} w_s\,(1+R_s)/\sum_{s=1}^{n} w_s\,(1+\frac{1}{N_s}\sum R_{s(i)})}$$

Sector Selection ("Strategic Selection Index")

Sector Allocation ("Strategic Allocation Index")

Security Selection ("Tactical Selection Index")

Security Allocation ("Tactical Allocation Index")

Decomposition III: (For total portfolio by security)

$$1+p = \frac{1+r'_f}{1+R_m} = \frac{\sum_{i=1}^{m} w_i\,(1+r_i)}{\sum_{i=1}^{M} W_i\,(1+R_i)} = \frac{\frac{1}{m}\sum_{i=1}^{m}(1+r_i)}{\frac{1}{M}\sum_{i=1}^{M}(1+R_i)} \times \frac{\sum_{i=1}^{m} w_i\,(1+r_i)/\frac{1}{m}\sum_{i=1}^{m}(1+r_i)}{\sum_{i=1}^{M} W_i\,(1+R_i)/\frac{1}{M}\sum_{i=1}^{M}(1+R_i)}$$

Total relative performance ("Performance Index")

Overall Security Selection ("Selection Index")

Overall Security Allocation ("Allocation Index")

NOTATION: r'_f = ROR on constant portfolio; r_s = ROR on s^{th} sector of constant portfolio; n = no. of sectors in fund; m = no. of securities in fund; w_s = Proportion of constant portfolio made up by s^{th} sector; $r_{s(i)}$ = ROR on i^{th} security in s^{th} sector; n_s = no. of securities in s^{th} sector; Similar meanings for the market when capital letters used.

$$1 + p = \frac{MV_n'}{V(\pi_m^o)} = \frac{V(\pi_a^o)}{V(\pi_m^o)} \times \frac{MV_n'}{V(\pi_a^o)} \quad -(6.4)$$

Total relative performance	=	Total Sector Strategy	x	Total Security Selection

The split is a very close analogy to that of Consultancy C in Table 6.1.

The major departure of Cocks' method from other methods is his further decomposition of each of the above two components according to the logic of (5.18). Total Sector Strategy is decomposed exactly according to components outlined in XII.1 Chapter 5. The decomposition of Total Security Selection is as follows:

1. Security Selection

   This component is the result of the comparison of two notional portfolios, both of which weight each sector according to its relative importance in the actual fund. The only difference is that a sector return for one notional portfolio is a simple average of the returns of all the securities in that sector in the <u>fund</u>. The other notional fund uses a simple average of all securities in that sector in the <u>market</u>. Thus the component isolates the effect of differences in average returns completely independently of differences between fund and market in both the weights given to the sectors and the weights given to individual securities.

2. Security Allocation

   This is a sort of residue which accounts for the role of differences in the relative weightings given by fund and market to the different securities in each sector.

This aspect of taking simple unweighted averages of returns in order to isolate the contributions of differences in weightings is unique to Cocks' approach.

Decomposition II is an entirely seperate analysis of performance along the lines of XII.1, Chapter 5 but based on individual securities. It is a more appropriate decomposition if securities are selected directly by the fund manager without thought for their implications about the balance between sectors.

Cocks' article illustrates this system with the detailed analysis of a U.K. equity portfolio, treating the FTA All Share industry classifications as sectors. The analysis can in theory be generalised to the level of a multi-sector portfolio, as was implied by the above description. Although Cocks' system is based on premium return, he chooses to interpret all his components as pure indices.

The advantage of this system relates primarily to the extra flexibility which can be attained in the construction of components. Cocks claims (13,p11) that his approach is ideally suited for the purpose of internal control.

> " ..... the method of analysing performance presented in this paper has been designed for use by the portfolio manager, while other methods .... have been designed for use by the trustee. The portfolio manager is probably less interested than the trustee in calculating the rate of return, which could have been earned on the capital invested in the portfolio, if it had been simply invested in a predetermined portfolio of securities. Instead he is probably more concerned with studying the results of his investment decisions and evaluating these decisions, given the benefit of hindsight with respect to the market."

Cocks admits (13,p11) however that the method can be used only if the fund ROR which is to be decomposed has been derived using the constant portfolio method of estimation. Hence this extra flexibility is gained at the price of the disadvantages of this technique of TWR estimation (refer II.4, Ch. 4).

Another disadvantage is the great amount of input data demanded by this system of analysis. Details of market prices, dividend payments and capital changes are required for every security in the index used to represent the market. Other methods require input on the aggregate level of the indices only. Cocks(13,p11) admits that this mammoth amount of input is really only feasible if a "comprehensive, computer accessible data bank" on market prices is available. This can only be achieved at some cost to the user.

IV.2 CONSULTANCY F

Cocks' decompositions I and II are applied by this consultancy using a model fund which is specified by the user. Decomposition I is used to decompose total performance on the basis of specified sectors, while decomposition II is done seperately on each sector, using that sector's index as the model fund for the purpose.

V. INTER-FUND COMPARISONS

This technique of analysis has already been argued to be a highly unsatisfactory mode of analysis from a theoretical point of view.

V.1 CONSULTANCY B

An analysis of performance is attempted through the use of marginal analysis (as described in XII.8, Ch. 5). The TWR of individual sectors is compared with the market return in the corresponding sector to show selection effects. Funds in the sample are ranked according to some of these marginal components and according to some sector TWRs.

V.2 BANK ADMINISTRATION INSTITUTE

The BAI study made no specific recommendations about the analysis of performance other than that the sources of performance should in principle be identified and that funds should be divided into groups which are internally homogeneous.

V.3 CONSULTANCY D

Comparisons are done on the basis of this consultancy's total performance index, p, as defined in (6.1). Funds are also compared on an index of activity and on a performance ratio for individual sectors (as defined by (5.8)). As these statistics are not specifically adjusted for any trustee restrictions, the comparisons suffer from the same disadvantages of all inter-fund comparisons.

VI. IDEAL CHARACTERISTICS OF A PERFORMANCE ANALYSIS SYSTEM

The literature has not specifically considered what criteria an ideal performance analysis system should satisfy, although various writers have mentioned desirable properties from time to time. The characteristics desired in a system are to a certain extent dependent upon the purpose for which that system is to be used. For example, the requirements of a system designed to analyse performance from an internal control point of view are less wide-ranging than those of a system designed to fulfill the purposes of both internal control and performance evaluation for trustees. In an attempt to be as general as possible, the following criteria are directed at a system which has such a dual purpose.

The characteristics have been divided into two classes. The first class consists of those regarded as being absolutely necessary in order for an analysis system to be at least adequate. The second type is one which is viewed as desirable but not absolutely necessary.

VI.1 NECESSARY CHARACTERISTICS

1. The system should satisfy the major needs for performance analysis (refer I, Ch. 5).

These are:

(i) a clear indication of the performance of management, net of any restrictions which were placed on the fund manager.

(ii) Feedback to the manager on the success of his investment philosophies, as reflected in the fund.

(iii) Indication of at least the fundamental causes of the observed superior or inferior performance.

2. It should not be so complex that it cannot be understood by the non-specialist with only a minimum amount of explanation.

3. The standard of performance against which performance is judged must be accepted as being valid by the eventual users of the analysis.

4. The use of the analysis system in itself should not bias the manager's investment strategy.

The system should not possess any consistent bias which encourages the manager to change his investment strategy to capitalise on the bias. Although this could result in the system showing him in a better light, it may not lead to better performance of the fund in reality.

5. The system should not be such that the manager can rationalise his way out of adverse figures.

The system's potency for internal control is otherwise diminished. For example, if the manager can successfully criticise the methodology (by pointing out that dealing costs are not considered

for example), he need pay little attention to the system's results.

6. It should not demand an amount or type of input data which is either very costly or grossly inconvenient to collect.

Although this sounds obvious, it is an important point in the light of the often poor quality of readily available information on some funds. Readily available data tends to be that necessary for accounting purposes, which does not always coincide with the data needed for performance purposes. (This was certainly the case with the bank involved in this study).

VI.2 DESIRABLE CHARACTERISTICS

1. The analysis should provide statistics which have clear meanings.

This sounds obvious, but it is easy, particularly with the aid of a computer, to generate piles of "data" which hold little "information". Performance data needs to be organised properly in order to yield a clear <u>explanation</u> of performance.

2. It should be able to accurately assess the performance of a variety of portfolios and management styles.

This is one of the major issues to which Dietz (16) addressed himself in his original study. It involves overcoming most of the problems of performance measurement listed in I, Ch. 2.

3. The overall ROR should be attributed to its various sources.

It is difficult to do this completely right down to the level of individual securities without producing considerable complexity and a large volume of output.

4. The analysis should be flexible enough to answer a wide range of questions which could be posed about performance.

5. The system should be robust.

The need for reliable information is greatest in troubled or unusual times. If the assumptions of a method are valid only within a narrow range of conditions, the system will not line up to this need.

6. Risk in addition to return should be assessed as an aspect of performance.

The subject of risk is taken up in the next two chapters.

7. As much of the fund as can be reliably measured should be assessed by the analysis system.

8. The analysis should provide a basis for the prediction of future fund performance.

Holbrook(41) and Cocks(12) agree that this is the major way in which performance analysis can be most useful.

9. The system should be relevant to what managers practice, rather than only on what they <u>should</u> practice.

Dietz(16) formulated this policy when confronted with the possibility of measuring Selection while the then current Random Walk theory dictated that superior return through this activity was impossible in the long run. The position is even clearer today, when capital asset pricing theory (described in the next chapter) combined with the efficient market theory dictates that all well-diversified portfolios can never hope to beat the market in a risk-adjusted sense. This would make performance measurement a futile exercise if it were not for the fact that managers and trustees still do try to beat the market, so creating a need for feedback on the success of their attempts.

VII. RELATIVE MERITS OF EXISTING SYSTEMS

A mere discussion of relative merits cannot pinpoint the best system. An objective examination of the pros and cons of each system can however help to eliminate those systems which are generally inferior according to the criteria outlined in VI.1 as being absolutely necessary in a useful performance analysis system. The remaining grey area of choice will be subject to the circumstances of the application at hand as well as considerations of how conveniently a method blends with the companion technique of TWR estimation. It will be argued here that on purely objective grounds alone, all existing constant portfolio decompositions can be considered to be inferior choices, leaving the choice between either the additive or multiplicative form of one particular component structure.

VII.1 EXISTING CONSTANT PORTFOLIO DECOMPOSITIONS

All existing systems of this nature are, by the characteristics listed as necessary in VI.1, inadequate analyses of performance. Their major disadvantages are their inability to quantify opportunity loss, the gross imperfection of the Changes component as a measure of managerial performance during the period, their ignorance of the effects of policy

restrictions and the need to perform analyses frequently. All these points except the last have been explained in previous sections. A need for frequent analysis stems from the need to avoid the situation where either, using Chiene's system, too much of performance is concentrated in the Changes component, or where, using Cock's system, too much of performance is being ignored because of the constant portfolio assumption. Using a dynamic decomposition, there is no theoretical need to limit the review period at all.

VII.2 ADDITIVE DYNAMIC PORTFOLIO DECOMPOSITIONS

Fox's system suffers badly today from its restriction to the equity side of a portfolio. The SIA's system represents a considerable improvement in this respect but is still less satisfactory than Consultancy E's system which uses as a primary reference point a model fund. It is the view of this study that no one existing additive dynamic decomposition is really satisfactory, and that a combination of the strengths of them all produces a hybrid which is clearly superior. The combination involves, on the one hand, retaining the concept of basing the model fund on average pension fund statistics and allowing for trustee policy (Consultancy C) and, on the other, incorporating a split of Strategy into Initial and Subsequent components as well as using a model fund as a permanent primary reference point (Consultancy E). Such a system is shown in the first line of Table 6.4.

VII.3 MULTIPLICATIVE DYNAMIC PORTFOLIO DECOMPOSITIONS

Once again, a hybrid of existing systems would seem to be the most satisfactory multiplicative system. Holbrook's system is a highly satisfactory method of analysis except for its use of an arbitrary model fund and its omission to use Initial and Subsequent Strategic components. The second system shown in Table 6.4 rectifies these two matters, and as such is the direct multiplicative analogy of the hybrid additive system suggested above.

VIII. PREVIOUSLY UNCONSIDERED VARIATIONS OF SYSTEMS

Table 6.4 lists combinations of components and reference points which to the author's knowledge have not been published and which are not currently marketed in Britain. The choice of a components system to be included in the software of this study was made from the systems in this table. This section aims to explain some of the features of the proposed systems, while the next section makes a final choice.

System III was proposed in Chapter 5 (refer Table 5.4) as an example of the importance of secondary reference points. It was explained there that it is the constant portfolio decomposition version of the SIA's original system. Note that for sectors not in the initial portfolio, the sum of Policy plus Strategy will always be zero, as will be Selection also.

System IV is equivalent to the above system with the further introduction of a secondary model fund reference point, enabling the quantification of opportunity losses to some extent. Market Gain is equivalent to Chiene's Index component (refer III.1 this chapter) while Policy is the extra gain made from the trustees' deviation from the model fund's profile (similar in concept to Chiene's Loading component). Opportunity losses are indicated by the Market Gain component. Note that for sectors unrepresented in the initial fund, the sum of Market Gain, Policy and Strategy will always be zero, as will Selection.

System V is a hybrid of existing constant portfolio decompositions and dynamic decompostions. The excess return decomposed by the system is the difference in profits between two alternative strategies:

1. The actual policy pursued by the fund, yielding a profit of $MV_n - MV_o - C$.

TABLE 6.4

PREVIOUSLY UNCONSIDERED VARIATIONS ON EXISTING PERFORMANCE ANALYSIS SYSTEMS

SYSTEM	DESCRIPTION	SPECIFICATION					
I	Combination of additive dynamic decompositions	$\underbrace{MV_n - V(\pi_m)}_{\text{Excess Gain}}$	$= \underbrace{MV_n - V(\pi_a)}_{\text{Selection}}$	$+ \underbrace{V(\pi_a) - V(\pi_b)}_{\text{Subsequent Strat.}}$	$+ \underbrace{V(\pi_b) - V(\pi_p)}_{\text{Initial Strategy}}$	$+ \underbrace{V(\pi_p) - V(\pi_m)}_{\text{Policy}}$	
II	Further decomposition of strategy in Holbrook's system	$\underbrace{\frac{1 + r}{1 + r(\pi_m)}}_{\text{Relative perf.}}$	$= \underbrace{\frac{1 + r}{1 + r(\pi_a)}}_{\text{Selection}}$	$\times \underbrace{\frac{1 + r(\pi_a)}{1 + r(\pi_b)}}_{\text{Subsequent Strat.}}$	$\times \underbrace{\frac{1 + r(\pi_b)}{1 + r(\pi_p)}}_{\text{Initial Strategy}}$	$\times \underbrace{\frac{1 + r(\pi_p)}{1 + r(\pi_m)}}_{\text{Policy}}$	
III	Additive constant portfolio decomposition with trustee policy secondary reference point	$\underbrace{MV_n - MV_o - C}_{\text{Total Gain}}$	$= \underbrace{MV_n' - V(\pi_b^o)}_{\text{Selection}}$	$+ \underbrace{MV_n - MV_n' - C}_{\text{Changes}}$	$+ \underbrace{V(\pi_b^o) - V(\pi_p^o)}_{\text{Strategy}}$	$+ \underbrace{V(\pi_p^o) - MV_o}_{\text{Policy}}$	
IV	Above system III but with model fund as secondary reference point	$\underbrace{MV_n - MV_o - C}_{\text{Total Gain}}$	$= \underbrace{MV_n' - V(\pi_b^o)}_{\text{Selection}}$	$+ \underbrace{MV_n - MV_n' - C}_{\text{Changes}}$	$+ \underbrace{V(\pi_b^o) - V(\pi_p^o)}_{\text{Strategy}}$	$+ \underbrace{V(\pi_p^o) - V(\pi_m^o)}_{\text{Policy}}$	$+ \underbrace{V(\pi_m^o) - MV_o}_{\text{Market Gain}}$
V	Additive constant portfolio decomposition with model fund primary reference point	$\underbrace{MV_n - V(\pi_m^o) - C}_{\text{Excess gain over investment of initial fund in market}}$	$= \underbrace{MV_n' - V(\pi_a^o)}_{\text{Selection}}$	$+ \underbrace{MV_n - MV_n' - C}_{\text{Changes}}$	$+ \underbrace{V(\pi_a) - V(\pi_p^o)}_{\text{Strategy}}$	$+ \underbrace{V(\pi_p^o) - V(\pi_m^o)}_{\text{Policy}}$	
VI	Multiplicative constant portfolio decomposition with model fund primary reference point	$\underbrace{\frac{1 + r}{1 + r(\pi_m^o)}}_{\text{Perf. relative to investment of initial fund in market}}$	$= \underbrace{\frac{1 + r'}{1 + r(\pi_a^o)}}_{\text{Selection}}$	$\times \underbrace{\frac{1 + r}{1 + r'}}_{\text{Changes}}$	$\times \underbrace{\frac{1 + r(\pi_a^o)}{1 + r(\pi_p^o)}}_{\text{Strategy}}$	$\times \underbrace{\frac{1 + r(\pi_p^o)}{1 + r(\pi_m^o)}}_{\text{Policy}}$ where r' = ROR on 'frozen' initial fund	
VII	Dynamic portfolio decomposition with initial fund primary reference point	$\underbrace{MV_n - MV_o - C}_{\text{Total Gain}}$	$= \underbrace{MV_n - V(\pi_a)}_{\text{Selection}}$	$+ \underbrace{V(\pi_a) - V(\pi_b)}_{\text{Subsequent Strat.}}$	$+ \underbrace{V(\pi_b) - V(\pi_p)}_{\text{Initial Strategy}}$	$+ \underbrace{V(\pi_p) - V(\pi_m)}_{\text{Policy}}$	$+ \underbrace{V(\pi_m) - MV_o - C}_{\text{Market Gain}}$

2. The profit from a passive investment of the initial value of the fund (MV_o) in the market with no receipt of new money at all. The resulting profit would be $V(\pi_m^o) - MV_o$.

System VI is the direct multiplicative analogy of system V. Note that multiplicative analogies to systems III and IV do exist but are not considered here for reasons of space.

Lastly, system VII is also a hybrid of existing constant portfolio and dynamic portfolio decompositions. It decomposes in a dynamic way the historical profit earned by a fund over the review period. All components are interpreted as in a normal dynamic system except for Market Gain, which represents the profit which any investor would have made during the period through the passive investment of both the initial fund and new money (with identical timing to that of the actual fund) in the market. It is the dynamic analogy of Market Gain in system IV.

VIII.1 RELATIVE MERITS OF PROPOSED SYSTEMS

Those constant portfolio decomposition methods which have been previously proposed in the literature were argued above to be inferior because of their omission of opportunity losses. This fault is overcome to some extent by system IV in Table 6.4. While opportunity losses are not quantified by the profit figure which is decomposed, the Policy and Strategic components would reveal them. This innovation still does not overcome the inability of the Changes component to indicate managerial performance during the period, and the consequent need to ensure that analysis is done frequently enough to prevent this component from becoming too large. For this reason, system IV was rejected as a viable analysis system, even though it quantified opportunity losses.

Systems V and VI are not useful modes of analysis for the

same reason of the Changes component. In addition, the primary reference point of these systems would rarely be acceptable to a manager. A primary reference point which completely ignores new money is not likely to be acceptable to a manager who must invest new money when he receives it, even if it is only to invest it in cash.

Hence it is concluded that the dynamic decompositions represented by systems I, II and VII are the best performance analysis systems from an overall point of view. It is argued that a logical choice between these three connot be made without reference to the situation at hand.

IX. PERFORMANCE ANALYSIS SYSTEM USED IN THIS STUDY

System I in Table 6.4 was incorporated into the software of this study in view of its superiority over all existing additive performance analysis systems and in view of a number of factors which made it a more preferable choice than systems II and VII proposed here.

The multiplicative system II was not considered to be a viable choice for two main reasons. First it is more complex and so is less intuitively appealing, as VIII, Ch. 5 argued is the case with all multiplicative structures. Secondly, as Chapter 8 will show, it is not directly related to an analysis of the riskiness of a portfolio as is an additive system. These two disadvantages (particularly the latter) were judged to outweigh the advantage of accurate linkage over time.

The remaining additive system VII is of course equally simple and as equally related to an analysis of risk as system I. The latter system was chosen on the purely subjective grounds that since it is performance relative to the market in which most people are primarly interested, this is the quantity which should be decomposed, rather than just historical profit.

PART C

RISK

CHAPTER SEVEN

PORTFOLIO RISK AND THE CAPITAL ASSET PRICING MODEL

Risk is without doubt the vaguest concept associated with portfolio performance, and consequently the area of biggest controversy amongst both academics and practising investment personnel. This chapter aims to outline in brief the academic work on this subject. The usefulness of this work to the needs of practical performance measurement and analysis is assessed in the next chapter.

I. DEFINITION OF RISK

Although there is no one undisputed concise definition of risk, most writers agree that it is a concept of the future:

> "The concept of risk is related to the uncertainty of future events. If one security is said to be more risky than another, the implication is that future values of the first security are believed to be more uncertain than future values of the second. Many different definitions of risk based on this general idea are possible."[1]

The literature has indeed excelled at exploring these many different definitions (but for less successful at devising corresponding measures for them). The complicating factor is that multiple views exist on the types of risk and even whether or not risk is objective or subjective (so that, like beauty, it is in the eyes of the beholder).

1: B.A.I.(1 ,p6)

Dietz(18,p5) maintains that the best definition of risk is:-

> " ..... the cumulative probability that the return of a portfolio falls below a target level of ruin over a period of time : both the ruin level and the time period are subjective factors."

This idea of ruin level has led to some definitions specifically oriented to pension fund portfolios. Eadie(21,p14) defines risk in this context as

> " ..... the probability that at some future time the invested assets will not be sufficient to meet the future liabilities for which they are intended."

With this definition, risk becomes not only a function of the portfolio's assets, but also a function of the associated pension scheme's benefits.

Markowitz(53) first defined risk in terms of volatility of ROR. The great issue is how to in turn define "volatility". Markowitz elected for volatility around average return. More modern writers have realised that although this definition may lead to the easy derivation of a measure of risk, as a definition of risk it does not relate to the future at all. Weaver(84,p147), for example, suggests the following:

> " ..... although we have been measuring risk as the variability of the returns from securities, our original definition of risk was the unpredictability of the return. This suggests that the variations should be measured against the analyst's prediction of what return is likely to be."

Markowitz and others' use of the average of past returns can therefore be seen to be a very poor substitute for the analyst's prediction of the future likely return.

I.1 TYPES OF RISK

While most academics tend to view risk in narrow terms relating to variation of return alone, some writers, including

practising investment personnel, see risk in wider terms. Cocks(13) even goes so far as to imply that risk is such a wide-ranging and abstract quality that all that one can hope for is to be able to measure a number of secondary characteristics of performance which are proxies for different aspects of risk. He quotes these aspects as the variability of return, its sensitivity to market movements and the portfolio's degree of diversification. Other writers talk of different types of risk. For example, an American pension fund manager in (37,Ch.3) classifies risk into four types:

1. Money rate risk

   This is the risk taken on government securities in the face of interest rate movements. The same risk exists to a far less marked extent for equities.

2. Purchasing power risk

   This is the risk of realising a negative real return after inflation.

3. Deterioration risk, which is the risk of total default.

4. Market fluctuation risk

   This is the risk of a security declining in value due to a general downward market movement.

Some writers (18,61,79,88) have added a fifth type:

5. Marketability

   This is the risk of being unable to realise the paper (or market value) return on a security.

Some aspects of this classification scheme do indeed confirm the academic view of risk. "Market fluctuation risk"

relates strongly to capital asset pricing theory, while money rate risk and deterioration risk can be viewed as mere causes of volatility of return. The suggestions of purchasing power risk and marketability do not fit neatly into the academic work on risk at all however.

I.1. PURCHASING POWER RISK

The academic work on risk has not considered the effect of inflation and, on a more general level, has not considered the effect of the time horizon on risk. The difficulty is that short term risk is a very different matter from long term risk. In the long term, absolute variability by itself may not be a good indication of risk. Figure 7.1 shows this for two shares. The conventional definition of risk would label Share A as the riskier security, yet is it, in view of the steady and reliable (i.e., risk-less) growth of its ROR? If the annual inflation rate has grown as shown, Share A is once again the less risky share on a real return basis. The inconsistency lies in the fact that in the long term it is only that variation of return which is unaccounted for by a steady long term trend which represents risk (ex-post).

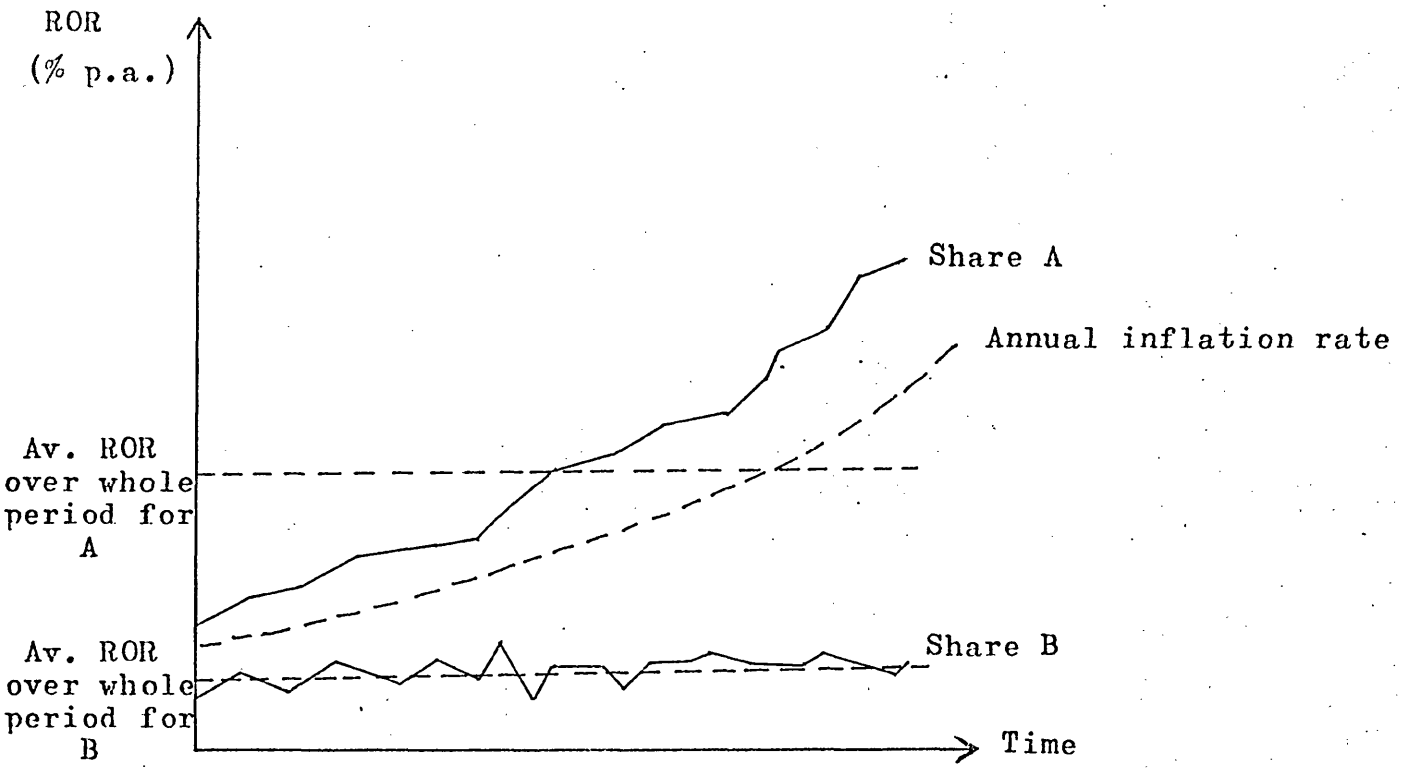


FIGURE 7.1

I.1.2 MARKETABILITY

Marketability has been omitted from almost a[illegible]yses of performance except for the occasional recognit[illegible] its role as a risk. It has never, to the author's kn[illegible], been incorporated into analyses in a quantifiable way.

In his original work Dietz(16) recognised ma[illegible]lity as a risk purposely taken by a large fund in order [illegible]crease return. This hypothesis has not been tested howe[illegible] [illegible]oncern over marketability is reflected in the service pr[illegible] by some consultants in which stocks in a portfolio a[illegible]ed in descending order of volume of holdings and then a[illegible] descending order of ROR. If the same stocks appe[illegible] [illegible]he top of both lists, it is argued that this is a source [illegible]k because the greatest source of the ROR on the fu[illegible]nates from the most concentrated holdings.

The measurement of non-marketability seems [illegible]poss-ible. Trying to use published figures on sales a[illegible]hases is like trying to measure undetected crime from p[illegible]ecords. If securities are recognised as being non-marketa[illegible]ey tend not to be sold at a rate beyond which an ad[illegible]ice effect reveals itself.

II. NET VERSUS GROSS RISK

A great source of confusion seems to be the [illegible]nt connotation of risk to different people. Investm[illegible]sonnel and layment often think of risk as a concept net [illegible]rn, whereas academics view it as being gross of retur[illegible] [illegible]nde-pendent of the average return on an asset. For e[illegible] Palmer and Dietz imply that risk in the long term [illegible]ot exist. Palmer(61,p25) quotes the example of equi[illegible] [illegible]up-posedly risky assets, yielding in the long run a h[illegible]turn, so denying their riskiness. Dietz(17,p6) argues o[illegible]lf of investment practisioners that:

> " ..... volatility per se is of no consequence for a pension fund, and that high rates of return, even if volatile historically are much better than low steady rates of return."

These points of view are derived from the popular meaning of the concept of risk. Using "risk" in a more technical sense, academics almost always mean variability and consider it to be quite apart from the average level of returns which caused that variability. Thus equities can be "riskier" (i.e., more variable) even though they have a high average return. To academics, a portfolio may be "risky" even though it has the highest return in the land.

This breakdown of communications between practisioners and academics has caused much confusion and will probably continue to do so. The fund managers involved in this study found the academic interpretation of risk difficult to appreciate.

III. MEASUREMENT OF RISK

One seemingly insurmountable obstacle to the measurement of risk has been expressed in its most severe terms as the following:

> "In the measurement of actual fund performance ... risk is a meaningless concept, since no uncertainty exists in past results."[1]

> " Portfolio risk theory is devoted to measuring risk retrospectively, which may be too late!"[2]

These views are of course misinterpretations of the purpose of using past results, which is to produce estimates of future riskiness. A more sensible expression of the obstacle is to observe that the future is not always an extrapolation of the past. The best illustration of the problem is provided by a contrast of Weaver's definition of risk (refer section I) with what is the most common measure of risk today, the standard deviation. The standard deviation is perfectly tailored

---

1: Mills(55,p1125)

2: Holbrook(41,Discussion)

to Weaver's definition as long as one can accept that the best estimate of future return is the average of past returns. This is not always the case, as Figure 7.1 showed.

III.1 TYPES OF RISK MEASURES

There have been several suggested measures of risk in the literature. All focus entirely on the pattern of past returns and all assume that the distribution of these returns is stationary. The most important suggestions are as follows:[1]

1. Standard deviation (S.D.) of past returns
2. Mean Absolute Deviation (M.A.D.)

This measure,

$$MAD = \frac{1}{n} \sum_{i=1}^{n} \left| r_i - \bar{r} \right| \qquad - (7.1)$$

has several advantages over the S.D. but two serious disadvantages which have prevented its wide adoption. Its advantages relative to the S.D. are its greater intuitive appeal and its greater stability. MAD has the mathematical property of being less affected by extreme values than the S.D. On a more theoretical note, there is some (inconclusive) evidence[2] that RORs on individual securities are distributed with infinite variance (according to a Pareto distribution). MAD in this case would lead to more sensible estimates of risk than the S.D.

The great disadvantage of MAD, and most of the other measures, relative to the S.D. is the former's relative difficulty of calculation and mathematical intractability. The latter is particularly limiting as it is difficult to analyse risk with a measure which cannot be easily manipulated.

1: A more detailed account may be found in Francis and Archer(34)
2: See, for example, Fama(25).

3. Semi deviation

Both MAD and S.D. quantify variability on both sides of the average ROR, when in fact risk really refers only to downside variability. The argument in support of S.D. and MAD is that there is some evidence that RORs are distributed normally, or at least symmetrically, so that downside variability equals upside variability. The evidence is inconclusive however. The semi-standard deviation measures only downside risk as follows:

$$S.S.D. = \sqrt{\sum_{i=1}^{n} w_i \, (r_i - \bar{r})^2} \qquad - (7.2)$$

where $w_i = 1$ if $r_i > \bar{r}$

$= 0$ otherwise

4. Probability of loss

Conforming to Dietz's definition of risk (refer section I), this measure has been attacked by Sharpe(71,p73) for the arbitrariness of the ruin level and for its omission to consider the size of the loss.

5. Sharpe's beta co-efficient

This is by far the most sophisticated of the risk measures, measuring risk in relation to the market environment. The β parameter is an index of an asset's sensitivity to movements in the general level of the market. A stock (or portfolio) whose return tends to vary to a greater extent than the market is regarded as being riskier than one which varies to a less extent.

The chief advantage of this measure is that it considers an asset in the context of its relation

to other assets, which is in keeping with Martowitz's famous finding that the contribution of a stock to the total risk of a portfolio is not simply just that stock's variability but also is a function of the correlation of its return with the return on the rest of the portfolio. The main and severe disadvantage of the measure is that it necessarily relies on the validity of the capital asset pricing theory from which it is derived. The validity of this theory is doubtful (as Chapter 8 will argue).

III.2 RELATIVE MERITS OF ALTERNATIVE RISK MEASURES

None of the measures is perfect and a selection of a specific measure must be on dogmatic grounds. Many academics choose the S.D. or β for their mathematical tractability. Mainly as a result of the cult of the capital asset pricing model, these two measures have been the most commonly used proxies for risk in the literature. The BAI(1) and SIA(76) recommend use of MAD.

Pieces of evidence do exist in the literature to support the contention that all the measures do a roughly equal job of measuring risk anyway. The BAI(1 ,p30) concluded that SD, SSD, MAD and β are so highly correlated that " ... one measure can be regarded as essentially a linear transformation of any of the others." Spiro(77,p10) quotes a study done in the 1960's which produced a similar finding, and where MAD possessed the highest cross-correlations.

One of the most interesting studies by Gooding(38) correlates various alternative risk measures with people's perception of what risk is in a financial context. Using multidimensional scaling, he found that β and the SD are the measures which are most correlated with perceptions of risk. His sample is not a representative one however and the list of shares used did not contain any share with a skewed distribution of past RORs.

III.3 DIFFERENCING INTERVAL FOR RISK MEASURES

An issue rarely discussed in the literature is the appropriate interval of time (the differencing interval) over which seperate RORs should be calculated so as to form the relevant historical time series of past returns. It is a fundamental issue to not only risk measurement but to any work which involves the calculation of returns which are meant to represent expected future returns. For an expected future return is only an expected return for an investor whose expected holding period of the relevant asset is the same as the differencing interval used. Theoretical works (e.g., Jensen(42)) attempt to overcome the differencing interval problem by assuming that investors continuously review their portfolios and so have a differencing interval of zero. This leads to the use of continuously compounded RORs, which (conveniently) also happen to be highly tractable from a mathematical viewpoint.

Empirical studies[1] have shown that risk measures such as those discussed in this chapter change in their relative rankings according to the differencing interval used. Nowhere in the literature is their a recommendation of a particular interval which is supported by facts. Both the BAI and SIA seemingly arbitrarily recommend a quarter as the appropriate interval on which to base a MAD risk estimate.

III.4 RISK MEASURE USED IN THIS STUDY

The software developed in this study uses MAD to estimate the risk of both the total fund and its sectors. In the absence of any information to the contrary, quarterly RORs were viewed as an adequate basis for the estimates, although the programs are general enough to incorporate returns based on other (mixed) differencing intervals. The exact estimate used is given in IX, Ch. 11.

1: See Dietz(17) and Hasty et al(40)

IV. RELATION BETWEEN RISK AND RETURN

The relevance of risk, as meant in the technical academic sense, to portfolio performance has been summarised in two ways:

> "Without any other information about the funds concerned, if one was informed that Fund E had an average return of 10 per cent, with mean deviation of 8 per cent, and Fund F had an average return of 10 per cent with mean deviation of 4 per cent, then one might be more optimistic about the chance of Fund F maintaining the return in future".[1]

> "If, as much evidence suggests, the market pays superior returns on the average to those who assume risk, then when evaluating performance it is valuable to know to what extent an actual rate of return can be explained by the level of risk that was assumed and to what extent an actual rate of return indicates superior or inferior ability to select investment assets that outperform other assets having similar levels of risk."[2]

The first explanation is largely an intuitive one, while the second draws attention to the relation between risk and return, which is the central issue quantified by capital asset pricing theory, on which all risk-adjusted performance measures are based. Fundamental to the logic of both views is the notion that extra risk is usually rewarded in the market by extra return. This can be observed on an intuitive basis, but has also been subjected to rigorous empirical testing in the literature under the banner of the validation of the capital asset pricing model (CAPM). It is not within the scope of this thesis to give a detailed account of such studies except to accept that the work has been done by so many different authors on so many different data sets that there is little doubt of the existence of some form of generally positive relationship in an average sense (i.e., there is a general trend from which there are some few exceptions). It will be argued in this study (Chatper 8) that the precise form of this relationship (i.e., linear or non-linear) is still open to debate.

1: Eadie(21,p4)

2: Fama(27,p2)

V. LOGIC BEHIND RISK ADJUSTMENT OF PERFORMANCE

Accepting this general relationship between risk and return, the fundamental logic behind the assessment of performance on the basis of risk as well as return may be explained as follows. The following explanation differs from that popularly given in that it is not explicitly based on the CAPM itself, but uses only some of the general principles of the theory.

Figure 7.2 illustrates the risk/return performance of several funds. Each fund is plotted according to its ROR over a recent review period and according to its risk measure based on returns taken over many past review periods. The risk measure is referred to in Figure 7.1 as "Dispersion" and could in theory be any of the measures discussed in III.1. Given that extra risk should be rewarded by extra return, the fact that fund F has achieved the same ROR as fund E but with lower risk indicates that fund F has performed better than E. Similar arguments can be used to show that A performed better than B, B better than C and C better than F. In general, any fund which is below (or level) and to the right (or level) of another fund in this risk/return space is an inferior performer relative to the latter fund.

The need for the hypothesis or deduction of a specific relationship between risk and return derives from two major shortcomings of this dominance approach. These are that:

1. Not all pairs of funds' relative performance can be deduced (e.g., A versus D).

2. Even if all possible pairs of funds could have their relative performance deduced, there exists no guide as to what constitutes "good" risk/return performance on an absolute level.

The need for a specific relationship may be met in two different ways. Each of these is discussed in the following

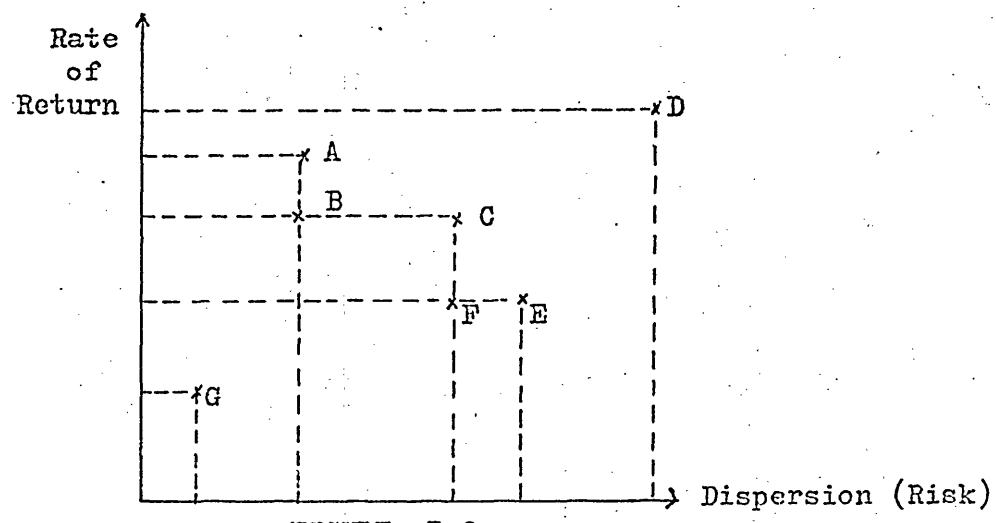


FIGURE 7.2

Position of 7 hypothetical funds in risk-return space

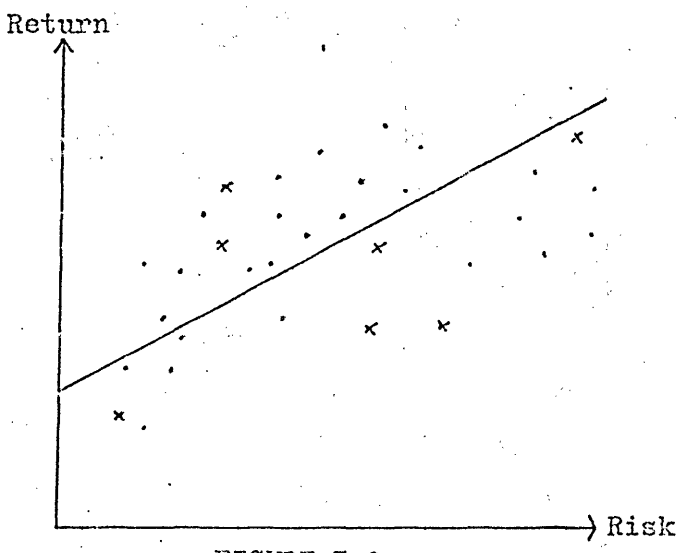


FIGURE 7.3

Line of best fit through scatter of risk/return points observed for a sample of funds.

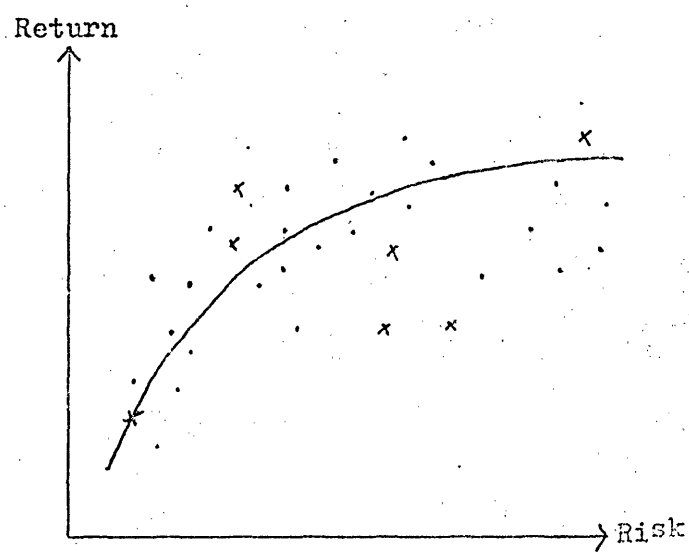


FIGURE 7.4

Curve of best fit through scatter of risk/ return points observed for a sample of funds.

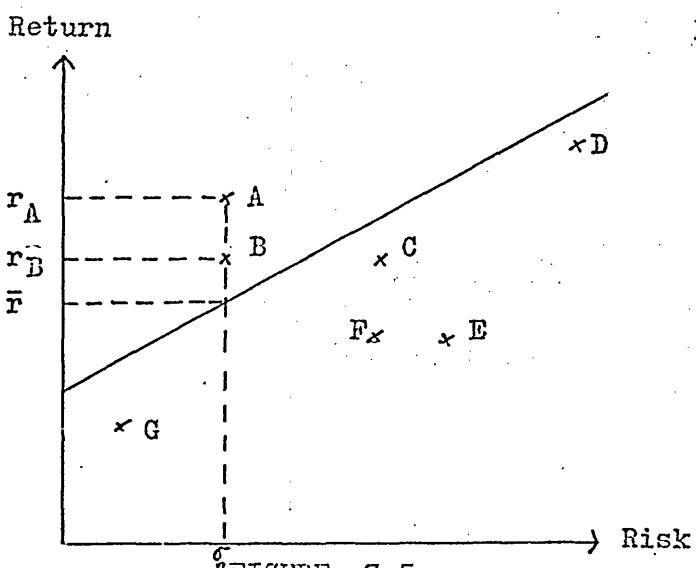


FIGURE 7.5

Risk-adjusted performance assessment using fitted average linear relationship.

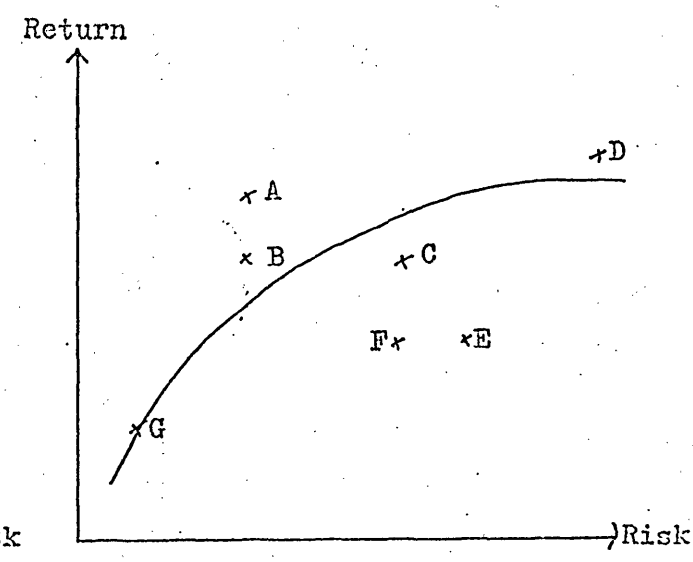


FIGURE 7.6

Risk-adjusted performance assessment using fitted average non-linear relationship.

two sub-sections. Their differences constitutes a remarkable parallel with the difference between the two major means of analysis of ROR performance. These are an inter-fund standard or a notional standard.

V.1 AVERAGE RISK/RETURN RELATIONSHIP OVER DIFFERENT FUNDS

Just as the use of inter-fund comparisons compare a particular fund's rate of return to the average return earned by a sample of similar funds, a standard of risk/return performance can be provided by the calculation of the average trend between return and risk for all funds in the sample. Figure 7.3 shows the scatter diagram of points which might be obtained and the line of best fit through these points. This regression line represents a sort of average relationship between risk and return, given that it is hypothesised to be linear in the first place.

Figure 7.5 shows this line super-imposed onto the original graph (Figure 7.2) of the 7 funds in question. Funds A and B are the only two funds to lie above the average risk/return relationship. It can be said that these funds exhibit a trade-off between risk and return which is above average; or, in other words, that their risk adjusted performance is above average and in that sense superior. The line indicates that on average, a fund with risk measure σ_A earned a return of r. A and B earned returns clearly in excess of r. Furthermore, it can be seen that fund A's performance is better than fund B's because its vertical distance from the line $(r_A - r)$ is the greater. Thus the use of this average risk/return line enables the assessment of the merit of risk/return performance on an absolute basis, providing that the average linear relationship is accepted as representing the levels of "fair" return for different levels of risk.

The line also enables the comparison of the performance of all possible pairs of funds. It is now possible to infer that fund D's performance was worse than A's and that the performance of fund G is even worse still.

Once the equation represented by the line is quantified, various measures of risk-adjusted performance can be devised to quantify the position of a fund relative to the line. These measures are known as risk-adjusted performance measures. They are discussed in the next chapter.

At this point it is useful to note that the average relationship between risk and return need not necessarily be linear. For example, if a curve is fitted to the scatter diagram of the sample of funds (Figure 7.4), the assessment of the risk/return performance of some of the 7 funds in question would change. Funds A and B are still pin-pointed as superior performers, and funds C, F and E are still identified as inferior performers. But fund G, previously accused of inferior performance, is now seen to lie on the average risk/return relationship, implying that its performance is neutral - neither good nor bad, but just average. Fund D, on the other hand, has had its assessment reversed. It is now shown to be a good performer.

V.2 NOTIONAL RISK/RETURN RELATIONSHIP

The difficulty of obtaining a representative sample of funds from which to estimate the average risk/return relationship is no less difficult than it is to obtain a sample from which a truly representative average return may be calculated. Chapter 5 showed that a solution to the latter problem is to form a model notional fund from information on the average profile of U.K. pension funds, and to regard the return on this as the average return of U.K. portfolios.

A similar approach may be adopted here. It is relatively simple to calculate a risk measure for a model fund. This gives us one point on a hypothesised risk/return relationship. This is the point corresponding to average return and average risk, a point through which, by definition, the average risk/return relationship should pass.

The problem is that a risk/return relationship needs to map the risk and return points of a theoretically infinite

number of notional portfolios, corresponding to the infinite number of possible risk levels which a portfolio can possess.

Fortunately, if the relationship can be assumed to be a linear one, the generation of all these notional portfolios is a simple matter. The point at which the risk/return relationship cuts the return axis is the point corresponding to an asset which has a zero risk measure - that is, a completely riskless asset. All points on the risk/return line may be mathematically represented as a linear combination of this point and the point represented by the model fund.

Figure 7.7 shows this diagramatically. The point M is the model notional fund, with market return r_m and risk measure σ_m. The riskless asset earns a return of r_o. Every point between r_o and M is generated by the general point:

$$\left[p_1 r_o + p_2 r_m, p_1 \sigma_o + p_2 \sigma_m\right] \qquad - (7.3)$$

as p_1 and p_2 vary between 0 and 1 and $p_1 + p_2 = 1$.

These points may be regarded as a notional portfolio, some of which consist of an investment in the model fund, and some of which is investment in the riskless asset.

The points on the line lying to the right of M are a special case of (7.3) where $p_1 < 0$ but $p_1 + p_2 = 1$ still. These points correspond to a notional portfolio which contains a negative amount of the riskless asset. These points correspond to a general notional portfolio which has been formed by borrowing some funds at an interest rate equal to the return on the riskless asset. This loan is equivalent to holding a negative proportion of the general notional fund as riskless assets. The funds so borrowed are deemed to be fully invested in the model fund. Now because the return earned on these borrowed funds will be r_m, while the borrowed funds cost only r_o, a profitable return of $r_m - r_o$ is made by investing the borrowed funds in the model fund. This

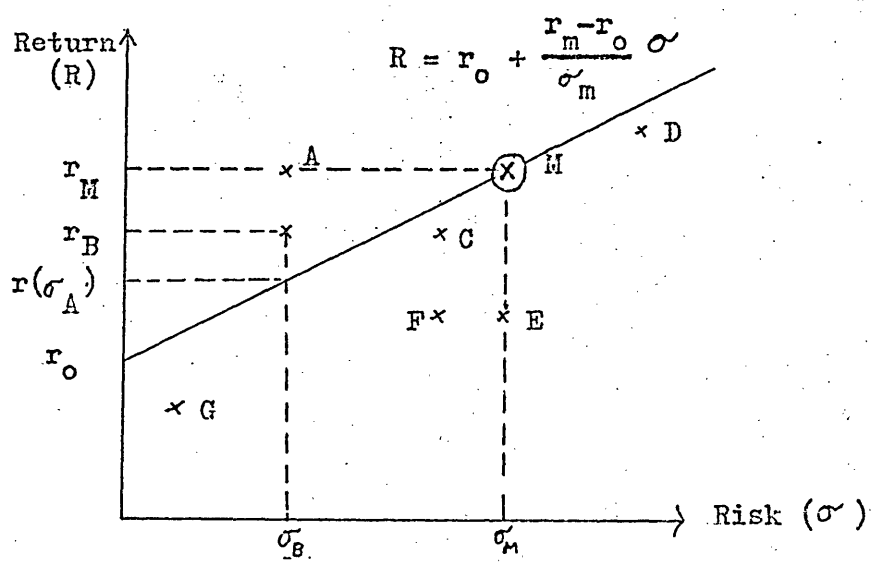


FIGURE 7.7

Application of notional risk/return line to risk-adjusted performance assessment of the 7 funds of Figure 7.2

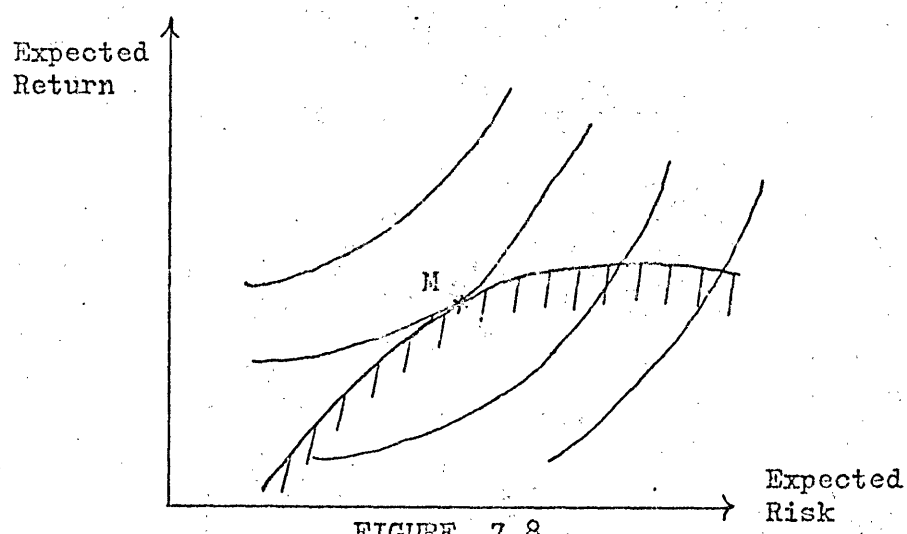


FIGURE 7.8

Indifference curves of risk-averse investors and Markowitz frontier of efficient investments.

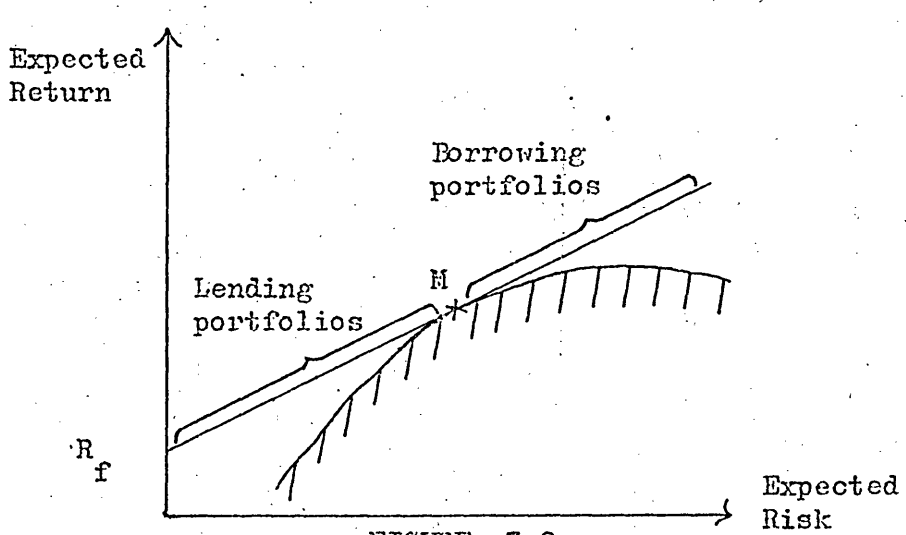


FIGURE 7.9

Various combinations of riskless asset and market portfolio dominate the efficient frontier

extra profit results in the overall rate of return on the general portfolio exceeding that of the model fund. This explains why the points lie above M on the risk/return line.

Figure 7.7 also shows how the resulting notional risk/return line can be used to assess the performance of the 7 funds illustrated in figure 7.2. Once again, funds A and B are deemed to be superior performers because they lie above the line. Fund B earned a higher return than did a passively managed notional portfolio with the same risk level, σ_A. Its excess return over the market, after adjustment for risk, is $r_B - r(\sigma_A)$. Similarly, fund D is shown to have performed less badly than G.

V.3 IMPORTANCE OF RISK IN THE ANALYSIS OF PERFORMANCE

The importance of assessing performance on the basis of risk as well as return can now be seen from figure 7.7. Recall that an analysis of performance using an additive decomposition of performance with a primary model fund reference point would identify fund B as having under-performed the market (since the difference $r_B - r_m$ is negative). The incorporation of risk into the analysis shows however that much of this difference is accounted for by the difference in risk between fund B and the model fund M. If B is compared to a primary reference point notional fund which has the same risk level as B, the analysis of performance would indicate B to have performed quite well, earning an excess return of $r_B - r(\sigma_B)$ over the average or market return associated with the same risk level.

This illustrates the general point that the techniques of analysis of performance using a model fund as the primary reference point against which performance is compared (described in Chapters 5 and 6) identify performance relative to the market which is not net of the effect of the difference in risk between the actual fund and the market. It will be shown in Chapter 8 that the decomposition of such relative performance

is a very simple method of analysing to what extent an observed difference in performance is due to risk effects and what part constitutes true excess return.

V.4 SIMILARITY BETWEEN AVERAGE AND NOTIONAL RELATIONSHIPS

It was argued in Chapter 5 that the return on a model notional fund could be viewed as the average return on all U.K. pension funds provided one could accept that the average return of all funds in each sector was the sector's market return as represented by the index used in the model fund to represent that sector. Thus the use of a model fund as a standard of performance is, in the limit, equivalent to an inter-fund standard of performance which is derived from a sample of funds which is in fact a complete census.

In a similar manner, the notional risk/return line may be regarded as the average risk/return relationship which would result from a regression of the data points of all UK pension funds. An important qualification is that this will be so only if one is prepared to accept that the intercept yielded by this regression is the riskless rate of return r_o.[1] The fitted intercept will only be consistent with a theorectical riskless rate (such as the rate of return on an extremely short term Treasury Bill) if the theory used to generate the linear notional risk/return relationship is 100% valid. Obviously this is unlikely to be the case.

VI. CAPITAL ASSET PRICING THEORY

The first inkling of capital asset pricing theory occurred in an isolated article in 1928, when Rose(65) assumed that a fraction of all return was "risk-free rent."

1: Any unconstrained linear regression automatically passes through the means, $\bar{r}$ and $\bar{\sigma}$ of the two variables involved. Since the above argument equates $\bar{r}$ with r_m, and $\bar{\sigma}$ with σ_m, it follows that the regression line will pass through the point r_m, σ_m or M in Figure 7.8.

Rose went on to measure ROR as an excess above the "riskless rental of capital." This approach went unexplored until W.F. Sharpe's pioneering formulation (69) of a capital asset pricing theory in 1963/64.

As this thesis is not centred on the capital asset pricing model (CAPM) and the literature contains several explanations of its derivation,[1] only a very brief outline is given here.

The following discussion of CAPM aims to illustrate how risk-adjusted performance measures were derived from, and depend on the validity of, capital asset pricing theory. It will be argued that because the CAPM is an inadequate and unrealistic model of the true relation between risk and return, these measures cannot be trusted. It will be argued however that the concepts supplied by capital asset pricing theory can be utilised to a limited extent by following the logic of the previous sections concerning the average relation between risk and return.

VI.1 BRIEF OUTLINE OF THE THEORY

VI.1.1 BASIC HYPOTHESIS

The fundamental hypotheses are that expected returns of both portfolios and individual securities are linearly related to expected risk. For a portfolio with an expected return of $\tilde{R}_p$ the hypothesis is that[2]

$$\tilde{R}_p = R_f + \lambda_p \tilde{\sigma}_p + \tilde{\varepsilon}_p \qquad - (7.4)$$

where R_f = Risk-free ROR (i.e., ROR on an hypothesised riskless asset)

1: See for example Francis and Archer(34), Jensen(42) or Fama(26).

2: Tildes will be used to indicated quantities which are expected, rather than known.

where $\tilde{\sigma}_p$ = The expected risk of the portfolio

$\tilde{\varepsilon}_p$ = That part of expected return which is not related to risk

λ_p = The "risk premium" of the market

$$= \frac{\tilde{R}_m - R_f}{\tilde{\sigma}_m^2} \qquad - (7.5)$$

where $\tilde{\sigma}_m^2$ = Expected risk of the market

$\tilde{R}_m$ = Expected ROR in the market portfolio[1].

For an individual security, a similar linear relationship is assumed but the measure of risk which is used differs. To use the S.D. of the return on an individual security as a measure of its risk would be naive. A sensible investor who diversifies his investments would realise that it is not the total risk of a security to which he is exposed, but only that fraction of total risk which cannot be "diversified away" through the correlation of the security's return with the returns on the securities in the rest of the portfolio. This undiversifiable element of risk can be expressed as the covariance between the security's expected return and the market's expected return R_m. It is this covariance which is the true measure of the risk to an investor, implying that for the ith security in the market

$$\tilde{R}_i = R_f + \lambda_i \text{ cov } (\tilde{R}_i, \tilde{R}_m) + \tilde{\varepsilon}_i \qquad - (7.6)$$

where λ_i = "Risk premium" of the market equal to (7.5) as before

(7.6) is referred to technically as the "Securities Market Line" (SML) for asset i. Fama(26) has shown that (7.6) may

---

1: A market which is assumed to be Markowitz efficient. See VI.3.2, this chapter.

be interpreted as follows. In a portfolio representing the whole market, total risk is

$$\tilde{\sigma}_m = \sum_{i=1}^{N} W_i \frac{\text{cov}(\tilde{R}_i, \tilde{R}_m)}{\tilde{\sigma}_m} \qquad - (7.7)$$

where there are N securities, each with a weight by value in the market portfolio equal to W_i.

(7.7) implies that the total risk of the market can be considered as the weighted average of the contribution to total market risk of individual securities,

$\text{cov}(\tilde{R}_i, \tilde{R}_m)/\tilde{\sigma}_m$. Thus (7.6) may be interpreted as:

$$\tilde{R}_i = R_f + \frac{R_m - R_f}{\tilde{\sigma}_m} \cdot \frac{\text{cov}(\tilde{R}_i, \tilde{R}_m)}{\tilde{\sigma}_m} \qquad - (7.8)$$

which says that the equilibrium expected return on the ith asset is the market return per unit of market risk multiplied by the contribution of the ith asset to total market risk.

A risk/return relation using this more sophisticated measure of risk can also be applied to portfolios, so that

$$\tilde{R}_p = R_f + \lambda_p \text{cov}(\tilde{R}_p, \tilde{R}_m) + \tilde{\varepsilon}_p \qquad - (7.9)$$

Use of (7.9) implies that only that part of risk which is due to market fluctuations is counted as contributing to expected return.

VI.1.2 BETA VALUES AND SYSTEMATIC RISK

The basic CAPM hypothesis (7.6) is frequently re-expressed in terms of the asset's beta value β_i. (7.6) may be re-expressed as

$$\tilde{R}_i = R_f + \frac{\text{cov}\,(\tilde{R}_i, \tilde{R}_m)}{\tilde{\sigma}_m^2}\,(R_m - R_f) + \tilde{\varepsilon}_i \qquad - (7.10)$$

$$= R_f + \beta_i\,(\tilde{R}_m - R_f) + \tilde{\varepsilon}_i \qquad - (7.11)$$

where $$\beta_i = \frac{\text{cov}\,(\tilde{R}_i, \tilde{R}_m)}{\tilde{\sigma}_m^2} \qquad - (7.12)$$

A beta value for an individual portfolio or asset may therefore be regarded as the parameter in

$$\bar{R}_i = \alpha + \beta_i\,\tilde{R}_m + \tilde{e}_i \qquad - (7.13)$$

Measuring the risk of asset i as the variance of its expected return,

$$\text{var}\,(\tilde{R}_i) = \text{var}\,(R_f + \beta_i\,\tilde{R}_m + \tilde{e}_i)$$

or $$\text{var}\,(\tilde{R}_i) = \beta_i^2\ \text{var}\,(\tilde{R}_m) + \text{var}\,(\tilde{e}_i) \qquad - (7.14)^1$$

This shows that the risk of an asset may be expressed as the sum of its systematic risk, β_i^2 var $(\tilde{R}_m)$ and unsystematic risk, var $(\tilde{e}_i)$.

Unsystematic risk need not be tolerated in an asset if that asset can be combined with others in a well-diversified portfolio. In such a portfolio, the different unsystematic risk elements cancel out and the total risk of the portfolio will be at the least the sum of the various systematic risks.

Recalling (7.12), systematic risk may be expressed as

1: R_f is a known constant (otherwise it would not be risk-free), and the residual e_i is hypothesised to be completely uncorrelated with R_m.

$$\left[\frac{\text{cov}\ (\tilde{R}_i,\ \tilde{R}_m)}{\tilde{\sigma}^2_m}\right]^2 \sigma^2_m = \frac{\left[\text{cov}\ (\tilde{R}_i,\ \tilde{R}_m)\right]^2}{\tilde{\sigma}^2_m} \qquad - (7.15)$$

showing that systematic risk is derived from the co-movement of the asset with the market. Further, the proportion of total risk which is systematic risk may be expressed as:

$$\frac{\text{Systematic}}{\text{Total}} = \frac{\beta_i^2\ \text{var}\ (\tilde{R}_m)}{\text{var}\ (\tilde{R}_i)} \qquad - (7.16)$$

VI.2 INTERPRETATION OF THE THEORY

The CAPM simply expresses in mathematical terms what is intuitively obvious after the fact. This is that when the market rises, some securities (and some portfolios) tend to go up by a greater percentage than the market rise, while others go up by far less. Securities (or portfolios) with $\beta < 1$ are deemed to be less risky than those with $\beta > 1$ because their contribution to a well-diversified portfolio (or, in the case of a portfolio, the total ROR) tends to vary less with market fluctuations. Conversely, a portfolio with $\beta > 1$ tends to fall in value more than the market during depressed times, so making it a risky portfolio, where "risky" is used in its academic sense.

VI.3 ASSUMPTIONS OF THE THEORY

To appreciate how much of a simplification the theory is, it is necessary to list the assumptions and examine their relevance to the theory's derivation. It will later be shown that as these fairly strict and sometimes unrealistic assumptions are relaxed, the theory's precision soon fades.

VI.3.1 ASSUMPTIONS

Francis and Archer(34, Ch. 5) list the following:

1. All investors are Markowitz efficient investors

   All investors are assumed to assess alternative possible portfolios and securities on the basis of average return and risk, as measured by variance of return. Further, they are assumed to seek investments which lie on Markowitz's "efficient frontier", which is the set of portfolios which dominate all others in the sense of greater return for equal or less risk.

2. All investors form identical subjective estimates of the future returns and risks of investments.

3. Any amount of money may be either lent or borrowed at a completely risk-free ROR, R_f.

4. All investments are infinitely divisible, so that minute adjustments to a portfolio are possible.

5. All investors have the same one-period time horizon.

   That is, they plan their investments over the same period, with no thought to what happens after that period.

6. There are no taxes

7. There are no transaction costs in the market

8. The capital markets are in equilibrium

9. There is no inflation during the period, so that monetary returns correspond to real returns.

Jensen(43) adds two more:

10. All investors are price-takers (i.e., the market is perfectly competitive)

11. The quantities of all investment assets are given.

VI.3.2 DERIVATION OF HYPOTHESISED LINEAR RETURN/RISK RELATIONSHIP

To illustrate the crucial extent to which the linearity of the CAPM depends on the validity of some of the above assumptions, this sub-section briefly outlines in a non-rigorous manner the derivation of what Sharpe calls the "Capital Market Line" (CML). Any assumption associated with an aspect of the derivation is quoted below as the relevant number in the previous sub-section.

Risk-averse investors will have indifference, or utility, curves in a risk-return space like those shown in Figure 7.8. All points on a curve are of equal utility to an investor, with utility increasing with the height of the curve. The mean-variance theory of Markowitz(53) dictates that all available investment possibilities are dominated by those investments on the efficient frontier. They represent the best portfolio opportunities available, given the supply of alternatives (assumption 11) and common expectations (assumptions 2 and 5). The point at which this frontier intersects tangentially with the highest possible indifference curve represents that efficient portfolio which yields the highest utility for an investor.

Two aspects of this maximum utility portfolio need to be noted:

1. It will be a Markowitz efficient portfolio

   That is to say that it will be "well diversified" in the sense that it combines securities in an

optimal manner so as to use their inter-correlations to minimise the total amount of portfolio risk.

2. It will be the "market" portfolio.

Since all investors are assumed to invest in a Markowitz efficient manner (assumption 1), they must all be holding a portfolio modelled on M. Hence M consists of the collection of all marketable risky assets. Each investor holds a portfolio in which the ith security is held in proportion to its presence in the market by market value.

Given this market portfolio, all investors should now continue to maximise the efficiency of their total portfolios by realising that a share in M may be combined with a quantity of riskless asset. An argument along the exact lines of that in Section V.2 of this chapter may be used to show that points along the line represent a total portfolio involving a proportion (possibly negative) of risk-free asset and a proportion of the market portfolio M (Figure 7.9)

The derivation of this line, called the Capital Market Line by Sharpe(69), is the most crucial element of the CAPM. It depends crucially on two assumptions:

1. That there exists a riskless asset (assumption 3)

2. That investors can borrow funds at this risk-free rate R_f as well as lend (assumption 3)

It is the linearity of this CML which forms the basis for the assumed linearity of (7.4) and (7.6). The next chapter illustrates a similar dependence of popular risk-adjusted measures of performance on these assumptions, after which the validity of the theory and these measures is questioned.

VII. DIFFERENCES BETWEEN CAPM AND AVERAGE RISK/RETURN RELATIONSHIP

The great similarity of the CML to the average linear relationship between risk and return which was derived in two different ways in V.1 and V.2 of this chapter is apparent, but there are some important differences between them.

The most important are as follows:

1. The intercept in an average linear relationship derived from actual fund data may not be anything like the riskless ROR R_f.

2. For both methods, the market portfolio M is not the same market portfolio as in the CAPM.

   In reality investors do not behave in the completely rational one-period manner required by the Markowitz efficient portfolio M in the CAPM. The market portfolio derived from average pension fund statistics will describe the market as it <u>is</u>, not as it <u>should</u> be. The chief differences of the actual market portfolio from the Markowitz efficient one will be:

   (i) A probable lower return (since it will not be optimal)

   (ii) A probable slightly greater risk, since the actual market portfolio will only be naively diversified. That is, it will only eliminate unsystematic risk and will not optimally combine negatively correlated securities so as to reduce total systematic risk beyond what it could otherwise be.

A notionally derived line will start at the risk-free rate but will probably have a smaller slope than the CML, due to the fact that the notional market portfolio will only be

naively diversified (and so have greater risk). This difference in slope has been verified empirically in the course of some attempts to validate the CAPM. These attempts are mentioned in the next chapter.

CHAPTER EIGHT

ADJUSTMENT OF PERFORMANCE FOR RISK

After arguing that conventional risk-adjusted measures of performance are too critically dependent on an unrealistic capital asset pricing model, this chapter demonstrates that risk-adjusted measurement can take place using the CAPM's basic ideas, but in a manner which is free from the latter's disadvantages. It is argued that this approach to risk adjustment is superior to any described in the existing literature.

I. RISK-ADJUSTED PERFORMANCE MEASURES

There are four main methods of adjusting performance for risk. Three of these are very similar while the fourth stands alone. This is the classification method recommended by the BAI(1). They recommend that funds of obviously different risk levels should be grouped seperately and not directly compared for performance assessment purposes. This method is of little use to most institutions however due to the small number of funds involved.

The common aim of the remaining three risk-adjusted measures has been expressed as follows:-

> " The entire rationale for one-parameter measures of investment performance is to replace two-parameter measures of performance - rate of return and risk - with a single measure which uses market data to combine the two different dimensions of performance into a single measure which adjusts for differences in risk"[1]

1: Friend and Blume(35,p153)

The following three sub-sections consider the three one-parameter risk-adjusted performance measures which have been derived from the CAPM. The last sub-section considers their relative merits.

I.1 JENSEN'S ALPHA VALUE

According to the CAPM, the expected ROR, R_p, on portfolio p should, if the portfolio is in equilibrium be

$$\tilde{R}_p = R_f + \beta_p (\tilde{R}_m - R_f) + \tilde{\varepsilon}_p \qquad - (7.11) \text{ repeated}$$

As Figure 8.1 shows, the degree to which a portfolio is out of equilibrium is represented by its vertical distance from the risk/return relationship (7.11). Calling this vertical distance α_p, a new more general CML may be described as

$$\tilde{R}_p = \alpha_p + R_f + \beta_p (\tilde{R}_m - R_f) + \tilde{\varepsilon}_p \qquad - (8.1)$$

The parameter α_p was suggested by Jensen(42) as a risk-adjusted performance measure.

The procedure involved in applying Jensen's measure to a particular portfolio is as follows:

1. Collect past information on the fund's return and market returns over the same periods.

2. Estimate by regression the relationship

$$R_p - R_f = \hat{\alpha}_p + \hat{\beta}_p (R_m - R_f) \qquad - (8.2)$$

The riskless rate is unually taken to be that on a government security whose maturity matches that of the differencing interval on the basis of which fund returns have been calculated.

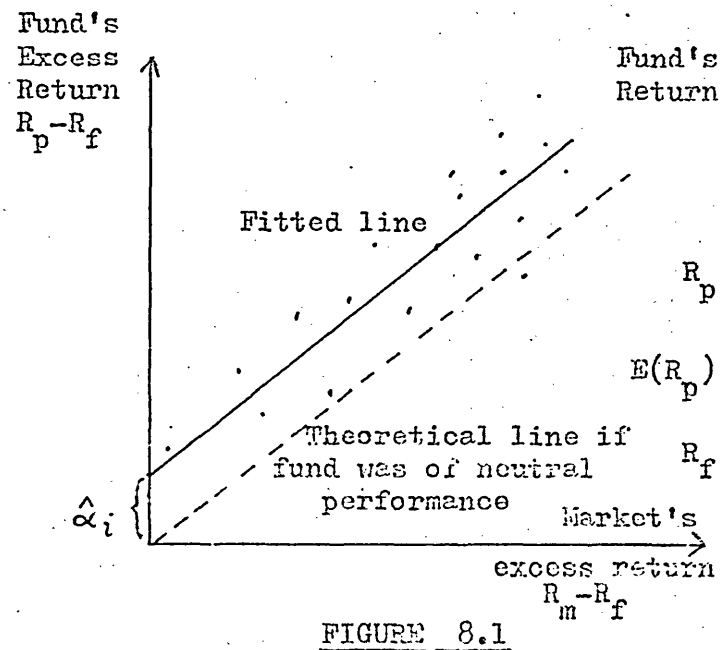


FIGURE 8.1

Jensen's risk-adjusted measure, $\hat{\alpha}_i$, in terms of the regression used to estimate it.

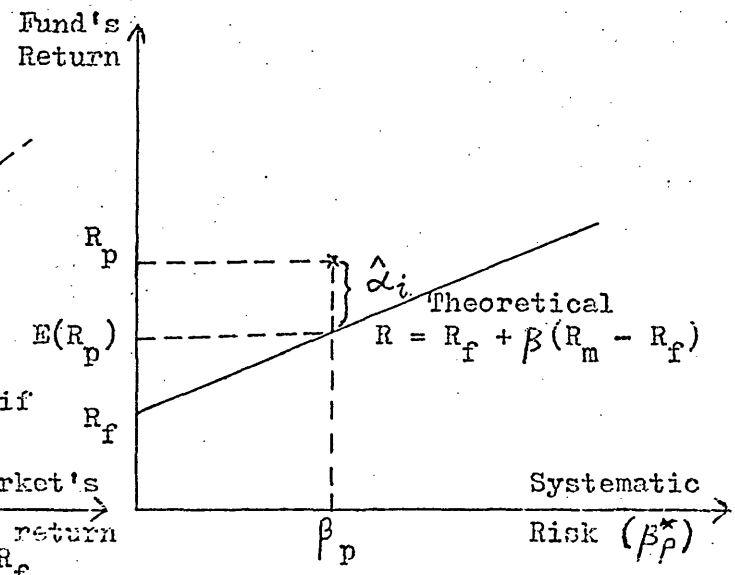


FIGURE 8.2

Jensen's risk measure, $\hat{\alpha}_i$, in terms of the SML.

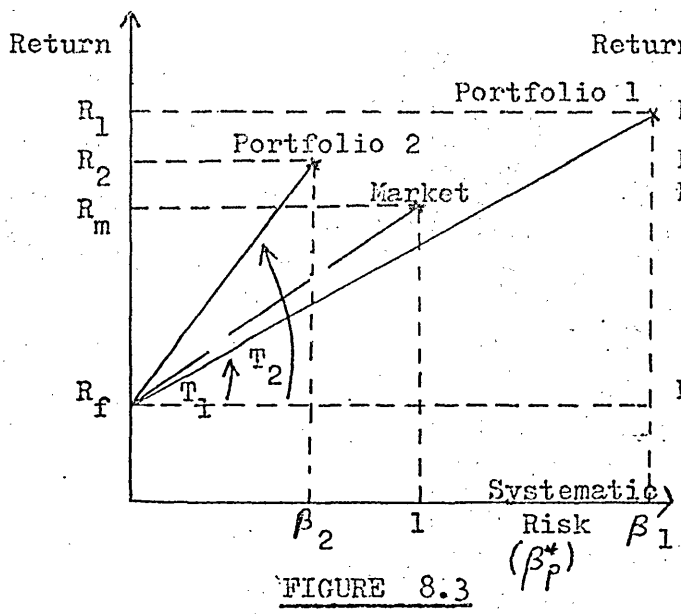


FIGURE 8.3

Treynor's risk-adjusted measure of performance

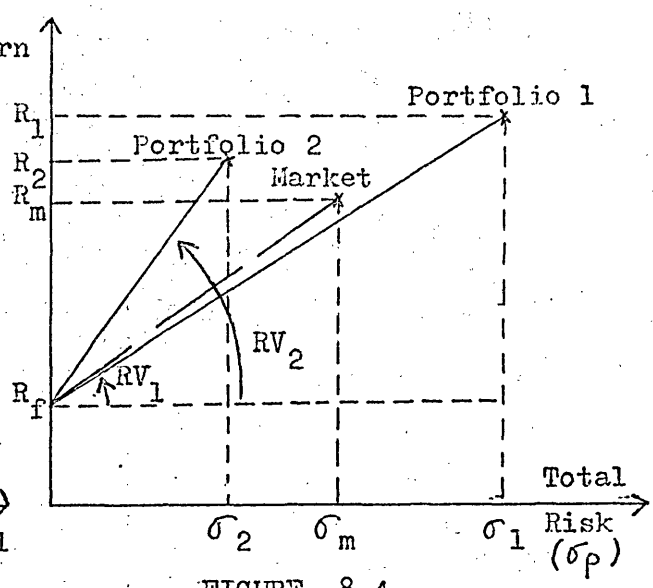


FIGURE 8.4

Sharpe's risk-adjusted measure of performance

3. The estimated intercept $\hat{\alpha}_i$ is the risk-adjusted performance measure of the fund. If it is significantly different from zero, the fund may be regarded as having performed significantly better (if $\hat{\alpha}_i > 0$) or worse ($\hat{\alpha}_i < 0$) than a similar naive portfolio with the same level of risk.

To facilitate comparison with other risk-adjusted measures note that Jensen's measure may also be regarded as the intercept of the fund's SML, which relates return to the fund's systematic risk. Recalling how (7.11) was derived from (7.6), (8.1) may be re-written as

$$\tilde{R}_p = \alpha_p + R_f + \frac{\text{cov}(\tilde{R}_p, \tilde{R}_m)}{\sigma_m^2} (\tilde{R}_m - \tilde{R}_f) + \tilde{\varepsilon}_p$$

$$= \alpha_p + R_f + \lambda_p (\beta_p \tilde{\sigma}_m^2) + \tilde{\varepsilon}_p \qquad - (8.3)$$

This is a SML since it relates return to systematic risk $\beta_p \tilde{\sigma}_m^2$. Figure 8.2 shows risk as a function of β_p only, since ex-post, σ_m is a constant. The amount by which the observed SML exceeds the theoretical line is Jensen's measure. If β_p^* were the fund's actual riskiness over the period, its actual ROR R_p exceeded by α_p what it should have earned, $E(R_p)$, according to the theory. Three of the most important things to notice about this measure of performance are as follows:

1. It is an absolute measure of performance

   Given the sign of α_p, performance may be regarded as either superior ($\alpha_p > 0$) or inferior ($\alpha_p < 0$).

2. It is completely independent of the riskiness of the portfolio.

Two portfolios may have completely different risk levels β_p yet the same α_p measures. This is because α_p is simply the excess return over and above a naive portfolio with the same level of risk as the portfolio. (It will be shown later in this chapter that α_p is in fact equivalent to the Selection component of performance as defined in Chapter 5).

I.2 TREYNOR'S MEASURE

To see how Treynor's measure of performance,

$$T = \frac{R_p - R_f}{\beta_p} \qquad - (8.4)$$

is derived from the CAPM, note that (8.1) may be re-arranged as

$$\frac{\tilde{R}_p - R_f}{\beta_p} = \frac{\alpha_p}{\beta_p} + (\tilde{R}_m - R_f) + \frac{\tilde{\varepsilon}_p}{\beta_p} \qquad - (8.5)$$

The right hand side shows that T is a composite measure, being a function of both Jensen's selection effect α_p and the systematic risk of the portfolio β_p. Thus portfolios which enjoy the same selection effect may differ on Treynor's measure because they are of different risk.

Treynor's measure is easily comprehended on intuitive grounds given that the role given to a riskless asset by the CAPM is accepted as valid. Treynor's measure simply discounts the extra return earned in reward for risk by the risk level itself. The fact that this extra reward has to increase proportionally with the measure of risk is a reflection of the CAPM's assumption of a linear relationship between the two. Treynor's measure is illustrated in figure 8.3 for two portfolios. Because the difference in returns of the two portfolios is higher by a sufficient proportion relative to

their differences in risks (as reflected by the unequal slopes T_1 and T_2), portfolio 2 has performed better than portfolio 1. Its Treynor measure, T_2, is the larger.

Francis and Archer(34,Ch.8) imply that Treynor's measure is only a relative measure of performance, useful for ranking risk-adjusted performances only. By itself, it does not indicate whether performance was good or bad on an absolute scale. This is not a serious drawback however as the measure for the market,

$$T_m = \frac{R_m - R_f}{\beta_m} = R_m - R_f \text{ since } \beta_m = 1 \qquad - (8.6)$$

can always be used as an absolute standard over any one review period. In figure 8.3, portfolio 1 under-performed the market while portfolio 2 has exceeded it on a risk-adjusted basis.

I.3 SHARPE'S REWARD TO VARIABILITY RATIO

Sharpe's is the simplest measure of the three simply because it uses the simpler measure of total portfolio risk rather than systematic risk. Called by Sharpe(70) the Reward to Variability ratio,

$$RV = \frac{R_p - R_f}{\sigma_p} \qquad - (8.7)$$

its derivation from the CAPM may be seen in either of two ways:

1. From (8.1)

$$\tilde{R}_p - R_f = \alpha_p + \frac{\text{cov}\,(\tilde{R}_m, \tilde{R}_p)}{\sigma_m} (\tilde{R}_m - R_f) + \tilde{\varepsilon}_p \qquad -(8.8)$$

and noting that

$$\text{cov}\ (R_m, R_p) = \rho(\tilde{R}_m, \tilde{R}_p)\ \tilde{\sigma}_m \tilde{\sigma}_p \qquad - (8.9)$$

(where ρ is the correlation coefficient of market return with fund return),

$$\frac{\tilde{R}_p - \tilde{R}_f}{\tilde{\sigma}_p} = \frac{\alpha p}{\tilde{\sigma}_p} + \rho(\tilde{R}_m, \tilde{R}_p)\left[\frac{\tilde{R}_m - R_f}{\tilde{\sigma}_m}\right] + \tilde{\varepsilon}_p \qquad - (8.10)$$

2. Recall that if risk is measured in terms of total variability, and not just systematic risk, the basic CAPM equation is (7.4), which can be re-expressed as

$$\frac{\tilde{R}_p - R_f}{\tilde{\sigma}_p} = \lambda_p + \frac{\tilde{\varepsilon}_p}{\tilde{\sigma}_p} \qquad - (8.11)$$

Thus RV is the reward for risk per unit of risk. (8.11) shows that it is equal to the market risk premium (refer (7.5)) plus a special factor representing additional return per unit of risk of the portfolio. Comparing (8.7) and (8.4), Sharpe's measure is equivalent to Treynor's with the measure of risk used being total risk and not just systematic risk. This is a most important point. Both Treynor's and Jensen's measures use systematic risk only (β_p). If the portfolio is not well-diversified, systematic risk will not be a complete measure of the total riskiness of the portfolio, and the Treynor and Jensen measures will over-estimate risk-adjusted performance. Another way of seeing this is to note that for anything less than a perfectly diversified portfolio, $\rho(R_m, R_p)$ in (8.10) will be less than one, yet Treynor's measure <u>assumes</u> ρ to be unity (comparing (8.10) to (8.5)).

Figure 8.4 illustrates Sharpe's measure and illustrates the great similarity to Treynor's statistic. As before,

although it is basically a relative measure, the measure for the market can be used to provide an absolute standard of performance for any one review period.

I.4 COMPARISON OF THE THREE MEASURES

Even though these measures adjust for risk, they still do not consider all aspects of performance. Each measure captures a different aspect of performance as follows:

1. Sharpe's statistic is the only one of the three to take into account the total risk of the portfolio

   Using the other measures, the total risk of the portfolio can vary while the risk-adjusted measures remain constant.

   "Thus a portfolio manager can improve his Jensen or Treynor rating without making any improvement in the quality of his selection skills merely by departing further from perfect diversification; because both measures ignore insurable risk[1], their widespread use could tempt portfolio managers to incur excessive amounts of insurable risk in seeking to increase trading profits."[2]

   Thus the Treynor and Jensen measures if used as part of a performance analysis system would violate one of the necessary characteristics of the system, as outlined in VI.1, Ch. 6. Holbrook(41,p20) has pointed this out in terms of the measure's ignorance of the goodness of fit of the risk/return relationship to the fund's data. The fitted value of β_p is independent of this. The worse the fit, the less the total variation in return which is explained by market movement (i.e., the less is the proportion of total risk accounted for by systematic risk).

2. Jensen's measure is the only one which is an absolute standard of performance which is invariant over time.

1: That is, diversifiable risk

2: Treynor in Jensen(41,p419)

A positive α value indicates superior performance relative to the market no matter what market return was. Using the other measures, a standard can be calculated for any given review period, but this standard may vary from period to period.

There is some evidence to suggest that all three measures are highly correlated. Draper(20) quotes one study which confirms this. Sharpe(70) demonstrates that rankings given by his reward to variability ratio are virtually identical to those yielded by Treynor's statistic for a small sample of US mutual funds.

More certain than their correlation however is that they are all crucially dependent on the linearity between risk and return. The next section, by implication, therefore assesses the robustness of these measures.

II. REALISM OF THE C.A.P.M.

The most crucial aspect of the CAPM, its linearity, unfortunately rapidly breaks down when a few assumptions are relaxed. Francis and Archer(34,Ch.5) illustrate this as follows:-

1. It is unrealistic to assume that investors can borrow at the same risk-free rate as that at which they can lend (assumption 3 of VI.3, Ch.7)

   If the theory is modified to allow for a higher borrowing rate, R_f^b, the result is a kinked CML (figure 8.5). Once an investor resorts to borrowing, the slope of the line lessens due to the higher interest payments, R_f^b. This kink has several important consequences:

   (i) If it really exists while a perfectly linear CML is used for performance assessment, the expected ROR for high-risk portfolios will be over-predicted. It will be mentioned later that risk-adjusted measures based on the perfect

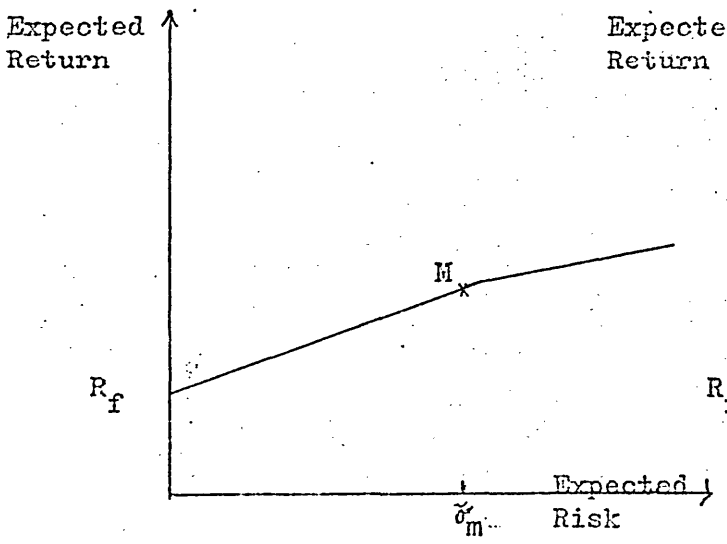


FIGURE 8.5

Capital Market Line with different borrowing and lending rates

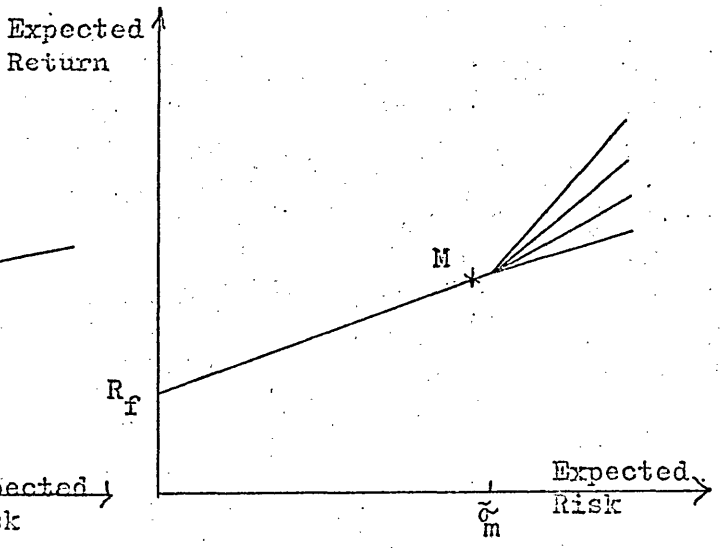


FIGURE 8.6

Capital Market Line with investors of different credit ratings.

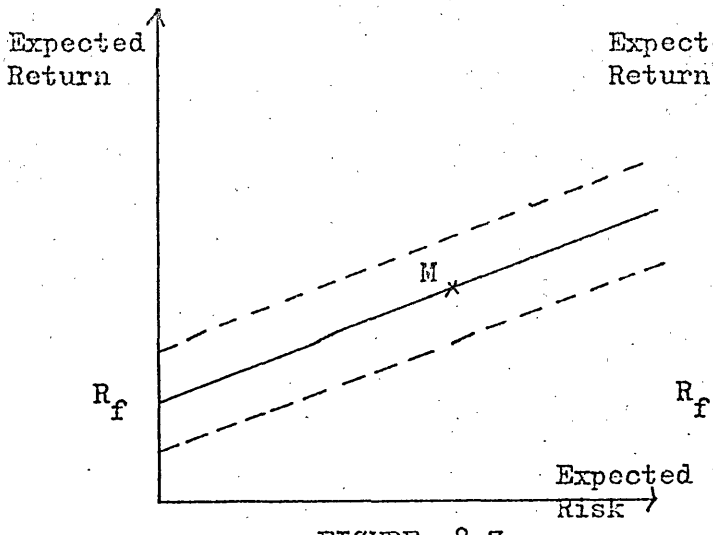


FIGURE 8.7

Capital Market Line with transaction costs

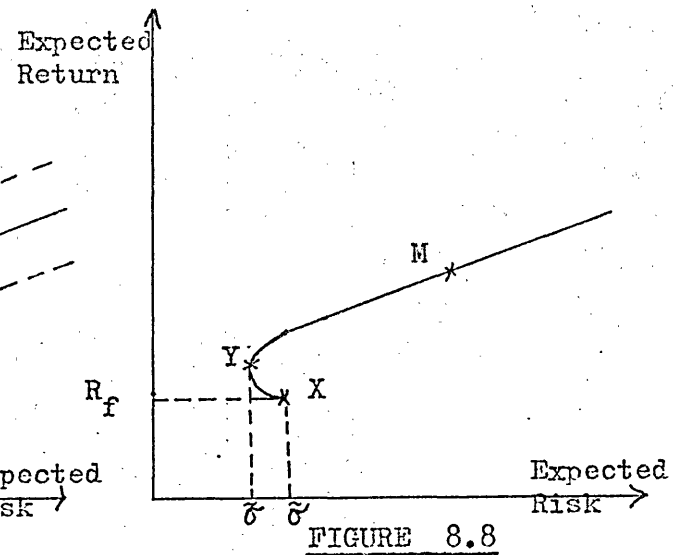


FIGURE 8.8

Capital Market Line with no riskless asset.

linearity of the CAPM have in fact been shown to judge risky portfolios harshly.

(ii) If investors differ in their credit ratings (i.e., assumption 10 is broken) the upper region of the CML becomes "fuzzy", as shown in figure 8.6. Many different lines exist, one for each of the different borrowing rates.

2. Transaction costs do in fact exist (assumption 7)

Transaction costs inhibit the minute adjustments to portfolios which would ensure that security prices were always at equilibrium. A dealer will not capitalise on an out-of-equilibrium-price if the margin does not exceed costs. The effect of this is to make the CML a region (figure 8.7). Securities will stay only within the band shown, rather than actually on the line.

3. Investor's perceptions of expected returns and risks will in reality not be homogeneous (assumption 2) and even if they were they would be tainted by different tax brackets of investors (assumption 6). These realities produce a general blurring of the Capital Market Line. Investors each see a slightly different Markowitz efficient frontier, and so each perceive a slightly different optimal market portfolio. Once again, the line becomes a region.

4. During inflationary periods, there is no completely riskless rate of return. (assumption 9).

In non-inflationary times, a riskless asset could be a very short-term Government bond. In inflationery times however, the uncertainty of future inflation makes all monetary returns, however certain in themselves, risky. The real return will not be riskless.[1]

1: An index-linked government bond could be argued to be completely riskless however.

It is well documented that if no riskless asset exists, linearity at the lower and of the CML completely breaks down. Jensen(42) demonstrates that if X is the lowest earning asset available, but still has a positive level of risk, $\tilde{\sigma}_x$, then the CML could appear as in figure 8.8. It may be possible to find some other risky asset with a return which is negatively correlated with that of X. A portfolio Y may then be formed from these two assets which achieves minium risk $\tilde{\sigma}_y$.

An imaginary combination of figures 8.5 to 8.8 will illustrate that in reality any optimal risk/return relationship will be a very blurred region and will almost certainly be non-linear. This last conclusion about non-linearity is the most essential point. It will be shown in the following sections that evidence of non-linearity does exist, and that it renders all existing risk-adjusted performance measures invalid.

III. EVIDENCE FOR THE VALIDITY OF THE CAPM

Although no-one has undisputably proven or disproven the CAPM, it is fair to say that after a little under a decade of empiricial testing, the evidence against its validity outweighs the evidence for.

III.1 THEORECTICAL IMPOSSIBILITY OF VALIDATION

Sharpe was the first to point out that because the theory is couched in terms of expected (or "ex-ante") return and risk, it need not perfectly fit realised (or "ex-post) values simply because actual events need not match up to expected events.

> "Results based on ex-post values that are consistent with the theory ... are, at the very least, reassuring. And results based on ex-post values that prove to be inconsistent with the theory would be unsettling, though not absolutely devastating."[1]

1: Sharpe in reply to West(70,p235)

The view is taken here that enough evidence exists against the traditional form of the CAPM to make the use of any performance measures based on that theory very "unsettled" and perhaps nearly "devastated."

III. 2 EMPIRICAL TESTS IN THE LITERATURE

The CAPM appears to have enjoyed some early support because of the manner in which it was at first tested, or not tested:

> "Most of the early evidence bearing on the model did not represent direct tests but, rather, emanated primarily from attempts to use the asset pricing model to derive portfolio performance evaluation models."

Early "tests" of the model were thus really not very strict tests at all. They were more applications of the assumed - correct CAPM to the problem of adjusting mutual fund performance for risk. All found an approximate linear relationship between fund returns and market returns but none yielded information on, for example, whether the intercept was in fact commensurate with a risk-free rate of return, or whether the observed regression line was anything near the correct slope according to the theory.

Although the tests varied in their design, they all attempted to judge to what degree the funds sampled stuck to an estimated CML, as in figure 7.5. Most such tests[1] of mutual fund performance have concluded that fund performance of U.S. mutual funds has on the average been just below market return, the deficiency being roughly equivalent to their management expenses (with obvious implications for mutual fund managers!).

After the initial enthusiasm of these tests spent itself however, more serious tests of the model were made, and some of the previous mutual funds studies were criticised. For example, Mains(52) maintains that one of the leading mutual fund studies, Jensen(42), incorrectly concluded that average fund performance after expenses is below market performance.

1: For example, Jensen(42), Treynor(81), Sharpe(70), Thackray (80).

Mains maintains that the conduct of the study on the basis of annual returns, combined with invalid assumptions of non-stationarity, led Jensen to systematically under-estimate the risk-adjusted performance of his mutual funds. Mains repeats the study for some of the same funds using monthly data and less strict stationarity assumptions to produce conclusions favourable to the mutual fund industry. (i.e., average performance after expenses equal to that of the market). Francis and Archer(34,p163) suggest that Sharpe's first use of the theory to test mutual fund performance was based on a sample of funds which may have been biased against smaller, younger funds.

More recently direct expermental empirical work on the validity of the traditional specification (7.6) of the CAPM has led to two main findings:

1. The slope of the estimated CML is less than one would expect from the theory

   Miller and Scholes(54) verified previous findings along this line by Lintner(50). This result is disturbing because it implies that the market portfolio is not the Markowitz efficient portfolio implied by the theory, but something less efficient, such as a naively diversified portfolio.

   Miller and Scholes attempted to show that the observed difference in slope is due to estimation errors and the effect of skewness in the rate of return distribution of some securities, the latter having a particularly major effect.. If one credits investors with the intelligence to at least learn from what they observe, it seems sensible that any realistic capital asset pricing theory would allow for the role of skewness in determining investors' preferences for alternative securities however.

2. Average rates of return over time deviate systematically from the levels implied by the CAPM.

After the production of its own evidence through intensive testing of the CAPM, one study (6,p82) concludes the following:

"The evidence presented ... indicates the expected excess return on asset is not strictly proportional to its β_i and we believe that this evidence .... is sufficiently strong to warrant the rejection of the traditional form of the model ....."

More than one study has found that the CAPM tends to over-predict the return on risky portfolios ($\beta > 1$) and under-predict the return on less risk portfolios ($\beta < 1$). This was the case in the above study, and has also been observed by Friend and Blume(35) and Lee(48). Friend and Blume regressed risk-adjusted performance measures (which should be completely independent of portfolio risk if the CAPM on which they are based is valid) on the systematic risk measures(β) of their corresponding portfolios. Significant relationships were found, indicating this bias against high risk portfolios. Lee(48) attempts to identify the correct specification of the risk/return relationship as far as linearity is concerned. He finds significant non-linearity. As Francis and Archer(34,Ch.8) explains, violation of the lending and borrowing assumption at risk-free rates leads to non-linearity and the observed bias. Black et al(6) proposed one (of many) possible modified formulation of the CAPM which relaxes the risk-free asset assumption and which explains the observed bias against high risk portfolios.

IV. USEFULNESS OF CAPM RISK-ADJUSTED PERFORMANCE MEASURES

The above results, combined with the rapid deterioration of the theory when some of its assumptions are relaxed, are sufficient to at least make the CAPM an unknown quantity, and probably to render it useless as an explicit, reliable theory on which risk-adjusted performance measurement may be based. The most important point, the linear trade-off between risk and return, is one of the hypotheses which is in greatest doubt.

However, as section V of the previous chapter aimed to show, the concepts of the CAPM can be useful even if the explicit theory is ignored and the interpretation of an average risk/return relationship is used. Therefore, if risk-adjusted performance measures are to be useful, they must rely on the average relationship concept. For any relationship to be useful however, it must enjoy a reasonable fit to the data. The fits which have been obtained in past studies of various types of funds are examined below.

IV.1 FIT OF AVERAGE RISK/RETURN RELATIONSHIP

All the U.S. studies of mutual fund performance, and some studies of the performance of British funds, adopt the same basic approach of fitting a regression line to the observed risks and returns. This fitted line (really an average relationship for the sample of funds) is then taken to be the estimated CML and the risk-adjusted performance measures of section I derived from its estimated parameters.

While American studies seem to enjoy good fits of the theory to their data,[1] some British studies have been less fortunate. A study (57,p37) of U.K. Unit Trust performance over the years 1966 - 75 involving 86 trusts concluded

> " .... there appeared to be no systematic relationship of beta to return; the trusts lie scattered haphazardly across the risk-return space."

The same study also found considerable non-stationarity of the observed beta values over time.

The most important thing to note about most of the fitted average risk/return relationships is that they have related to

---

1: Sharpe(70) achieved an average R^2 of the fitted relationship of $\tilde{R}_p = \hat{\alpha}_p + \hat{\beta}_p \tilde{R}_m$ of 88%. Jensen(42) achieved an average of 87%.

the equity market only. This is a fair assumption in the case of mutual funds and unit trusts who stay within this market except for liquidity needs. The application of risk-adjusted measures to pension funds could not restrict itself to an equity index in view of those fund's wider diversification into gilts, debentures and overseas assets.[1] The use of risk-adjusted measures with a composite market index is practically unrecorded in the literature. There is conflicting evidence about the sensitivity of the method to the type of index used. Friend et al(35) find that results can be sensitive to the type of index used, while Miller and Scholes (54) seem to imply that results are insenstive to the index used.

IV.2 STATIONARITY OF BETA VALUES

All three measures of risk-adjusted performance depend for their validity on the assumed stationarity of a portfolio's β over the time period of the study. This may involve the assumption of constancy over a period of anything from 2 to 10 years, depending upon the differencing interval used to calculate returns.

But to assume that fund managers do maintain constant betas goes against common sense, particularly for very widely diversified funds. There is some evidence for the stationarity of the betas of U.S. mutual funds, but mutual funds are different from pension funds. They are marketed according to a set of objectives (growth/income/balanced etc.) and so purposely adopt a certain risk exposure consistent with these objectives[2].

One of the things a pension fund manager is paid to do however is to adjust the profile of his fund in accordance with anticipated trends in the various sectors of the market. (i.e., indulge in "market timing" or "Strategic moves" in the

---

1: The resulting dilemmas of an attempt to do so are well illustrated by Beebower and Bergstrom(4).

2: See, for example, McDonald(51).

language of Chapter 5). These adjustments would almost certainly alter the beta value of the portfolio.

Sharpe(71,p461) has shown that the average risk/return relationship when market timing is operative can become non-linear. The fitting of a line in such cases could only lead to uncertain results.

IV.3 BIAS AGAINST HIGH-RISK PORTFOLIOS

It has already been mentioned that non-linearity in the basic risk/return relationship can produce bias against high-risk portfolios. Friend and Blume(35,p168) have confirmed that this bias exists by establishing significant relationships between the risk-adjusted performance measures of various portfolios and the risk measures of the corresponding portfolios. They conclude:

> "The Sharpe, Jensen and Treynor one-parameter measures of portfolio performance based on (CAPM) theory seem to yield seriously biased estimates of performance, with the magnitude of the bias related to portfolio risk. Thus the numerous studies of mutual fund performance based on these one-parameter measures are suspect, especially when they attempt to appraise individual portfolios, or when the average risk differs from that of the market as a whole ....
>
> .... it is probably preferable at the present state of knowledge to use the traditional two parameters - rate of return and risk - to measure portfolio performance, in preference to the more elegant but also more dangerous one-parameter measures, since in the former it is not necessary to stipulate an explicit functional relationship between risk and return."

IV.4 CONCLUSION

Although the evidence taken as a whole is inconclusive, it has been attempted to show above that the theory on which risk adjusted measures are based is at best very uncertain and certainly unproven in its validity. Further, it has been argued that even if estimated linear risk/return relationships

are taken at their face value to be representative of average relationships quite apart from any CAPM, the use of such relations to justify risk-adjusted performance measures would be dangerous. Their fit for an individual portfolio is not always guaranteed and they fly in the face of common knowledge of pension fund practice in terms of constancy of beta values. Further, if the CAPM is in error at all, it is probably in its assumption of linearity, the very quality on which all risk-adjusted measures are so crucially dependent for their validity.

It is this sort of evidence and logic which has prevented the widespread use of risk-adjusted measures.

> "While most academics, intrigued with the implications of capital market theory, attempt to compare 'risk-adjusted' results, this is not often true in the business world. Practitioners generally point to some of the unrealistic assumptions of capital market theory and to the limitations of volatility measures."[1]

V. COMPONENTS OF PERFORMANCE AS RISK-ADJUSTED MEASURES OF PERFORMANCE

Fama(28) outlines methods by which the CAPM may be used to decompose total return in excess of the risk-free rate into various components which reflect the role of differences in risk levels in determining total return. This section aims to show that some of these components and others like them correspond exactly to the components of performance described in Chapter 5 with only one change of concept. This has the important implication that, through performance analysis, risk is indirectly measured and performance indirectly adjusted for risk. Neither the academic or professional literature has recognised this link. It implies that the basic ideas of risk adjustment according to the CAPM have been unwittingly utilised for some time.

1: Dietz(18,p6)

V.1 FAMA'S CAPM DECOMPOSITION OF PERFORMANCE

Fama(28) uses the CAPM to decompose performance as shown below and as illustrated in Figure 8.9. The notation used here differs from that of (28) in order to facilitate later comparisons.

Fama's basic idea was to use the CML to simulate the returns on relevant notional portfolios. This is a very similar concept to the use of notional portfolios simulated via indices, except that the CAPM, questions of its validity aside, simulates the notional returns far more easily. Although Fama suggested several decompositions, the one of interest here is derived from the following notional portfolios:

1. A notional portfolio which has exactly the same level of systematic risk, β_a as the actual portfolio. This has return (according to the theoretical CML) $r(\beta_a)$.

2. A notional portfolio which has a level of <u>systematic</u> risk equivalent to the level of <u>total</u> risk of the actual portfolio.

   This notional portfolio will have a β equivalent to σ, the standard deviation of the actual fund's return. It earns a return of $r(\sigma)$.

3. A notional portfolio which has systematic risk equal to some target level, β_p, which is set according to the investor's basic policy of investment. The return on this is $r(\beta_p)$.

4. A notional portfolio consisting entirely of the risk-free asset, earning a return of R_f.

Fama uses these notional portfolios to decompose the excess return earned by a portfolio over the risk-free ROR:

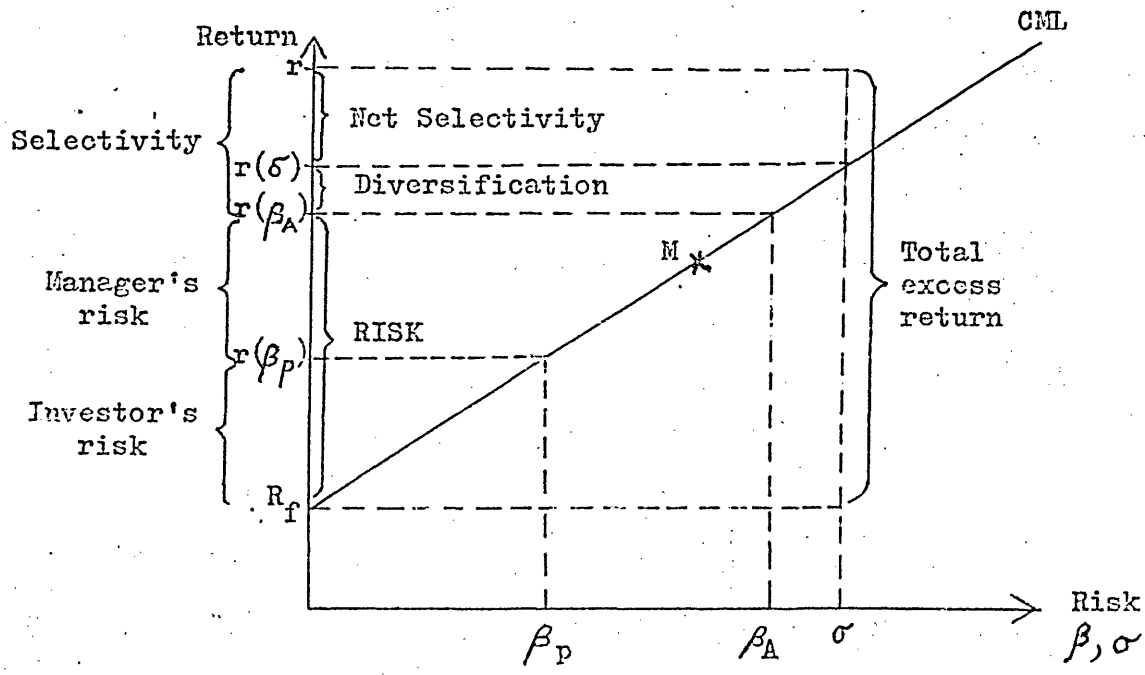


FIGURE 8.9

Fama's CAPM decomposition of total excess return over riskless rate:

Excess return = Investor's risk + Manager's risk + Diversification + Net selectivity

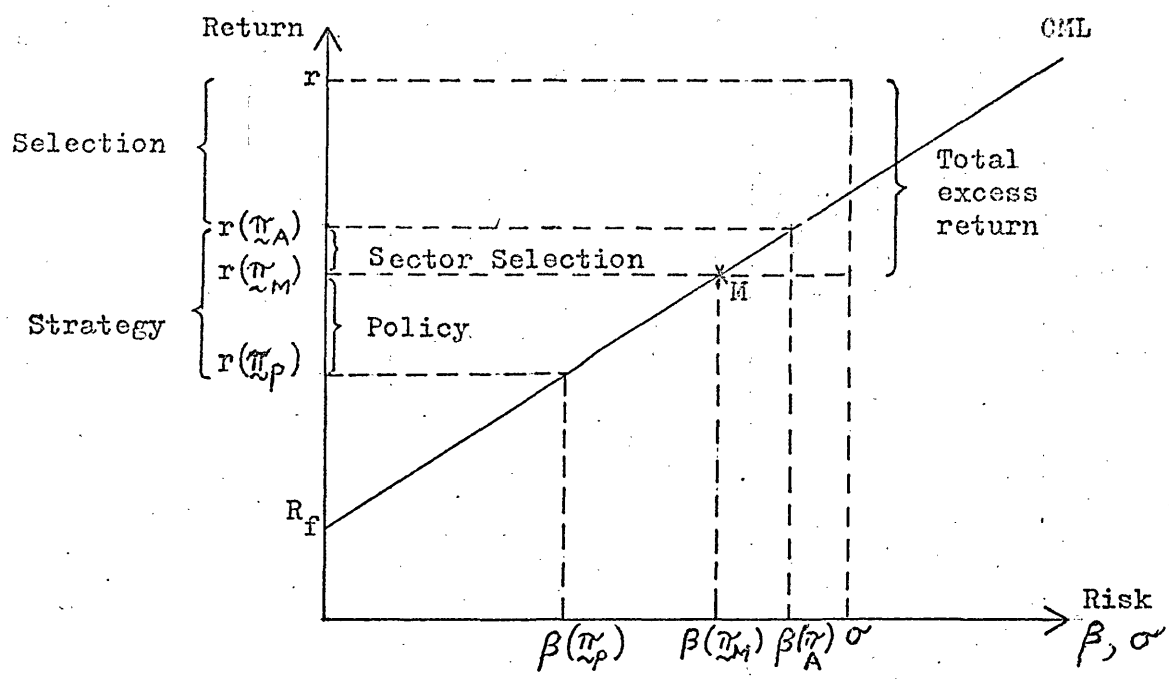


FIGURE 8.10

Additive decomposition system with model fund primary reference point

Excess return = Policy + Strategy + Selection

$$\underbrace{r - R_f}_{\text{Excess return}} = \underbrace{r - r(\beta_a)}_{\text{Selectivity}} + \underbrace{\underbrace{r(\beta_a) - r(\beta_p)}_{\text{Manager's Risk}} + \underbrace{r(\beta_p) - R_f}_{\text{Investor's Risk}}}_{\text{Risk}} \quad -(8.12)$$

He then goes on to consider other components, as follows:

1. Selectivity is a combination of two factors:

$$\underbrace{r - r(\beta_a)}_{\text{Selectivity}} = \underbrace{r - r(\sigma)}_{\text{Net Selectivity}} + \underbrace{\left| r(\sigma) - r(\beta_a) \right|}_{\text{Diversification}} \quad -(8.13)$$

"Net Selectivity" is the vertical distance of the fund's actual ROR from the CML, which gives what it should have earned given its <u>total</u> level of risk, σ. "Diversification" is the return earned in addition to Net Selectivity due to the fact that total portfolio risk was greater than it needed to be if it were perfectly diversified (given by its systematic risk level, β_a). Diversification measures the extra return earned because the portfolio's resources were concentrated in a few prospective high yielding securities rather than spread efficiently over all opportunities so as to diversify away all non-systematic risk.

2. He defines a component called "Risk":

$$\underbrace{r(\beta_a) - R_f}_{\text{Risk}} = \underbrace{r(\beta_a) - r(\beta_p)}_{\text{Manager's Risk}} + \underbrace{r(\beta_p) - R_f}_{\text{Investor's Risk}} \quad -(8.14)$$

Risk is the return earned through the assumption of the amount of systematic risk in the portfolio, β_a. This is made up of Investor's Risk and Manager's Risk, which is the added return on top of Investor's

Risk which is due to the Manager's incorporation of extra risk into the portfolio in excess of what his client, the Investor, wished.

3. Fama suggests an alternative decomposition of Risk as follows:

$$\underbrace{r(\beta_a) - R_f}_{\text{Risk}} = \underbrace{r(\beta_a) - E\left[r(\beta_a)\right]}_{\text{Total Timing}} + \underbrace{E\left[r(\beta_a)\right] - E\left[r(\beta_p)\right]}_{\text{Manager's Expected Risk}}$$

$$+ \underbrace{E\left[r(\beta_p)\right] - R_f}_{\text{Investor's Expected Risk}}$$

where $E\left[r(\beta_a)\right]$ is the expected return from the actual portfolio using the ex-ante CML relationship. That is, it is the return which would be expected to be earned on the portfolio if market return was as expected, instead of being what it actually turned out to be.

and where $E\left[r(\beta_p)\right]$ is the expected return from the Investor's desired level of risk given the expected market returns.

Fama himself acknowledges (28,p555) that the practical application of these decompositions is likely to be difficult, given the failings of the CAPM theory on which they are based and the numerous measurement problems associated with risk. The following section shows however that direct analogies to these components can be easily and practically developed using normal market indices with no direct reference to or dependence on the CAPM itself.

V.2 EQUIVALENCE OF ADDITIVE DYNAMIC PORTFOLIO DECOMPOSITIONS OF PERFORMANCE

Holbrook(41,p23) was the first to recognise the

similarity of Fama's decomposition to his own multiplicative decompostion system. He saw the broad similarities as follows:

$$\frac{1 + r}{1 + r(\pi_m)} = \frac{1 + r(\pi_p)}{1 + r(\pi_m)} \times \frac{1 + r(\pi_a)}{1 + r(\pi_p)} \times \frac{1 + r}{1 + r(\pi_a)} \quad - (6.1) \text{ repeated}$$

Excess return	=	Investor's Risk	x	Manager's Risk	x (Net Selectivity and Diversification)

and the differences as:

1. A multiplicative structure

2. Diversification and Selectivity are merged into the one component.

3. $r(\beta_p)$ depends on the trustee's specification of a target risk level, whereas its analogy here, $r(\pi_p)$ is determined by their specification of sector proportions.

4. The return on the model fund, $r(\pi_m)$ is substituted for the riskless ROR.

It will be argued that all of these differences can be either overcome or justified to produce an end result of complete equivalence. With respect to the first two points above, Chapter 5 has already shown the equivalence of dynamic additive and multiplicative systems of components, while V.3 of this chapter will show that Diversification can, at least in theory, be quantified by conventional component analysis. In any case, it will be argued that ignorance of Diversification is equivalent to the already common practice of using only the systematic risk (as opposed to the total) risk of a portfolio with which to adjust performance. The following two sub-sections consider the remaining points above.

V. 2.1. SECTOR PROPORTIONS DETERMINE MOST OF PORTFOLIO RISK

Holbrook's observation that the choice of sector proportions and choice of β are different processes is not necessarily true. If it can be assumed that a portfolio's holdings are perfectly diversified within each sector of the market (so that each sector return is perfectly correlated with the corresponding market return), then the choice of sector proportions for that portfolio automatically determines its β value. If the sth sector has weight by market value w_s and risk measure β_s, then total fund volatility will be

$$\beta a = \sum_{s=1}^{S} w_s \beta_s \qquad - (8.16)$$

Further, the fund representing trustee policy, or any other notional fund, will have its risk level determined solely by the sector decisions represented by w_s, since the fund is perfectly diversified in each sector through its use of market indices to represent sector returns.

The logic that it is decisions about the profile of a fund which determine its basic risk exposure is intuitively present in the minds of practising investment personnel. The fund managers involved in this study insisted that one could not properly compare the return of a fund wholly invested in equities with that of another fund spread more evenly across gilts, equities, debentures and cash etc. The reason given was that the former fund was riskier, being totally exposed to the equity market.

V. 2.2. MODEL FUND AS PRIMARY REFERENCE POINT

The use of the model fund as the basic benchmark against which achieved return is measured, rather than the riskless rate, can be justified on several grounds:

1. Riskless rate is only relevant if CAPM theory is valid.

The improbability of the theory's validity renders the relevance of a riskless asset dubious. Section II suggested that no truly riskless asset exists.

2. Managers have got to compete more with the market (or average) ROR than with the riskless rate.

3. The model fund, if constructed properly in order to reflect the average pension fund's alignment between sectors, can be regarded as possessing the "market" ROR as far as pension fund investors are concerned.

Appendix 5-I shows that a model fund profile calculated from UK government statistics is an adequate representation of the market as far as pension funds are concerned.

VI. THE EQUIVALENT COMPONENTS

The equivalence of conventional components of performance to both Fama's CAPM decomposition and risk-adjusted performance measurement may be seen in either graphical or algebraic terms.

VI.1. GRAPHICALLY

Figure 8.10 shows the CAPM interpretation of the additive dynamic portfolio decomposition shown in Table 5.5. $\beta(\pi_p)$ is the beta value of the notional fund used to simulate trustee policy. Similarly, $\beta(\pi_a)$ is the beta value of the simulated actual fund, while $\beta(\pi_m)$ is, by definition, unity. The two sets of components match as follows:

Selectivity	=	Selection
Manager's Risk	=	Strategy
Investor's Risk	≡	Policy
Risk	≡	Sector Selection

The correspondence in nomenclature is intuitively appealing. The return on a trustee policy fund is entirely due to the risk level of that fund as embodied in the trustee's (who are the investors on behalf of the beneficiaries) profile decision. Similarly, Manager's Risk is the return from the difference in risk between the manager's sector strategy and the trustee's policy. Total Risk is determined by total Sector Selection.

The major difference between the two decompositions concerns Selection. True Selection according to the CAPM is Net Selectivity, since the complete risk of a fund is measured by its total risk. The Selection component in the conventional analysis however measures the increased return due to both Net Selectivity and Diversification. In interpreting Selection therefore, one must either accept the compounding with Diversification or assume that the fund is perfectly diversified anyway. As I.1 of this chapter indicated, this assumption is made even by the CAPM's own risk-adjusted measure of Selection. Jensen's α is the vertical distance of actual return from the CML based on systematic risk, β_a (refer figure 8.2)). Hence α is equivalent to Selectivity and ignores Diversification.

It is at least theoretically possible to derive a component of performance based on index simulation which does measure Diversification. Suppose that a fund is not perfectly diversified in its equity sector because the manager considers that the only parts of the equity market worth investing in are the Capital Goods and Oil Sectors. Then, using the logic of XII.4, Ch.5, a notional fund may be created which uses an index to represent the equity sector which is based only on these two sub-sectors. The difference between the return on this fund and the return on the simulated actual fund (which used an index of the whole equity market to represent the equity sector) will yield a Diversification component of performance. Net Selectivity is

then the difference between Diversification and Selection.[1] The Diversification component will reflect the added systematic risk present in the actual fund due to the distribution of its equity holdings amongst industries differing from the distribution implied by the complete equity index used to derive $\beta(\pi_a)$.

Analogies can be drawn to some others of Fama's components with some further modifications of associated concepts. For example, Fama's expected returns in (8.15) are generated through the role of expected market return according to the CAPM theory in determining expected fund return. A parallel concept which is of more interest to fund managers is the return which would have been obtained if the fund's risk were not altered, but kept at $\beta(\pi_b)$, instead of being adjusted during the review period to $\beta(\pi_a)$. In a sense, $\beta(\pi_b)$ is the risk which can be expected to exist in the portfolio before the review period begins. Thus, treating $E[r(\beta_b)]$ as $\beta(\pi_b)$ and $E[r(\beta_p)]$ as $\beta(\pi_p)$, (8.15) becomes

$$r(\pi_a) - R_f = r(\pi_a) - r(\pi_b) + r(\pi_b) - R_f \qquad - (8.17)$$

which is directly analogous to the Subsequent and Initial Strategy components outlined in XII.3, Ch. 5.

VI. 2. ALGEBRAICALLY

The following returns based on notional portfolios have the following equivalents in CAPM terms:

1: If the equity sector constitutes the majority of a fund, it may be worth it in terms of greater accuracy in the representation of the actual fund's systematic risk level to simulate the equity sector of that fund not with just the All-Share Index, but with a weighted combination of industry indices, where the weights refer to the weightings of the industries in the actual fund (rather than in the index). By doing so, one would also be allowing for any additional systematic risk which existed <u>within</u> the equity sector due to a difference in the fund's weightings of sub-sectors from the weightings implied by the index used to represent the equity sector. This was not done in this study and the possible gain in accuracy is unknown.

$$r(\pi_a) = R_f + \beta(\pi_a)\ (R_m - R_f)$$

$$r(\pi_b) = R_f + \beta(\pi_b)\ (R_m - R_f)$$

$$r(\pi_p) = R_f + \beta(\pi_p)\ (R_m - R_f)$$

$$r(\pi_m) = R_f + \beta(\pi_m)\ (R_m - R_f)$$

$$= R_m \text{ since } (\beta_m) = 1 \text{ by definition.}$$

Thus the additive System I in Table 6.4, the equivalent of which in terms of MWRs is

$$r - r(\pi_m) = r - r(\pi_a) + r(\pi_a) - r(\pi_b) + r(\pi_b) - r(\pi_a) + r(\pi_p) - r(\pi_m) \qquad - (8.18)$$

may be expressed in CAPM terms as:

$$\underbrace{\frac{r - R_m}{R_m - R_f}}_{\text{Excess return}} = \underbrace{\frac{r - R_f}{R_m - R_f} - \beta(\pi_a)}_{\text{Selection}} + \underbrace{\beta(\pi_a) - \beta(\pi_b)}_{\text{Subsequent Strategy}}$$

$$+ \underbrace{\beta(\pi_b) - \beta(\pi_p)}_{\text{Initial Strategy}} + \underbrace{\beta(\pi_p) - \beta(\pi_m)}_{\text{Policy}} \qquad - (8.19)$$

This equation reveals the components as a means of adjusting performance for risk. Consider the simpler form of (8.19) obtained by aggregating the last three components into a total Sector Selection component.

$$\underbrace{\frac{r - R_m}{R_m - R_f}}_{\substack{\text{Excess}\\ \text{return as}\\ \text{proportion}\\ \text{of market}\\ \text{return for}\\ \text{risk}}} = \underbrace{\frac{r - R_f}{R_m - R_f} - \beta(\pi_a)}_{\substack{\text{Excess return}\\ \text{over the market}\\ \text{at constant}\\ \text{risk}}} + \underbrace{\beta(\pi_a) - 1}_{\substack{\text{Return from}\\ \text{excess risk}\\ \text{over the}\\ \text{market}}} \qquad - (8.20)$$

To the extent that the fund's reward for its riskiness $r - R_f$, exceeds the market's reward for its riskiness, $R_m - R_f$, by more than the factor $\beta(\pi_a)$ expected by the CAPM, the fund has exhibited superior Selection. The remainder of the fund's return for risk relative to that of the market is due to its different risk position. This remainder is quantified by the second difference in (8.20).

Therefore it appears that Selection is as much of a risk-adjusted performance measure as any of the three theoretical measures derived directly from the CAPM. A comparison of figures 8.7 and 8.2 will confirm that it is the direct analogy of Jensen's α statistic.

VI.3 ADVANTAGE OF SELECTION COMPONENT AS A RISK-ADJUSTED MEASURE

Components derived from index simulation are not dependent at all on any of the assumptions behind the CAPM, especially the linearity of the risk/return relationship. Figure 8.11 illustrates one possible relationship between risk and return which could exist. It would represent the locus[1] of points generated by an infinite number of notional portfolios $V(\pi)$, each with parameters $r(\pi)$ and $\beta(\pi)$. As the figure shows,

---

1: When π involves more than two sectors, it is possible that more than one specific value of π will yield the same point $(r(\pi), \beta(\pi))$, or that a given risk measure can be associated with more than one return. This multidimensional aspect is ignored in this explanation for simplicity.

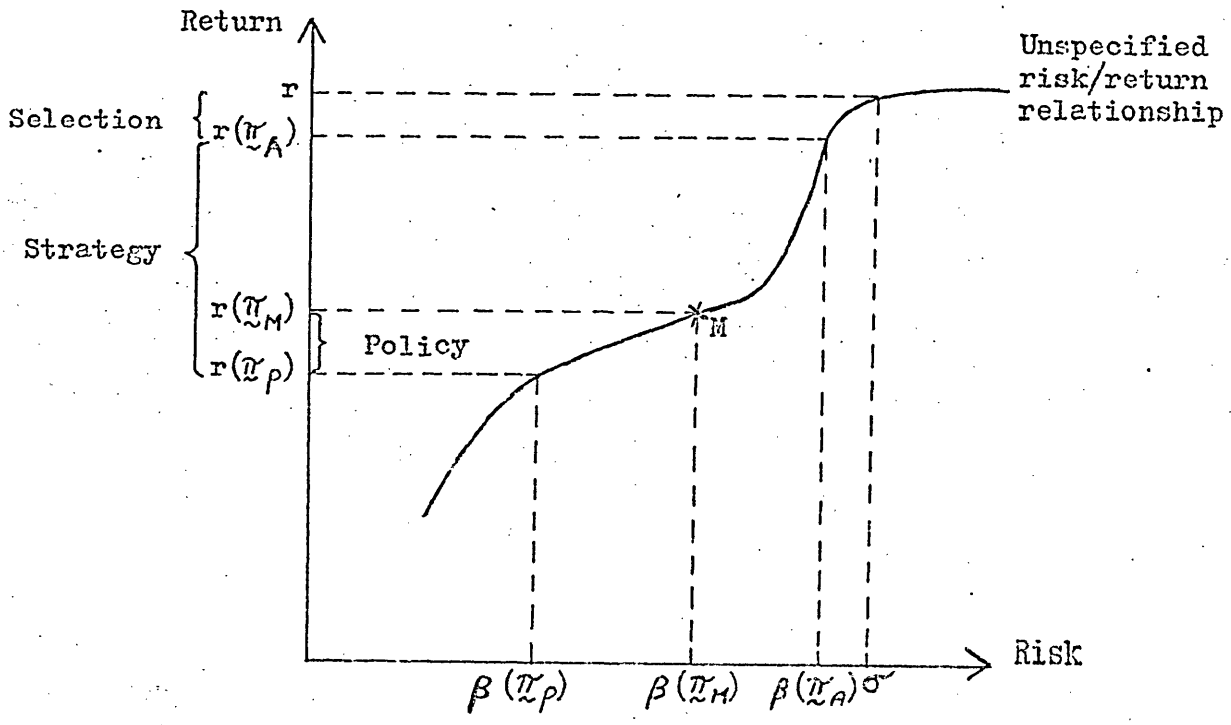


FIGURE 8.11

Decomposition of performance using index simulation with an unspecified risk/return relationship.

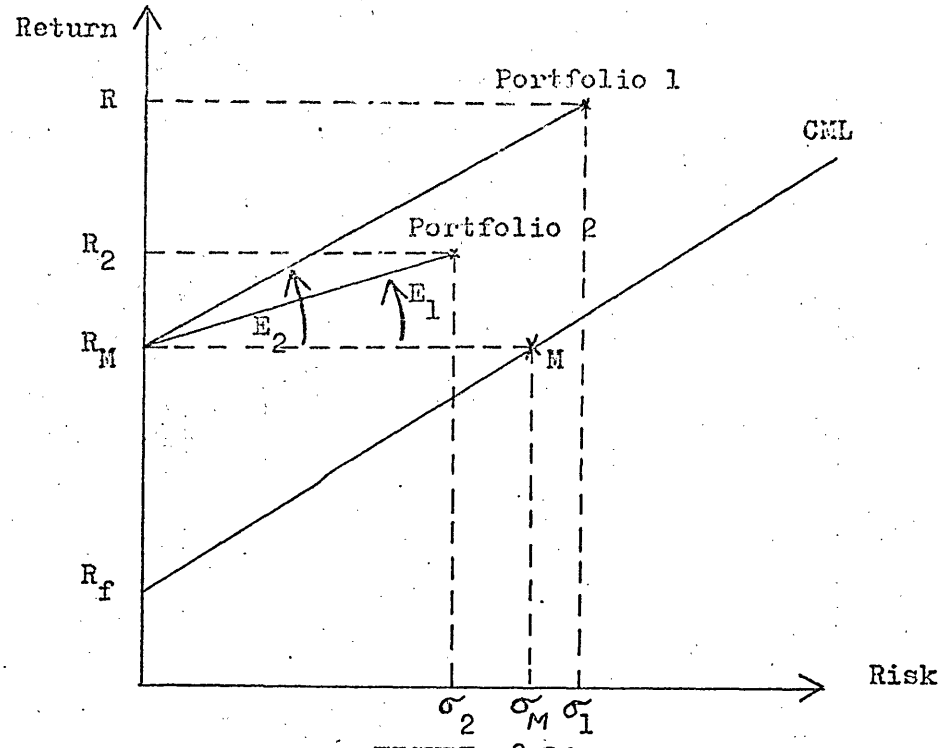


FIGURE 8.12

Graphical representation according to CAPM theory of the risk adjusted measure $E = \frac{R - R_m}{\sigma}$

the sizes of the components have altered drastically relative to their sizes under an assumption of a linear CML. The great advantage of the index simulation method is however that to derive a risk-adjusted performance measure for a fund, it is not necessary to simulate all these portfolios, but only the one portfolio corresponding to the point ($r(\pi_a), \beta(\pi_a)$) in figure 8.11.

Thus the approach to risk adjustment described in this Chapter has the following advantages over any measure based on the CAPM:

1. Even if there is a stable relationship between risk and return in the market, its precise form does not have to assumed.

2. The risk/return relationship can take any form with no effect on the validity of the risk-adjusted measure.

3. Selection as a risk-adjusted measure makes no assumptions about stationarity of the risk/return relationship in the market over past review periods.

   It estimates points on the risk/return relationship as it existed for the current review period alone.

4. Similarly, it makes no assumption about the stationarity of the portfolio's β value over past periods.

5. As a practical matter, no historical data is required to implement the analysis.

All these constitute a considerable improvement on the apparent fragility of existing risk-adjusted performance measures based on the CAPM.

VII. RISK-ADJUSTED PERFORMANCE MEASURES USED IN THIS STUDY

For the reasons outlined in the previous sections, any measure based directly on the CAPM was considered to be totally impractical. Instead, three indications of risk were relied upon:

1. The Selection component of performance

2. The provision of risk measures pertaining to both the fund and the market

3. A crude but simple measure of fund risk relative to market risk.

The Selection component, although probably the best of the three approaches is not high-lighted as a risk-adjusted measure by the software developed. The reason was that it was judged to be a probable cause of confusion if it were to be billed as such. To explain why it was a risk-adjusted measure would require at least some allusions to the CAPM concept of a risk/return relationship. This was considered not to be worthwhile in terms of the benefit to be gained and the possible damage of resulting confusion. In addition, as Chapter 13 will argue, risk-adjusted performance is not the ultimate measure of a manager's performance, as he is also paid to adjust the portfolio to the right level of risk to suit the right market conditions at the right time.

The MAD measure of risk is provided for the total fund plus each sector on a percentage per annum basis. The MAD for market return as well as fund return is quoted and the ratio of the two is given as a measure of fund risk relative to the market. This ratio at least allows the identification of whether the fund is more risky or less risky than the market (on a total risk basis). The user can then, if he so chooses, weigh the excess return against excess risk in his own mind according to his subjective trade-off between the two.

VII.1 MODIFIED REWARD TO VARIABILITY RATIO

Continuing the logic that market ROR is the logical benchmark of performance as far as fund managers are concerned, the risk-adjusted statistic

$$E = \frac{r - R_m}{MAD} \qquad - (8.21)$$

was considered but rejected. It is a modification of Sharpe's reward to varibility ratio, being excess return over the market divided by a measure of the total risk of the fund. It could be used in a similar fashion to Sharpe's measure, as shown in figure 8.12, where portfolio 1 is shown as the better performer.

The measure is intuitively appealing because, of two funds with equal excess return over the market, the fund which took the lower risk to earn that excess is ranked as a better performer. E is also independent of any risk-free rate.

E was not built into the software developed in this study however because of the uncertainty of its usefulness due to its implict dependence on an assumed linear risk/return relationship.

PART D

SPECIFICATION AND USE OF THE SOFTWARE PACKAGE

CHAPTER NINE

INDICES

This is the first of 5 chapters which aim to explain the problems encountered, and the methods used, in the development of a collection of computer coding designed to provide a comprehensive measurement and analysis of pension fund performance along the lines indicated in previous chapters. The next chapter outlines the input required by the system, while Chapter 11 specifies the various computer routines involved. Chapters 12 and 13 illustrate the products of these routines.

This chapter examines the availability of indices to describe each of the market sectors relevant to U.K. pension funds. The problem of combining these into notional portfolios is also discussed.

I. FACTORS AFFECTING CHOICE OF AN INDEX

Given that an index must represent the opportunities for a pension fund in a certain sector of the market, the following factors determine its suitability for performance measurement purposes.

1. Frequency of publication

2. Accuracy

   Accuracy is a function of three main qualities of an index:

(i) Its coverage. i.e., how widely based it is.

(ii) Its structure. This is how it combines the various representative security prices making up the index. Indices can be either arithmetic weighted averages or geometric weighted averages. Rose (66) and Latané et al (47) show that geometric indices understate share price changes relative to arithmetic indices, and hence are not as suitable for performance assessment purposes.

(iii) Consistency. That is, how it copes with additions to and subtractions from the market while maintaining a consistent series of values.

3. Acceptability

This is a subjective factor which should ideally be a function of the above two factors. But sometimes an index can be obviously lacking in one or both of the above factors yet become a generally accepted standard of performance. This appears to have happened, for example, with the use of the 7 day Local Authority rate as an index of return available in the cash sector.

Conversely, as mentioned in Chapter 6, an index can be near perfect but useless to performance measurement if it is percieved for some reason by fund managers as being an unfair standard.

Usually the room for choice of an index to represent a sector is not large, except possibly in the equity or overseas sectors. These larger sectors possess two or three alternative indices.

Since it is not the intention of this thesis to delve into the details of the construction of an index, the reader is referred to (30) for an explanation of the mechanics and theory of index series.

II. PROBLEMS OF USING INDICES

Most problems concerning indices which are cited in the literature are concerned with their use rather than the indices themselves.[1] There are two main problems connected with the very existence of an index in a performance measurement system however. These are as follows:

1. The treatment of income

   While an index of capital values can be quite accurate, its associated index of income can be quite poor due to the greater uncertainty of income payments, as in the case of dividends for example.[2]

2. Its effect on management behaviour

   Wilson(86, p13), talking of the American scene, observes:

   > "Pension fund managers tend to use the S & P 500[3] as a kind of amorphous 'approved list' which also does double duty as something of a 'shadow portfolio' ".

   He goes on to argue that managers are particularly sensitive to the top five stocks in the index because these determine a large part of the movement in the very index to which they realise their performance will be compared.

1: Cocks(12), for example, complains of their inability to assess timing effects. Nursaw(59) complains that they do not allow for dealing costs and Palmer(61) objects to their bias against funds during bull markets.

2: The quality of an income index is an issue quite separate from how the simulated income should be re-invested in the index. This is considered in Chapter 11.

3: Standard and Poors Composite index of the New York Stock Exchange, analogous to the FTA All-Share Index.

Both of these problems are facts of life with which practical performance measurement must live. While the effect of the second problem may be negligible (since most large pension funds have to invest in the largest stocks anyway), the poor quality of some income indices must always be borne in mind.

III. AVAILABLE SECTOR INDICES

III. 1 U.K. EQUITIES

The easily most well-recognised and generally accepted indices are those published by the Financial Times, of which there are two. The F.T. Ordinary Index is comprised of the top 30 shares on the London Stock Exchange and as such is primarily designed for quick and frequent calculation. A more broadly based index is the F.T.-Actuaries All-Share Index. This is a very large index of shares consisting of the following three basic tiers, each tier being represented by its own index.

1. The Industrial Share Index

   This is in turn divided into sub - indices representing sectors of the economy (Capital Goods, Consumer Goods - Durable, Consumer Goods - Nondurable, and other miscellaneous groups). Each of these groups can in turn be sub-divided into finer groups according to type of product.

2. The 500 Share Index

   This is simply the Industrial Share Index, consisting of 497 representative shares, plus 3 oil shares which were taken out in 1971 because of there heavy effect on the overall Industrial Index.

3. Financial Group Index

   The financial sector is represented by this index, ranging from Banks to Property.

All three indices are combined (with appropriate weighting) to produce the All-Share Index.

A detailed discussion of the pros and cons of the All-Share Index is fruitless since as a practical matter is is undoubtedly the best available. Its advantages over its companion Ordinary Index are worth noting however:

1. Greater Accuracy

   This is derived from both a greater coverage and its arithmetic rather than geometric structure.

2. Greater potential for analysis of equity performance

   The existence of sub-indices for sectors facilitates the analysis of strategic decisions within the equity market, as described in XII.5, Ch. 5.

The All-Share Index has been mildy criticised by some writers on two points however:

1. Both Nursaw(59) and Brew(7) express reservations about the quality of the All-Share Dividend yield index.

   This income index is based on both declared dividends and precise forecasts of dividends made by companies. It is thus theoretically possible for the dividends which are actually paid to differ from the index. Holbrook(41, p 11) argues that the resultant error in performance estimates is likely to be insignificant.

2. Its usefulness for detailed performance analysis of the equity sector is inhibited by two problems:

   (i) Short and Brumwell(72) note that some sub-sectors (e.g. Office Equipment) are heavily dominated by one or two shares.

   (ii) The classification of highly diversified companies according to product type is inevitably arbitrary.

All the performance measurement services surveyed by this study used the FTA All-Share Index to set the standard for U.K. equities. This study followed suit.

III.2 BRITISH GOVERNMENT SECURITIES (GILTS)

Selection of an appropriate index to describe the gilt market has, until recently, been a fairly open question, involving a choice between the following alternatives.

1. An index made up of a single, usually subjectively chosen, gilt.

2. An index comprised of several, usually subjectively chosen gilts.

   The constituents were chosen as represenative of different aspects of the gilt market (eg low coupon versus high coupon).

3. An index based on estimates of the yield curve.

   Phillips and Drew, for example, publish indices for short, medium and long-dated stock. A polynomial if fitted to represent the current yeild curve and used to estimate the market yeilds for bonds of 3, 10 and 25 year durations. These yields are then converted to prices using standard DCF methods after the assumption of a 12% coupon.

4. The Financial Times Government Securities Index

   Its fifty year old base date makes this index's relevance almost nil.

5. The Financial Times - Actuaries 20 year Government Stocks Index

   Until recently, this was probably the most accurate published gilt index even though it only represents the long end of the market. It is derived from an index yield calculated from a

complicated weighted average of six stocks, when the weights force the average term to 20 years. The index yield is transformed to a price with the use of a 4% coupon assumption.

III.2.1. F.T.A. BRITISH GOVERNMENT SECURITIES INDEX

A discussion of the relative advantages and disadvantages of the above options is made irrelevant by the recent introduction of the Financial Times - Actuaries British Government Securities index. This index is best described as the direct analogy of the FTA All-Share index but applied to the gilt market. Its objectives have been described (19, p9) as the following:

> " The first objective of fixed interest indices is to provide a description of the level and possibly also the shape of the yield structure at any one time .... A second major objective of fixed interest indices is therefore to provide a standard against which the 'portfolio performance' of investors in the fixed interest market can be measured."

A gilt price index is constructed in much the same way as the FTA All-Share index. That is, it is an arithmetic average, weighted by market value. An associated yield index is calculated independently from prices, and used with the price index to obtain estimates of income earned on the index. Gilts are classified according to low/medium/high coupon and according to three classes of term-to-maturity. Within each coupon class, a curve is fitted and the yield index determined from this. Price indices and income indices are quoted on an All-Share basis and in addition separate such indices are quoted for four classes of term-to-maturity.

Experience with the index is as yet too small to provide an unqualified verdict on its merits. It has been calculated on a daily basis since its base date of 1/1/1976. Some comments can be made however.

1. The income index should be of a very high quality, since it is based on known yields rather than forecast yields.

2. The All-Share index has extremely wide coverage due to the replicated nature of the gilt market, with many copies of a finite number of types.

3. The extent to which the index can be held as representative of the gilt market as far as pension funds are concerned is less clear than is the case with the All-Share index.

Because there are many other types of institutional investors (eg. banks, discounts houses etc.) in the gilt market with specific maturity requirements different to those of pension funds, there is no assurance that the market value weightings used in the index are equal to the weightings in aggregate pension fund holdings. Pension funds tend to bias their holdings towards high coupon stocks for example.

III.2.2 SUB-INDEX OR ALL-STOCKS INDEX

It is a popular view that since pension funds are primarily invested in stocks which are either or both long-dated and high coupon, that any standard of performance should restrict itself to this sector of the market. It is argued that when it comes to gilts, pension funds have a natural preference for bonds of a "low risk" nature. These are bonds which can provide a high income for an assuredly long period of time. No-one in the literature on performance measurement has openly questioned this reasoning, possibly because the best previously available index was itself a long-dated one. Now that a broadly based index is available, this issue can be reviewed on a practical basis.

On the one hand, there are three arguments in support of restricting a comparison to the long end of the market (since long dated stocks tend to be high coupon ones):

1. The standard of performance should relate to what pension funds actually do, rather than to what they should do (if one believes that a wider spread across the market is what they should do).

2. A closer representation of the market as pension funds see it would be obtained through the use of a long-dated index, making the model fund a more accurate representation of the average return on a U.K. pension fund (Refer Appendix 5-I).

3. If an All-Stocks index were used, it would be too easy for pension funds to beat the market during times of declining interest rates, while its use during times of rising interest rates would be unfair (since long-dated stocks react with greater sensitivity than other stocks to rising rates).

On the other hand, the arguments in favour of an All-Stock index are equally impressive.

1. There is no legal or other type of restriction on pension funds to prevent them from investing in the short end of the market.

2. Investing in the long-dated stocks does not necessarily reduce risk at all. The "interest rate" risk exists of becoming locked into long-dated stocks when interest rates continually rise.

3. A market-wide performance standard would indicate the opportunity losses from pursuing a strategy oriented to only one corner of the market, rather than taking a balanced view. The loss would show in the Selection component for the gilt sector of the fund.

4. It is a fairer measure of performance during interest rate changes. It is neither automatically easy or difficult to beat the index. It is only beaten if the manager correctly anticipated the trend in

interest rates.

The issue, from a technical point of view, involves a conflict between a wish to make the model fund representive of the average return of UK pension funds, and a desire to indicate opportunity losses. It is a good example of a case when average return is not really a "fair" standard of performance in a absolute sense. A possibly higher average return would result if the industry-wide practice of investing mainly in long-dated stocks were modified (refer X.2.3, Ch.5).

For the purpose of analysis of the five funds which were the concern of this study, a market-wide index was used, although the software can easily use any index which it is fed. The wider index was used in an attempt to indicate opportunity losses.

III.2.3 INDEX USED IN THIS STUDY

For the evaluation of funds after the beginning of 1976, the FTA British Govt. Securities index was used. No market-wide index is available for earlier periods, so one was constructed using the three Phillips and Drew Gilt Indices[1]. The indices were combined into a weighted arithmetic average, when the weight for a particular maturity class was the proportion of total market holdings made up by that class. The weights were calculated on the basis of Bank of England figures.[2] The resultant index is a crude one, primarily due to the fact that the Bank of England's figures are nominal values only, while the weights should theoretically be based on market values. As a check, this composite Phillips and Drew index was compared over the years 1976 and 1977 with the FTA All-Stocks index. The resulting series, for both prices and income, are graphed in figures 9.1 and 9.2 respectiviely.

1: As published in their "Gilt Edged Data" Bulletin, last page.

2: Table B "Estimated Distribution of the Sterling National Debt" appearing annually as at the end of March in (2), fourth quarter.

FIGURE 9.1

F.T.A. British Government Securities All-Stocks prices and composite Phillips & Drew income index constructed for this study.

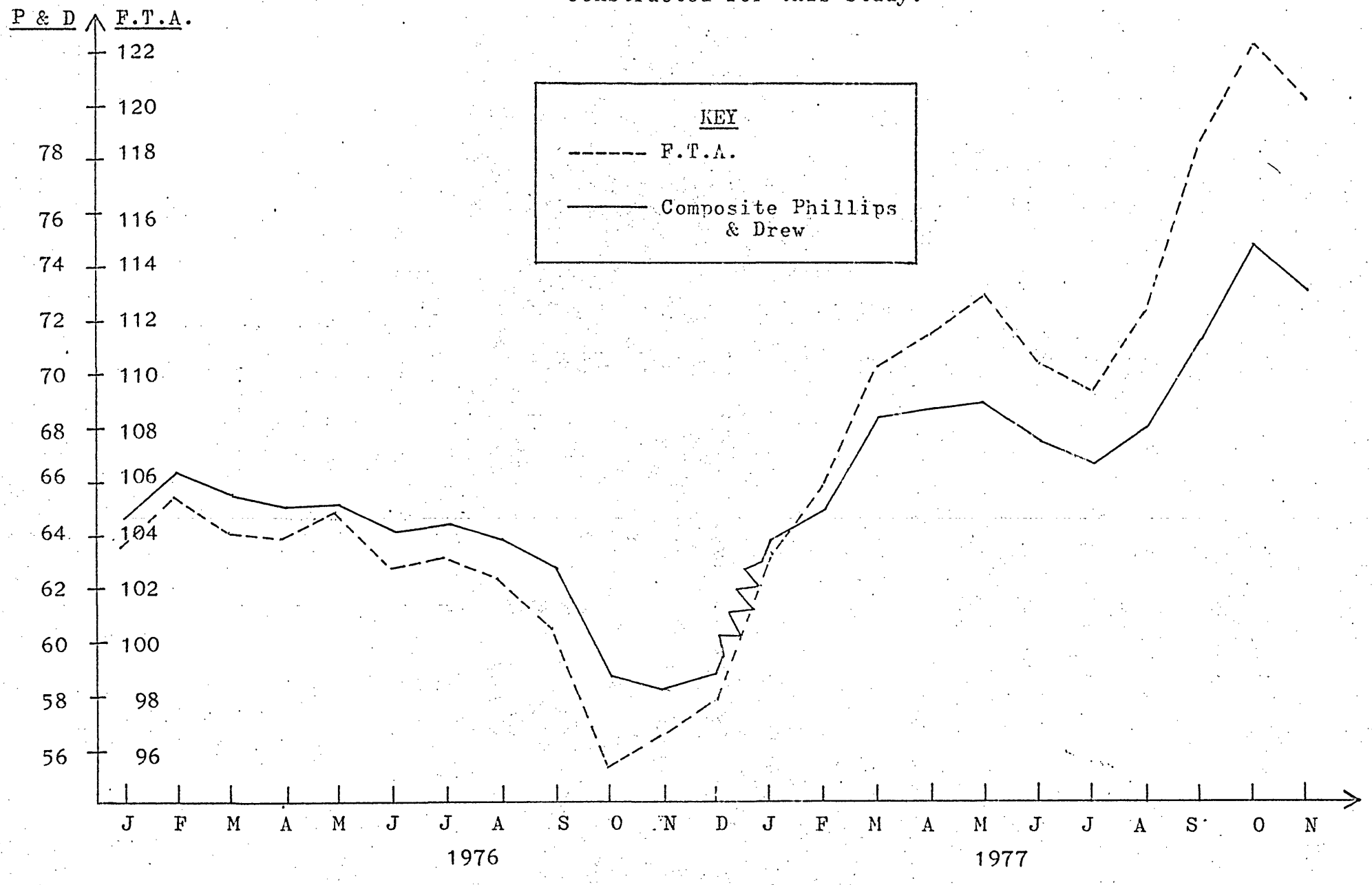
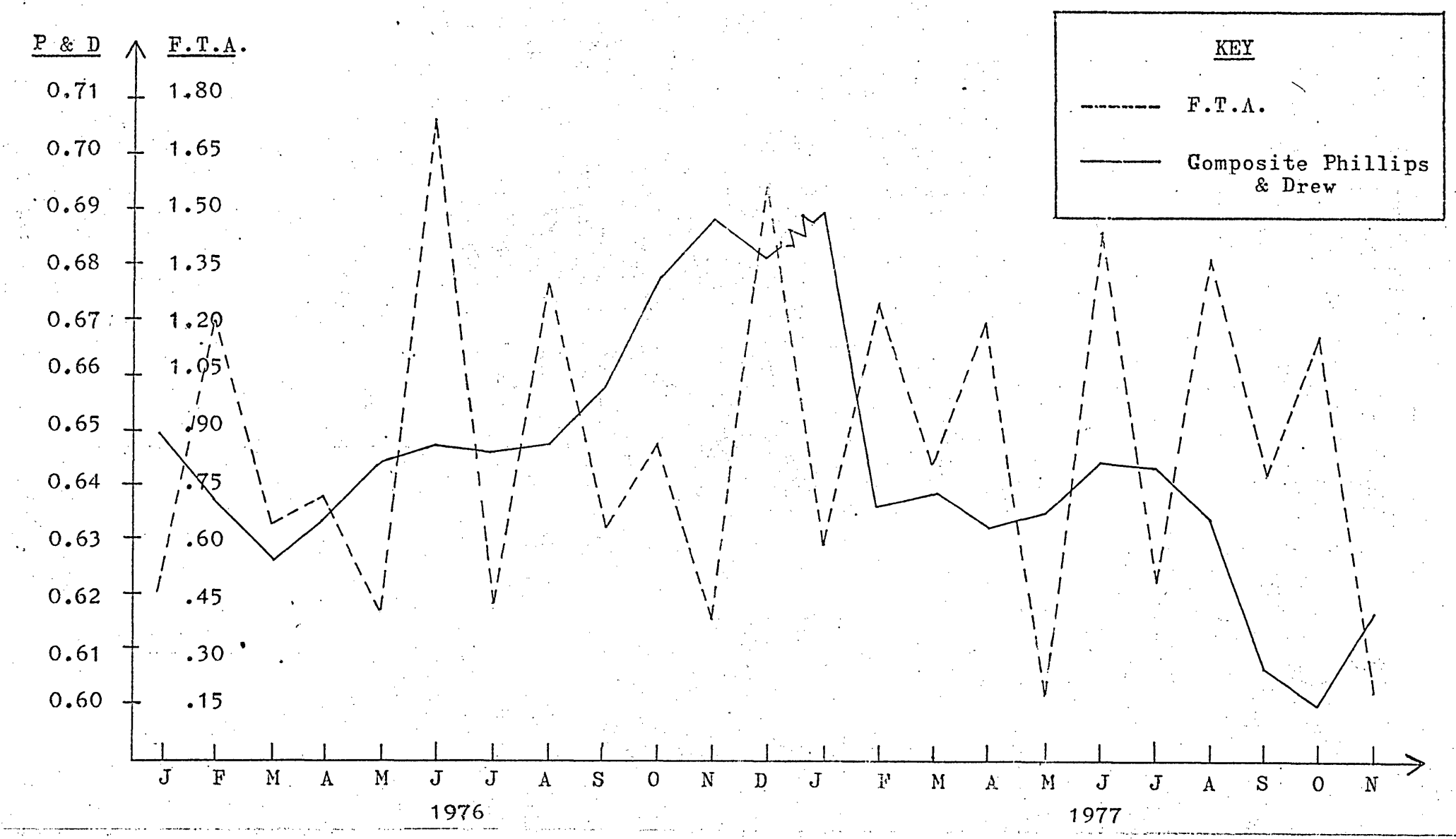


FIGURE 9.2

F.T.A. British Government Securities All Stocks income index and composite Phillips and Drew income index constructed for this study.



Remembering that it is only the change in the index which matters, the price indices are very closely correlated with a co-effecient of 0.93. The income indices are disappointingly less well matched (near zero correlation). Because of the poor correlation on the income side, results strongly affected by gilt income earned before 1976 for the five funds examined in this study must be treated with some caution. Appendix 9-I gives greater detail on how the composite gilt index was created.

III.3 FIXED INTEREST SECURITIES OTHER THAN GILTS

Indices for this sector, comprised mostly of debentures and unsecured loan stocks, are practically non-existent, reflecting the shrinkage in the importance of this sector over the last decade. Probably the most recognised (if not, the only existing) index of this sector is the Financial Times 20 year Redeemable Debentures and Loan Index. It is constructed in much the same way as the 20 year Government Stock Index.

Because this sector comprises only a very small part of most pension funds, any inaccuracy of this index should introduce little error into a performance analysis. Indeed, some measurement services combine a fund's holdings in this sector together with its gilt holdings and assess the total against a gilt index. The sectors were kept separate in this study in order to isolate any error from the gilt sector, to which considerable attention is usually paid. The F.T. index mentioned above was used.

III.4 OVERSEAS SECTOR

In contrast to the previous sector, there is a multiple number of the indices concerning this sector, yet paradoxically no generally correct <u>one</u> index. The problem of course lies in how to combine the indices of all the different countries together into a general index.

The ideal solution would be to use as weights the average distribution of UK pension fund money over all

these sectors and countries. However figures on a country-by-country basis (let alone split by sector) are not published. Existing measurement services adopt one of four approaches:

1. Ignore the overseas sector althogether.

2. Assess overseas investments using the UK equity standard of performance. Eadie(21) recommends this approach. The idea that overseas investments have to beat what one could otherwise obtain at home has intuitive appeal, but unfortunately does not contribute meaningfully to strategic or Policy components in the sense that the overseas markets' return is indistinguishable from the domestic UK markets' return.

3. Use the American Stock Market as representative of the overseas sector.
   This is thought to be the most popular destination of pension fund money invested overseas. Kingston(45) recommends this as probably being a satisfactory measure for most funds.

4. A composite index of overseas equity markets.
   Consultancy C uses a weighted index of the American, EEC and Australian equity market indices with weights of 0.85, 0.10 and 0.05 respectively.

   Questions of the relevance of the weights aside, such a composite index has obvious advantages, notably the ability to derive stategic components within the overseas sector to indicate the effect of choice of country independently from choice of securities.

   (refer XII.5, ch.5)

   It has to be said however that the weights are a large and largely irreconcilable problem. Consultancy C does not state the basis on which its weights are derived. Presumably some agreement

could be made but it would be far from conclusive in view of the lack of published information.

The Standard and Poors Composite Index of the New York Stock Exchange was used in this study to represent the overseas sector. This was viewed as the simplest way to represent overseas opportunities as a distinct sector without getting involved with questionable weights and the associated extra data input also. In addition most overseas investments of the funds of this bank were American.

III.5 PROPERTY UNIT TRUSTS

This was delineated as a seperate sector for the purpose of this study in view of the role which this type of security has played in many of the funds operated by the bank studied. Some funds were holding securities of this sector as a matter of Trustee Policy and the opportunity cost of these holdings was desired to be evaluated.

To the writer's knowledge, there is no publicly available index of property unit trusts. This study was fortunate enough to have access to the index prepared by Phillips and Drew ("Phillips and Drew Property Unit Trusts Index", 1973 onwards). This index is not as yet published on a regular basis. It is an arithmetic index, based on a weighted average of price changes of seven of the leading trusts, where the weights are the total capitalisations of the trusts. It is a monthly series and does not enable precise timing tests, which would be irrelevant to a relatively small sector such as this anyway. The income index is also monthly.

III.6 CASH SECTOR

Although pension funds may invest their cash in any of a number of places (short-term deposits with many types of institutions, including the money market), a generally accepted measure is the local authority interest rate for seven day money.

One is really confronted with the same problem as

occurs with the overseas sector. There are many interest rates available, but little data on which to base a weighting system to combine them all together into a composite index. The local authorities are used as a proxy in view of their prominence in the market.

III.7 OTHER SECTORS

Commodities, options and art works represented such tiny fractions of the funds under study that these were ignored. Indices for these sectors are, in any case, at a very primitive stage especially in the case of art, where infrequent valuations make indices difficult to derive. This is also the problem with the following sector.

III.8 DIRECT PROPERTY HOLDINGS

This sector represents the most serious neglect in the field of performance measurement as it now stands. There simply exists at the present time no satisfactory index of UK property values. Most existing commercial services choose to ignore the propety sector althogether. The one service which does not ignore it measures performance against that of property unit trusts. Although appearing reasonable at first sight, the comparsion is not a good one, since trusts can hold substantial amounts of cash during hard times and so boost their overall return. Their prices are also affected by the markets' perceptions about the quality of management.

Property indices do exist, but none are very reliable due to the paucity of information which exists on current market values of property generally. It is a very illiquid investment with low turnover and is also expensive to value. A recent survey(83, p3) of available property indices concluded:

> ".... no satisfactory index yet exists for us to be able to make a proper comparison between direct property and equities or gilts."

There are three indices currently available, two of which lack adequate coverage. The index with adequate coverage is unfortunately an index of rental values only (ie. an income index and not a price index).

The inability to measure property performance is a serious omission, as funds have been increasingly diversifying into this area over recent years. As at the beginning of 1977, an average of 14% of pension fund money (by market value) in the private sector, and 20% in the public sector, was invested in direct property holdings. These holdings could be safely ignored only in the case of local authority funds, who were on average invested in property to the extent of less than 4% of their total market value as at 1977. One must remember also that these figures are weighted averages only. The proportion for individual funds can run as high as 30%.

Because of the different skills involved in property management relative to general investment management, the direct property sectors of some funds are not managed by the same manager. In these cases, inability to measure property performance does no damage to performance measurement in so far as its aim is to assess managerial performance.

Kingston(45) suggests the use of the fund's rate of return on its own property investments as the notional rate of return for the purpose of creating a notional fund. This would produce a zero selection component for this sector but at least allow a strategic component to be evaluated. The difficulty is, of course, that the same difficulty of frequent valuation which hinders the development of an index also prevents the repeated objective calculation of rates of return on actual holdings.

The seriousness of the measurement problem in this area has been highlighted as follows:

" ....too elegant a system of analysis of overall investment expertise may easily founder because of

the lack of an appropriately objective measure of the value of the property element in the portfolio...."[1]

This study regretfully was forced to omit porperty altogether from the application of the software developed to the funds studied. Information on property values was practically non-existent in the records of these funds.

IV. CONSTRUCTION OF NOTIONAL PORTFOLIOS

IV.1 TRUSTEE POLICY FUND

Kingston(45 , p13) expresses reservations about whether trustee policy constraints can be reflected in a notional fund:

> "In practice, I doubt if many supervisory boards of investment funds would lay down percentages as tightly as (needed) - if they did, it might have a stultifying effect on investment management."

The point is however that if trustees do not have a stultifying effect on management, there is really no purpose in having a Policy component. This was the experience of this study in dealing with the 5 funds reviewed here. Restrictions varied from an extreme case with one fund whose trustees demanded equity investments only, to cases where no binding directions were given at all.

A careful distinction must be drawn when applying the Policy fund concept between "soft" and "hard" restrictions. Almost all funds had soft restrictions, whereby trustees laid down future investment plans for the fund. The distinctive characteristic of these soft restrictions are that they are drawn up almost wholly as a result of the advice given by the fund manager. In these cases, policy merely reflects his strategy and there is no point in quantifying them separately (Strategy would be zero).

Hard restrictions are those laid down by trustees independently of the fund manager's advice. The manager may or may not agree with them. Whether he does or not

---

1: Short and Brumwell (72,p20)

will effect the interpretation of the Policy Component. If he disagrees, Policy is a factor of performance he would have liked to change before the beginning of the review period. If he agrees, Policy is in a sense a part of Strategy, Strategy being an extension of it.

IV.1.1 PROBLEMS

There are two main problems with the derivation of policy sector proportions from hard trustee restrictions:

1. The restrictions can be incomplete.

2. Trustees hardly ever comment on the required liquidity of the fund.

3. Restrictions may not always be "single-point" restrictions.

Incomplete restrictions arise when a limit is placed on only one sector and nothing is said about any of the others. For example, if it is policy to limit overseas investment to 10% of the fund, that says nothing about the split of the rest of the fund except that it has to add to 90%.

The solution adopted here was to assume that Trustees desired a profile similar to that of the average (i.e. model) fund, but with the secondary effects of the incomplete restriction spread evenly over all sectors. Continuing the previous example, the domestic sectors of the policy fund would be distributed over the remaining 90% in the same proportions as they were distributed over the remaining percentage of the model fund after its overseas sector was subtracted.

The cash sector represents a special problem in that, technically speaking, it is unrealistic to specify that none of a pension fund should be invested in cash. All funds have a need for some liquidity to pay unexpected benefits and cover unexpected expenses. In some cases, the institution administering the pension fund keeps such a liquidity reserve separate from the funds given to the fund manager

to invest, so that the balance kept for liquidity purposes can be easily distinguished from the balance kept by the fund manager for timing reasons. This was the case with all the funds examined in this study. If it is not the case, some arbitrarily small figure should be assumed in the construction of the policy fund.

Single-point restrictions refer to the specification that a sector must constitute x% of the fund and no more or not less. These are relatively rare in practice. Trustee restrictions usually take the form of one-sided restrictions, of the nature of "no more than x%" or alternately "no less than y%". The difficulty with the one sided (or even two sided restrictions like "between x% and y%) is that the imposed limit may not always be a restriction in the true sense of the word. For example, if the trustess specify that overseas investments are to be at <u>most</u> 10% of the fund, this will effectively act as a single-point restriction on the fund's potential performance if overseas markets boomed while domestic markets did less well. It would not be a single-point restriction if the reverse was true. If overseas sectors did poorly, it is not clear that trustees would still want 10% of the fund invested there. Similarly, the relevant proportion will vary from side to side in a two-sided restriction depending on the relative performance of the sector to which it refers.

There are two solutions to this problem:

1. Use a representative single point restriction for the purpose of deriving a policy fund, and regard rewards to the fund from deviating within the allowed range from this single point as part of strategy.

2. Use a linear programming approach to identify those single points which were binding on potential performance over the review period.

Using the notation of XI.2.1 in chapter 5, the linear programme (5.10) can be modified to include

one-sided and two-sided trustee policy restrictions as follows:

$$\text{Max} \sum_s (1 + r_s)\, p_s$$

subject to

$$p_s \leqslant U_s \qquad \text{for } s = 1 \text{ to } S$$

$$p_s \geqslant L_s \qquad \text{for } s = 1 \text{ to } S$$

$$\sum_s p_s = 1$$

$$p_s \geqslant 0 \qquad \text{for } s = 1 \text{ to } S$$

where U_s = upper limit on the proportion of the fund to be invested in the sth sector.

L_s = lower limit for the sth sector.

The solution to this programme would yield the best possible sector choice decisions (represented by the variable p_s) given the trustees' wishes. However, of greater interest are the values of the dual variables at the optimum solution, for these would indicate those restrictions which were preventing the solution from being better. The constraint associated with non-zero dual variables would indicate those trustee restrictions which should be represented as single-point restrictions.

While the second method is much more sophisticated it is unfortunately beyond the comprehension of most laymen and so was not persued in this study. The first solution was seen as being far simpler, though less adequate.

IV.2 MODEL FUND

Previous chapters have already pointed out the advantages of basing this fund on the average profile of all U.K. pension funds. Appendix 5-I contains details of how the average weights are derived from government statistics and comments on their likely accuracy. Some measurement services base their model fund on proportions

thought to be average by inspection of a sample of funds subscribing to the service. The latter approach is similar to, but probably less accurate than, the one discussed in Appendix 5-I.

IV.2.1 SEPARATE MODEL FUNDS FOR DIFFERENT TYPES OF FUNDS

Pension fund statistics are available separately for three kinds of funds:

1. Private Sector pension funds.

2. Pension funds of local authorities.

3. Pension funds of public sector institutions other than local authorities (called "Other Public Sector" funds).

The distinction is important because of the regulations which govern the management of the funds. Local authority funds are subject to the Trustee Investment Act (1961). These funds are limited to an investment of a maximum of 50% of their total fund in what are called "wider range" securities. These are the more risky sectors, such as equities and property. A minimum of 50% of the fund must be invested in "narrow range" securities (cash or government securities). Other public sector funds are limited to a maximum of 75% in wider range securities, of which no greater than one third (ie. 25%) must be invested overseas and direct property holdings taken together. There are no similar restrictions on pension funds in the private sector.

The existence of these restrictions implies at once that comparisons between funds in different groups will not be valid. This can be overcome in one of two ways:

1. Compare the performance yield with a common average fund and treat the legal restrictions as trustee policy, including their effect on individual

funds in a Policy component of performance.

2. Use a different model fund for each type of pension fund, based on statistics for that type of fund alone.

   Judgements of performance relative to such a model fund would automatically not have to allow for the effect of legal restrictions, since all the funds from which the average profile on which the model fund is based were subject to the same restrictions anyway.

The second approach was judged here to be the better. All funds may be compared on their excess return over their respective model type, and the varying legal restrictions should not affect the comparisons. The disadvantage is that the performance measurement system must keep track of three model funds.

CHAPTER TEN

SYSTEM DESIGN AND INPUT REQUIREMENTS

The final shape of the software package for portfolio performance evaluation which was written and tested for this study was a function of all the decisions which have been discussed in the preceeding nine chapters. This chapter now turns to a description of the set of computer programmes which were written to perform the calculations necessary to produce the measures and analyses so chosen. An overall systems view of the package is first given and then the input required by the system is discussed in detail.

The literature on performance measurement rarely discusses technical points involved in the design of systems or programmes to carry out the general procedures which it suggests. Indeed, the precise mechanics of how to produce performance statistics appears to be something of a secret. Although articles have been written by personnel of some measurement services, specific details have never been discussed, possibly for obvious commercial reasons.

I. PUBLISHED PERFORMANCE MEASUREMENT SYSTEM DESIGNS

Two systems have been published in detail.

I.1 FOX

Fox(33) gives details of the required information input and their sources, as well as a fair description of the calculations involved. This system, as understood from his verbal description, is schematically represented as Figure 10.1. The input effort required by the system appears to be both intensive and expensive. Each transaction of the fund is

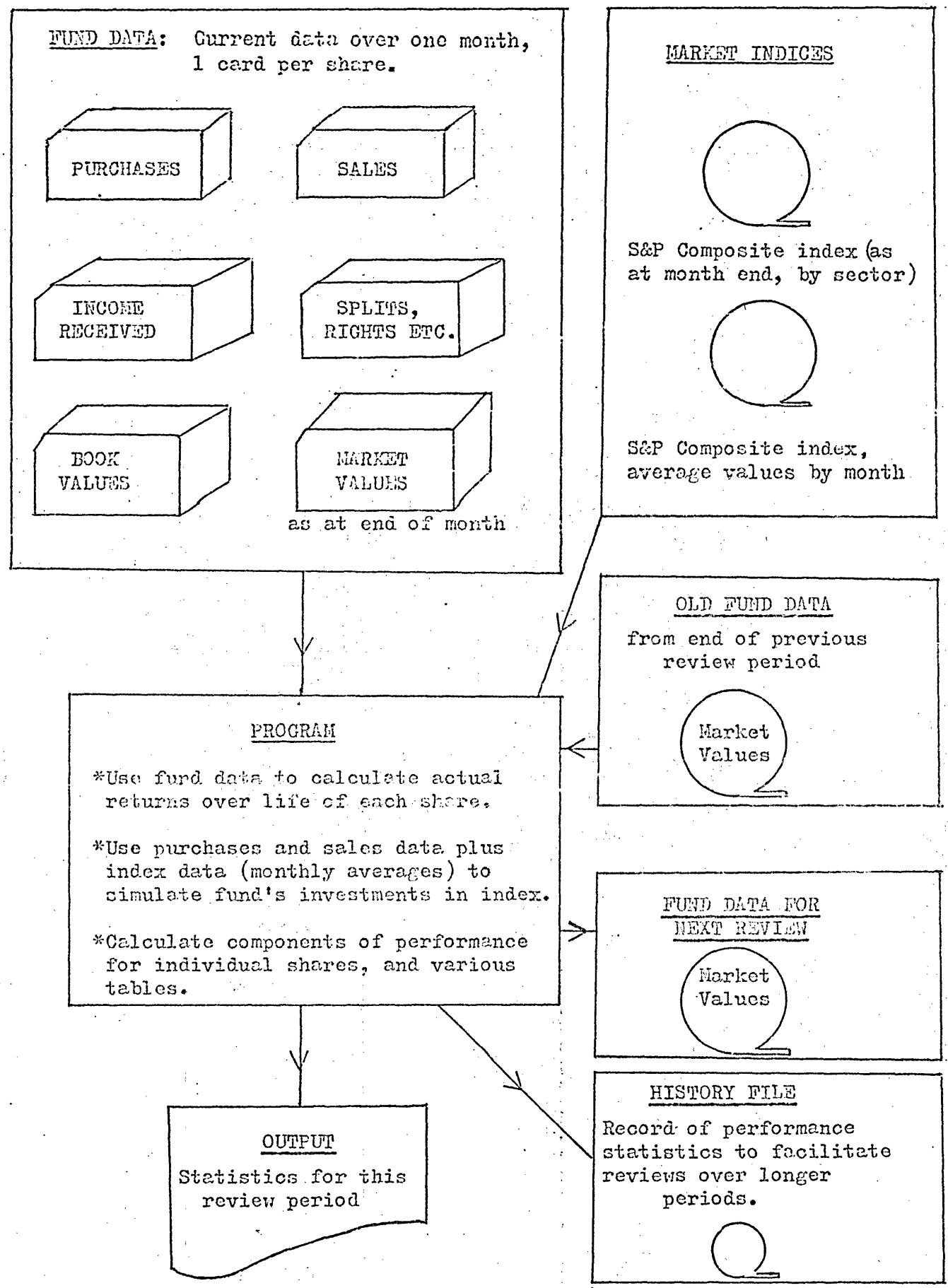


FIGURE 10.1

Overview of Fox's performance measurement system

recorded on a punched card, giving an identifier for the share, its classification as cyclical/defensive/growth and the transaction value. A similar card is required each time income is received on a share, or there is a stock dividend or split. For an active fund with a hundred or so shares, the input would be very voluminous.

Index values are pulled off a comprehensive data bank of the Standard and Poors Index, probably purchased and updated from the agency itself. This would be expensive.

The input effort required for reviews over longer time periods (say annually after four quarterly reviews) is aided considerably by the automatic recording of quarterly performance results on a history file.

While Fox's system was viewed as being too impractical and expensive for current purposes, the system developed in this study exhibits some of its fundamental features.

I.2 BANK ADMINISTRATION INSTITUE

The BAI (1 ,AppII) gave detailed requirements for the use of their regression method to estimate a fund's time-weighted rate of return.

A schematic interpretation of their verbal description is given in Figure 10.2.

Because the input is on a sector-by-sector basis, it is not as detailed as Fox's. The overhead calculations involve computation of market rates of return. The old history file contains the data on which past regressions have been based. To these old observations are added the current observations and the regression updated. The new history file presumably stores the updated regression data set. No specific mention is made of provison of data for later reviews over longer periods.

II. SYSTEM DESIGN IN THIS STUDY

II.1 GENERAL FEATURES

FIGURE 10.2

Over-view of the calculation system recommended by the B.A.I.

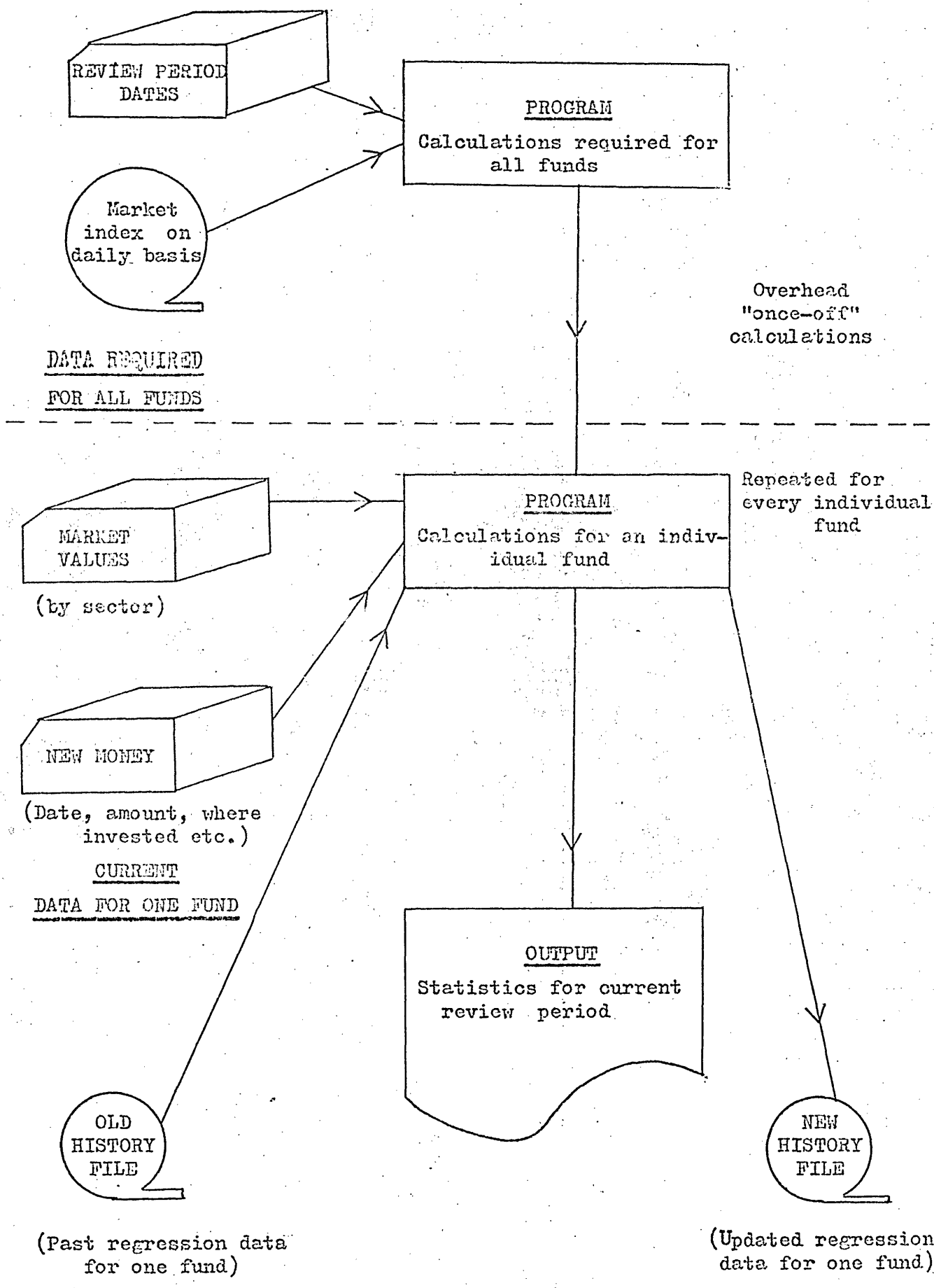


Figure 10.3 shares the overall design of the performance measurement software developed here. On a very general level, the major differences in design from that of Fox and the BAI are the following:

1. Historical performance data is kept on the market as well as the funds.

   This enables a comparison of a fund's cumulative performance with that of the market over the same period.

2. There is no need for a comprehensive data base of market index values.

   Since the purchase or collection of daily market indices is an expensive process, the system is built to require only three types of index information:

   (i) Average indices on a monthly basis.

   (ii) Index values as at the beginning and end of the review period.

   (iii) Index values as at the dates new money flows.

   In analysing 30 or so different funds, the particular dates of new money flows may coincide considerably (particularly if they are appropriate, representative dates), making the retention of a file of daily index values wasteful. Monthly averages for most values are published in either offically or privately produced publications.

3. An historical summary of past performance can be provided in the same report as that in which statistics for the current review period appear (programme III in Figure 10.3).

FIGURE 10.3

Over-view of system design of this study

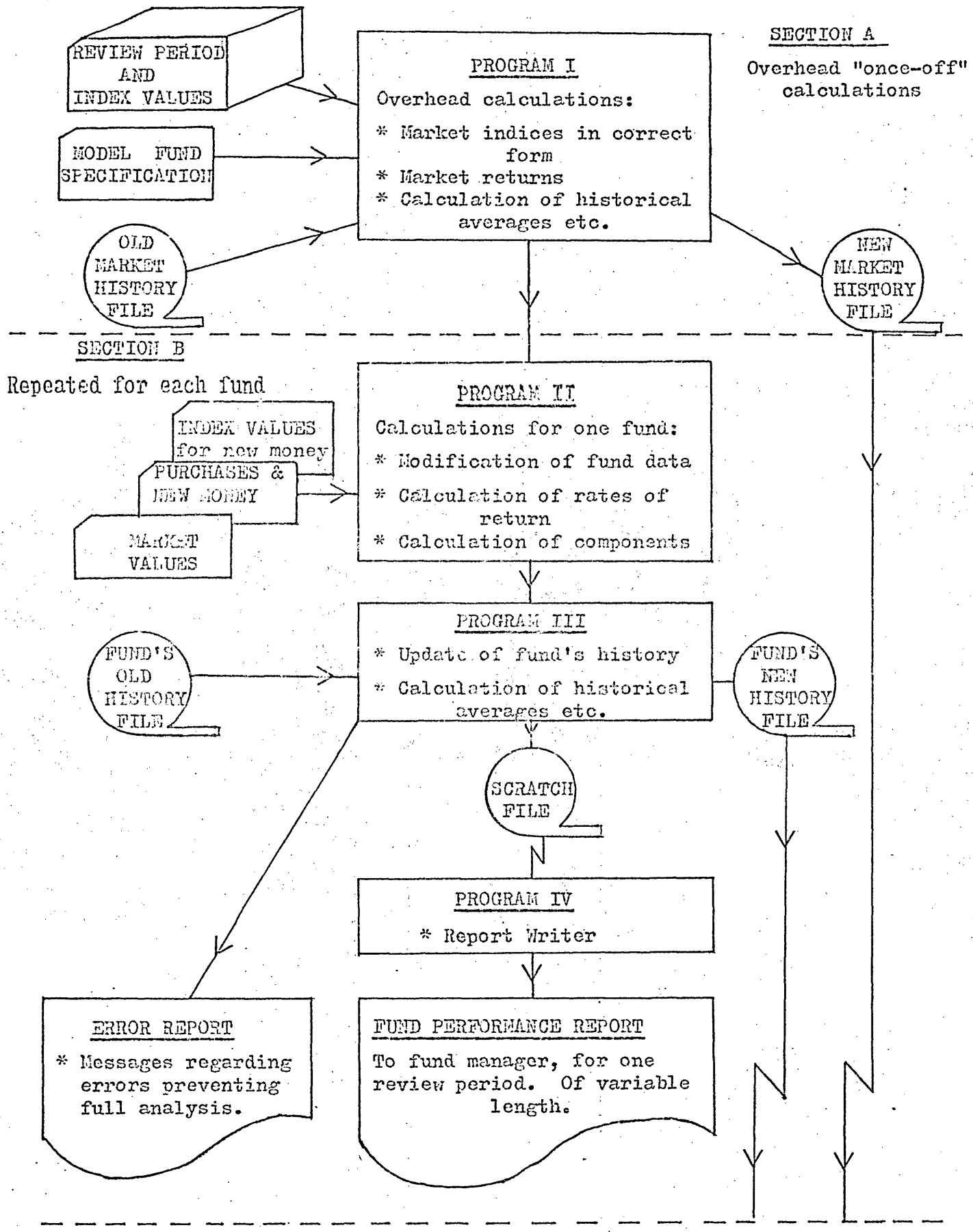


FIGURE 10.3 CONTINUED

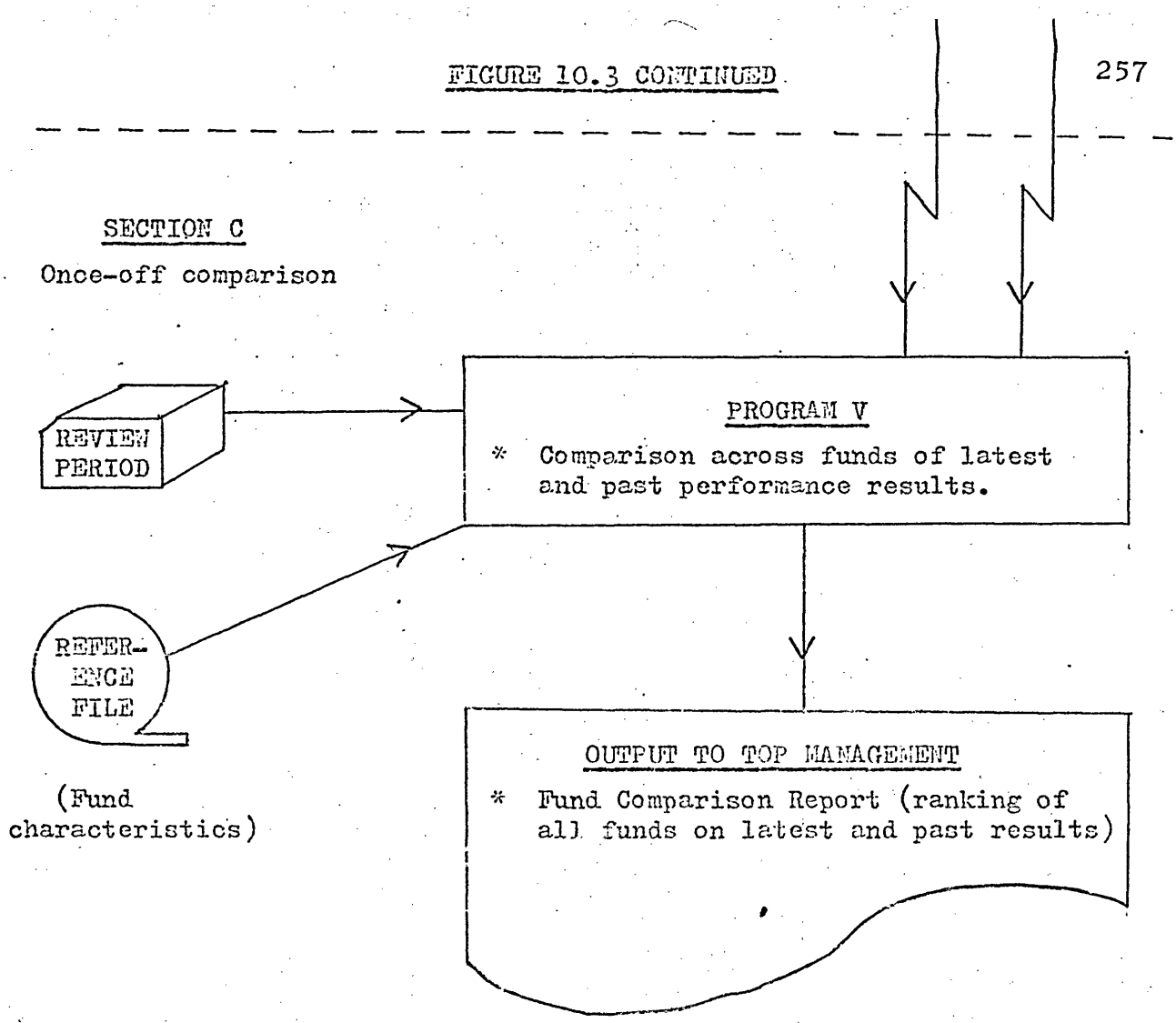


FIGURE 10.4

(See notes next page)

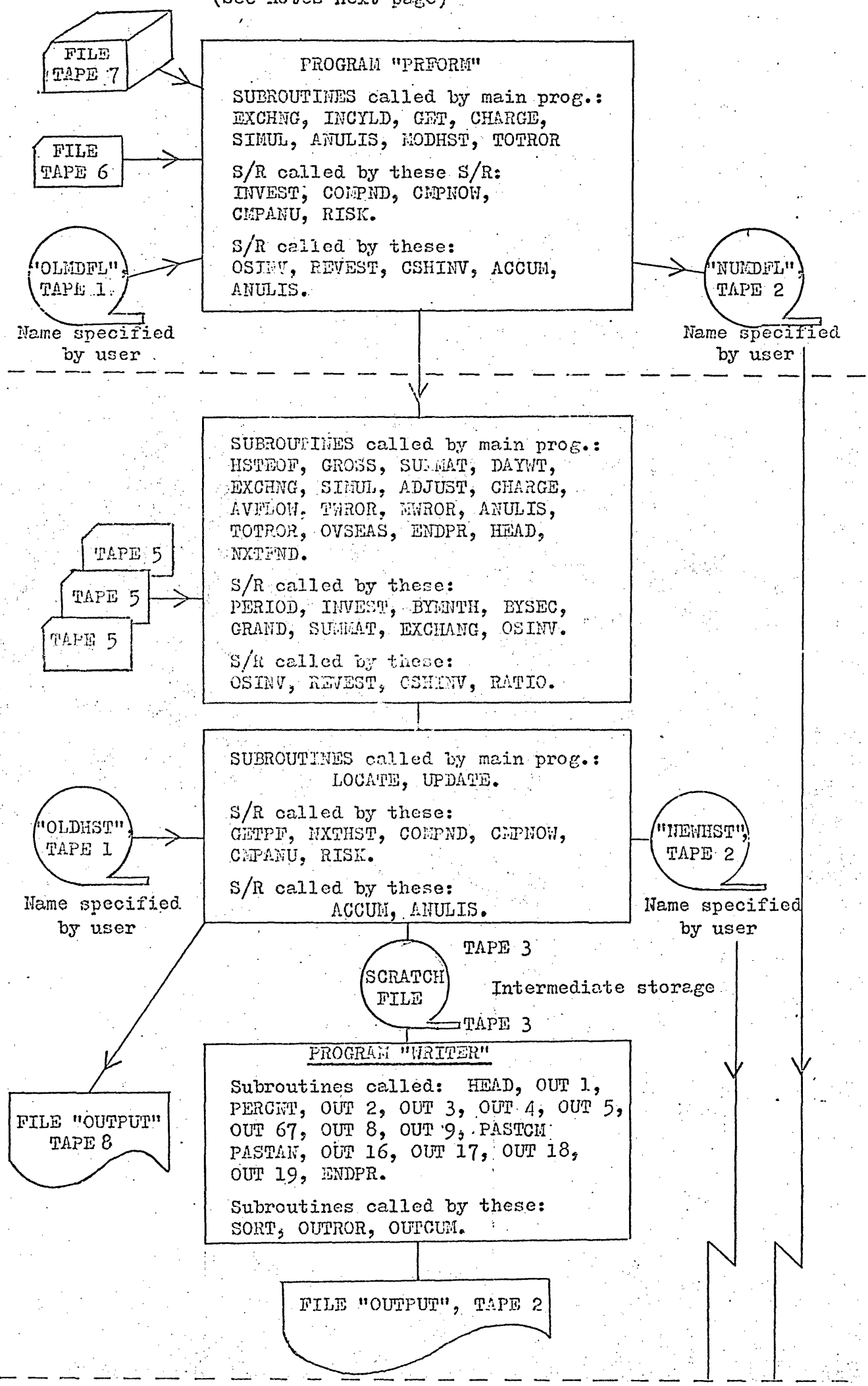
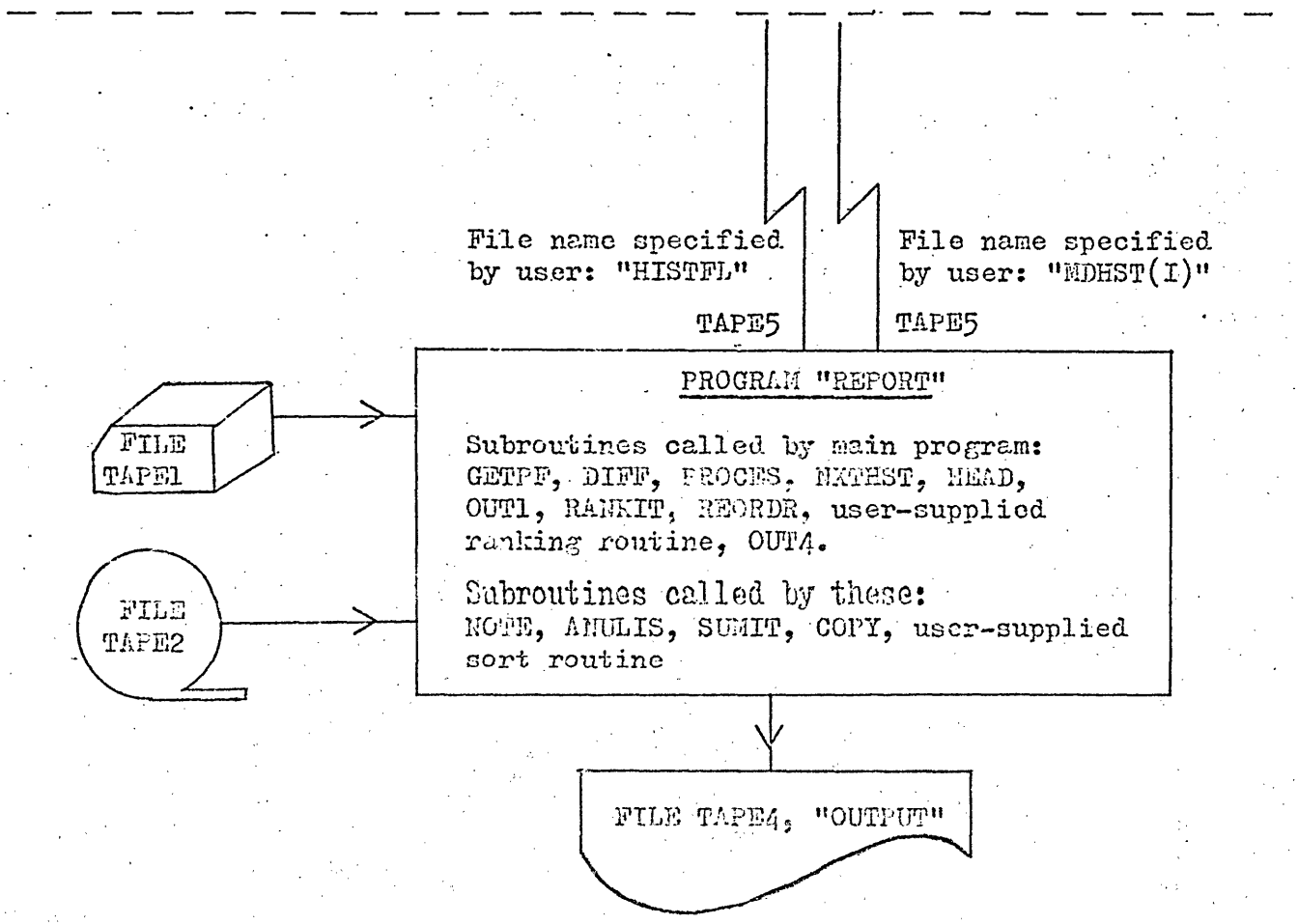


FIGURE 10.4 CONTINUED



Over-view of system design of this study giving file and subroutine names corresponding to Figure 10.3. File names in quotes are variables representing file names specified by the user. TAPEx refers to the unit number of the input/output device.

Other general features of the system are:

4. The report is written by a programme (IV) which is independent of the main programme (I) which calculates the results.

   This enables the format of a report to be changed easily, without fear of harmful repercussions working through the whole system.

5. A report is provided which compares the performance of all funds (at one moment in time) by ranking them according to various performance statistics.

   This is provided by Program V, which can be applied at any time to the history files of the funds and the markets.

6. The system is especially designed for the repetitive analysis of many funds in the one run.

   The calculations concerning market returns and the updating of their history (section A in Figure 10.3) are done only once, and then section B is repeated as many times as there are funds to be analysed in the one run. Subsequent separate runs for other funds for the same review period may be made with the option of either repeating the market calculations or using the previously calculated results (read from the updated market history file).

   Each fund in the one run may have its own unique history file, or all funds may be on the one history file in no particular order.

7. The system is designed to be of maximum flexibility in its use.

   Some of this flexibility was illustrated in

point 6 above. Other features are:

(i) History files can be prevented from being updated if so desired.

(ii) Funds without history files can be equally well analysed.

(iii) History files for new funds are automatically created if not deliberately prevented from being so.

(iv) The report to the fund manager can vary in length from 4 tables to 19 tables, depending upon what tables he chooses to veto.

(v) In a run of a multiple number of funds, an inconsistency in the data of one fund will not prevent the analysis of the following funds. If, for example, the fund's supplied data does not add up, or the fund's historical data cannot be found on a nominated file, an error message is printed and the system moves to the next fund in input.

(vi) All time periods are variable.

The logic and technical methods to not assume a particular review period length. The range of time over which historical averages are calculated can vary from fund to fund according to the users' wishes. In addition, funds do not always have to be reviewed over periods of equal length. Two successive review periods for the one fund can be 3 months, followed by 1 month for example.

8. The system may be applied in a batch process mode or on a time sharing basis.

Its use in batch mode has already been described in point 6 above. It can be used on a remote terminal basis because of its facility to nominate the names of relevant history files as part of the input. It must be stated however that it is really more suitable for batch processing in view of the few advantages of any inter-action with the user, and in view of the need to overlay much of the main program PRFORM2 in order to reduce its core requirement to a level compatible with most time sharing systems.

9. In recognition of the sometimes incomplete availability of data concerning a fund's income, the system is programmed to estimate those income figures which are missing.

   Or, if the user prefers it, performance can be assessed on the basis of capital value only.

10. Although the system is designed around the concept of all funds (of the same basic type) being compared with the one model fund, the option does exist for a fund manager to have his fund compared to a model fund of his own specification.

Figure 10.4 illustrates the same system design as Figure 10.3 but indicates the names of the corresponding files, programs and sub-routines. The matching of these two figures should assist the formulation of an impression about how the pieces combine to form the whole. Listings of these routines will be found in the appendices which are referred to as the associated methodolgies are described in this and the next chapter.

II.2 GENERAL METHOD

For reasons of computing efficiency, programs I, II and III of Figure 10.3 were combined together into the one program called PRFORM2. PRFORM2 outputs its performance statistics for all funds in the one run onto a temporary

scratch file in the form of block data. Program WRITER picks up this data for one fund at a time and re-organises and re-formats it into a legible report. This report will be referred to as a "Fund Performance Report", Once all funds in an office have been reviewed up to a certain date, program REPORT can be used to produce an across-the-board comparison of funds' performances. It ranks the funds in order of merit according to a fixed set of criteria. Managers are also ranked according to the average performance of funds under their control. To do all this, REPORT obtains each funds' earlier and past performance figures from their respective up-dated history files. It compares only those funds nominated on a reference file and can segregate funds into groups on the basis of an indicater on this file. This report produced by REPORT will be termed a "Fund Comparison Report".

II.3 OBJECTIVES OF THE REPORTS

Only one, a few, or all of a manager's funds can be reviewed at once. The funds of any number of managers can be processed in the one batch, although they should all be of the same model type (private, local, authority etc). A manager then receives one Fund Performance Report for each of his funds. A report will vary in detail and length depending on what tables he vetoed as part of the input for that fund.

At any point in time, the office manager who over-sees the fund managers can apply REPORT to all the funds in the office for which history files exist in the computer. If a fund has not been reviewed up to within two weeks of the specific date of this across-the-board review, it is not included in the comparison and a message is printed to indicate the offending fund and its shortfall. The Fund Comparison Report is briefer than those going to fund managers. It is a form of exception reporting in the sense that the best and worst performers are highlighted by the ranking system used in the report. Because such across-the-board comparisons are full of traps however, which can lead to false conclusions, the more detailed and more technically correct Fund Performance Reports should be referred to in

order to verify the rankings of the funds so identified as best or worst. For example, if the Fund Performance Reports of the bottom 5 funds on current performance show that current performance was severely affected by trustee policy (i.e., a negative Policy component), they may be exonerated if it is known that the manager would have acted differently over the review period in the absence of these policies.

III. LEVEL OF ANALYSIS

It has already been observed (XII.5, Ch.5) that analysis of performance can take place at the levels of sub-sectors and even individual securities. The system of this study confines itself to sector level only however, for two reasons. The first is primarily a practical reason. The extra input required by an analysis on sub-sector, let alone security, level would be very demanding and is impractical for most accounting systems unless they are tailored to meet the needs of detailed extraction of performance data. The second reason is broader. Since sector decisions constitute the major determinant of the ROR on a fund, it was viewed as more important to highlight the profits and losses from this type of decision, rather than produce many statistics on less important sub-sector and security selection decisions, which could blur the picture considerably.

The contention that sector selection decisions (i.e. Strategy and Policy) are the major determinants of total Rate of Return is supported by many independent sources. On the theoretical side, Chapter 8 has already shown that these determine most of the systematic risk level of a fund, which in turn tends to determine the level of expected return in relation to funds of different risk. The efficient Market Theory implies that funds cannot hope to gain superior returns from any source other than strategic decisions. On a less theoretical side, practisioners have observed the importance of sector choice in the form of timing of purchases and sales decisions in the different sectors.

> "The major distinction between the equity and balanced timer is the latter's belief that equities should be treated as a portfolio sector and that the positive return from cash equivalents can be enhanced by managing debt as the economic cycle and yield curve shifts."[1]

Dietz(16,Ch 7) emperically observed the importance of timing in this context years ago. Irwin Tepper(79,p101) demonstrates using simulation that the "... optimal stock bond mix is the single most important element of the investment policy decision" over the long term, determining as it does the basic risk/return characteristics of the portfolio. Holbrook's(41) survey of about 100 funds confirmed that performance was heavily correlated with sector choice decisions. The same result was obtained in this study in the form of Strategic and Policy components which were typically much larger than selection figures (refer table 12.3 for example).

Given the importance of strategic decisions, there seems little point in concentrating on the fine points of security selection. For a portfolio with a large equity sector however (constituting say 80% of the fund), there may be a case for analysis on the sub-sector level. The software can provide for such an analysis for up to five sub-sectors. The model fund would be the whole F.T.A. All-Share index.

IV. INPUT DATA

The methodology of the software considers a chosen review period to consist of a user-specified whole number of separate and consecutive sub-periods. Most examples quoted in this study use three calendar months in a quarterly review period. However the software is written so that if weeks were wished to be used, only a few DATA statements need be changed within PRFORM2. The description of the software will assume a monthly sub-period.

1: Klitzberg and Bowes (46, p26).

IV.1 FIXED FORMAT REQUIRED

Data is read in by the system in a fixed format mode rather than free-format for two reasons. Firstly, the uniform spacing serves to highlight errors of omission or the existence of too many figures. Secondly, it will be argued later in this section that a small inter-active program to re-organise input into a fixed format mode is the most convenient way to input data.

Examples of the data files needed for the analysis of one fund are given in Figures 10.5 and 10.7. The following sub-sections describe the contents of the files by labelling data items. These labels are used in Appendix 10-I to detail the exact format requred by the system.

IV.2 MARKET FILE

This file is intended to contain all the information necessary for the processing of a fund over a review period specified by this file, no matter what type of model fund is to be used. The file (Figure 10.5) contains the following data.

M1. Date of the first day (inclusive) of the review period.

M2. Date of the last day (inclusive) of the review period.

M3. Number, n, of sub-intervals in the review period. This will usually be whole months.

M4. Value of each sector's index X_0^s , as at the first day of the review period. This is normally the closing value of the previous day.

Note that a price index for Cash is meaningless so is not required anywhere in this file. It is important to note that the order along the line in which these indices are arranged determines the "standard sector code numbers" used in the rest of the analysis to identify sectors. For example, the standard order in which sectors are arranged

M1	M2	M3
1 71976	30 91976	3

M4	155.41	103.27	50.6	104.28	89.97	
M5	7	157.70	103.109	50.60	104.20	89.125
	8	150.86	102.430	50.120	103.29	89.705
	9	142.07	100.595	47.62	105.45	90.240
M6	135.00	98.53	46.7	105.24	90.42	
M7	5.87	0.43	14.61	3.64	6.39	11.0
	6.25	1.30	14.75	3.74	6.46	10.625
	6.71	0.63	15.48	3.71	6.56	10.625
M8	1.2264	1.7847	0.25			
M9	1.2505	1.7865				
	1.2829	1.7834				
	1.2173	1.7302				
M10	1.1255	1.6680	0.25			

FIGURE 10.5

Format of a Market Data file

FIGURE 10.6

Format of a Model Type file

T1	0.56	0.22	0.09	0.07	0.02	0.04	
T2	AVERAGE PROFILE OF NON-L.P. PUBLIC FUNDS.						
T3	HHU276	HHU276	T4	2 4 6 8 9	T5		T6

F1 A NON-L.A. PUBLIC UTILITY CORPORATION (C)

F2 1

F3 6

F4 HNW276 HNW376 F5 2 4 6 8 0 F6 F7

F8 2 3 1 4 5 6

F9 NIL. (PROPERTY IN SEPERATE FUND) F10

F11 0.30 0.0 0.6919 0.0 0.0081 0.0 F12

F13 15% TO PROPERTY FUND, + LAMIT HOLDING.

F14

12645175	401376	21271924	4735224	350391	4289365

F15

14700303	359588	20627705	5932225	360346	2255432

F16 F44

-3127000	0	777000	407000	0	
1081000	0	1227000	396000	0	
4722000	-36100	647000	505000	0	

F17 INCOME EARNED F18 F19 NET F20 F21

F22 F45

226306	0	150776	9309	0	11213	
0	0	51120	4429	0	14452	
0	5980	31311	6903	9874	131144	

F23 F24 F25

16 71976	1712929	103.36	50.25	160.95	104.66	89.215
8 81976	1739119	102.59	50.36	153.04	103.49	89.705
12 91976	741200	100.69	47.34	143.12	104.29	90.240

F26 REFAID INCOME NONE F27

F28

1.2374	1.7754
1.3190	1.7869
1.2051	1.7537

F39 FINISH

F40 END

FIGURE 10.7

Format of a Fund Data file

in Figure 10.5 is as follows:

Sector 1 : UK equities
2 : Gilts
3 : Other fixed interest
4 : Overseas
5 : Property Trusts
6 : Cash

This is the order used for all examples quoted in this thesis. The first five sectors may be nominated in any order, but Cash must always be the 6th sector without fail. Using the above codes, all sector information for the overseas sector in this file must appear as the 4th number along the relevant line.

Because the history files used internally by the system are structured according to these codes, they should be permanently at the outset of the package's implementation.

M5. Each line represents the average index values, $\bar{X}_t^s$, for one month. The first integer is the calendar number of the month, followed by the average indices in standard order.

M6. Index values X_n^s, in standard order as at the end of the review period.

M7. Income indices in standard order, with one line for each month.

An income index may take on of two forms:

1. An index yield, in per annum terms as a percentage.

2. A pure income index IX_t^s, for direct use to simulate income. (ie. it should be the income paid, in £, on one index unit over the month).

Whichever is the more convenient form can be used. For example the FTA All-Share Index has its income published as an annual dividend yield, while the FTA gilts index has a pure income index. The software knows which form to expect through an array YIELDS in PRFORM2 which is set

in a DATA statement. The income index for the overseas index, in whatever form it is provided, should relate to foreign currency income. The income code for the cash sector should be either the annual interest rate as a percentage[1], or the income (in £) to be earned on £100 during the month.

M8. Exchange rates as at the beginning of the review period plus the level of the dollar premium penalty, α_o, at the beginning of the review period. The rates are expressed as the price for £1. As a US equity index was used in this study to represent the foreign sector, the numbers in Figure 10.5 refer to US dollars. The first is the "investment currency rate" (including premium), E_o^p. The second is the ordinary rate, E_o^o.

M9. Average exchange rates, $\overline{E}_t^p$ and $\overline{E}_t^o$ for each month. One line for each month, premium rate first.

M10. Exchange rates, E_n^p and E_n^o and premium penalty α_n, as at the end of the period. Same format as M8.

M11. Details of a change in the premium penalty. Required only if the value in M10 is not equal to that in M8. (Not shown in Figure 10.5).

IV.3 MODEL TYPE FILE

This is a very short file of two lines of information, as shown in Figure 10.6.

T1. Profile proportions of the model fund against which all funds in the one batch run are to be assessed (unless option F41 is exercised for a particular fund - refer IV.4 below).

T3. Name of the old history file for this type of model fund.

1: This annual rate is converted to a monthly rate by the program using (10.3), so should not be a compounded rate for complete accuracy.

T4. The name by which the user wishes to identify the updated model history file. It should differ from T3.

T5. These integers specify the time periods into the past over which part results (taken from the history file) for the model fund are to be accumulated. Each number refers to the number of past reviews over which ROR's must be accumulated and averages calculated. The figures in Figure 10.6 request that results be continued over the past 2 review periods, then the process repeated for over the past 4 review periods, then the past 6 review periods and so on. Up to 5 separate past periods can be specified.

These figures, referred to as the "pattern of accumulation" of past results, have default values of 1, 2, 3, 4, 5 if no numbers are specified. Note that the specification is in terms of the number of consecutive past reviews, so that the length of time involved depends solely on the lengths of the individual past review periods, each of which may have varied from 12 months to 1 month.

T6. This field, if filled with any character whatsoever will prevent the model's history file from being updated.

It may not be desired to update a model's history file if either it has already been updated, or the system is to be used without history files, or an experimental run is being done.

The Model Type file is so short that it can be attached to the front of the Fund Data file as a matter of convenience.

IV.4 FUND DATA FILE

Figure 10.7 shows the structure of this file in the case when only one fund is to be analysed in a run. The format of the middle section of this file varies according to how much is known about the income of a fund. Figure 10.7 and the following description, for simplicity, refer to the case when complete information on income is available. Formats when this is not the case are described in section

VI to follow.

F1. Title of the fund as it is to appear in the Fund Performance Report.

F2. A special numerical code unique to the fund. This sets as an identifier and must agree with field FH1 on the same fund's history file.

F3. The number of sectors, S, in which the fund is invested, including any sector which is invested in for the first time during the review period, or sold off during the review period.

F4 to F7 correspond to items T2 to T5 in IV.3 above. They are the names of the fund's old history file (F4) and new history file (F5), the desired pattern of accumulation of the fund's past results (F6) and a no-update option (F7). If no numbers are specified for F6, the pattern specified as T5 is used by default, even if this itself was set by default.

F8. The standard sector code numbers (refer M4) of the sectors in which the fund is both invested and not invested. They must be specified according to the following rules:

(i) The first S numbers must refer to the sectors in which the fund is invested. The remaining numbers refer to the sectors in which the fund was not invested during the review period.

(ii) Invested sectors may be specified in any order, provided only that Cash (ie. code 6) <u>always</u> appears last (as the Sth code number). Uninvested sectors may appear in any order.

(iii) The order of sectors implied by the first S code numbers implies the order of all sector information in the rest of this file.

These numbers also determine the order in which sectors will appear in this fund's Fund Performance Report. Using the codes of IV.1 above, Figure 10.7 specifies a fund invested in all of the sectors gilts, other fixed interest, equities, overseas, property trusts and, lastly, cash. Figure 10.8 shows a fund which has no holding of Property Unit Trusts.

F9. Description of those investments which have been excluded from the analysis. This will appear exactly as it is in the Fund Performance Report.

F10. Estimated value as at the beginning of the review period of the excluded investments described in F9.

This estimate will be quoted in the Fund Performance Report as a percentage of the initial value of the fund unless a figure is absent.

F11. This field should be left blank if a policy fund is to be included in the analysis of Performance. If no policy fund exists, "NO POLICY" should appear (as in Figure 10.8) with the rest of this line left blank and line F13 omitted altogether.

F12. If a policy fund is to be used, its profile proportions should be specified in the same order as the sector code numbers in F8.

F13. Description of the basis for the policy fund, as it is to appear in the Fund Performance Report.

An option exists for a fund manager to specify a model fund with which his performance will be compared which differs from the model specified by T1. A manager may wish to do this if he disagrees with the commonly nominated model (T1) for example. To do so will produce a model fund ROR which will differ from that used to assess other funds in the same run. The cumulative and average ROR's calculated from the common model's history file will however appear unchanged in the Fund Performance Report of this fund. (i.e. Tables 12 and 15 will be the same as those of other funds).

```
A MANUFACTURING COMPANY'S STAFF FUND (C)                                  4                    5
HAS476     HAS177          2     3     +     5     6
                1          2     3     4     5     6     7
NIL. (PROPERTY IN SEPERATE FUND).
NO POLICY
    5187261    2126255     833454      69733      98329
    6331911    2683243    1040805     237120      60674
      46914          0          0          0
     -23650          0          0     114728
      60905      97345          0     103167
INCOME EARNED          NOT AVAILABLE          NET          NOTIONAL  CAPITAL
1          5                                                         MONTHLY TOTALS
       1212
       2231
       2001
     122227      10488      39701

31 11977       179682     166.52     105.51      50.5     102.03      83.73
26 21977       136425     176.77     106.44      49.3      99.82      86.75
31 31977        45618     176.51     114.24      55.3      90.42      87.85
REPAID INCOME          ALL
     1.3257     1.7150
     1.2459     1.7128
     1.2221     1.7201
FINISH
END
```

FIGURE 10.8

Example of a Fund Data file with the "NO POLICY" option

```
A CONSUMER GOODS MANUF.'S PENSION FUND (W)                                2                    4
HR376      HR476
                1          4          2          6          3          5
NIL.
                           1.0        0.0        0.0        0.0        0.0        0.0
TRUSTEES' WISH (R) GILTS OF OVERSEAS).
   7652371     311122      71433     603310
   7357628     294362      76125    1363427
   -100553      -1142          0
    -23652          0          0
   +340034          0
INCOME EARNED          NOT AVAILABLE                    NOTIONAL  GRAND TOTAL
    353523
  +101976     355914     135.04     134.33      98.88      46.37      87.71
   111976     294362
   121976     119746
REPAID INCOME          ALL
     1.1323     1.6563
```

F29 OPTIONS [ ] [ ] [1] [1] [1] [1] [1] [ ] [1]
FINISH
END F30 F31 F32 F33 F34 F35 F36 F37 F38

FIGURE 10.9

Example of a Fund Data file with the default option for some new money details, as well as some print options

To exercise this option, "MODEL" (F41) should appear in field F11 instead of a blank. Instead of policy proportions F12 there should appear the manager's own model profile (F42). Next follows a description of the basis for his model fund (F43). If a policy fund exists for this fund, items F11 to F13 should follow F43 as outlined.

F14. Initial market value, MV_o^s, of each sector.

F15. Final market value, MV_n^s, of each sector.

F16. Net purchases, P_t^s, for each sector, month by month. Each line gives the net purchases for one month of the sectors arranged in the order implied by F8.

F17. A label to act as a check on the correct format of the file. It must appear.

F18. This field should be left blank if complete data on income is available. Otherwise it should show "NOT AVAILABLE", as in Figure 10.8.

F19. Indication of whether tax has been paid on at least some income. If all income figures to be quoted lower down in the file (even if they are incomplete figures) are gross of tax, this field should be left blank. Otherwise "NET" should appear.

The system knows the sectors whose income earned has to be grossed up by reference to an array INCTAX, which is set in a DATA statement.

F20 and F21 concern options regarding the estimation of missing income data. They are explained in IV.4 below.

F22. Income earned data, I_t^s. Each line refers to the income earned in the various sectors during one month. They include any income repaid to trustees.

F23. The dates on which new money is deemed to have been first available to the fund. Each line concerns the aggregate new money flow for one month.

If no day number is specified in the date, the 15th of the month is used by default for the purpose of calculating average new money $\bar{C}$. A definite day may not be indicated because the money was spread evenly over the month, or because such an assumption is necessary due to a lack of information. An example is given by Figure 10.9.

F24. The amounts of new money, $C_{t(i)}$, i=1 to n.

F25. Index values, $X^s_{t(i)}$, as at the date of the new money flow $C_{t(i)}$. The values appear in the order of sectors implied by F8, even for sectors in which the fund is not invested.

If no index values are quoted, they are set by default to the averages M5 provided that the day number in the corresponding date F23 is blank. If it is not blank, the absence of index numbers is interpreted as an input error and the analysis of this fund is terminated after an error message is printed. Thus if a user is not concerned about the timing of new money (for example because it is only small), some input effort can be saved by the use of this default.

F26. This field acts as a format check. It must appear.

F27. Depending on this field, figures for income repaid to trustees, $R1^s_t$, are set by default or according to subsequent input. The options are:

(i) "NONE". All repaid income is set to zero (Figure 10.7).

(ii) "ALL". Repaid income is equated to income earned (F22). That is $R^s_t = I^s_t$ for all s and t (Figure 10.8).

(iii) "SOME". Some, but not all, of income earned was repaid to the trustees. The amounts repaid (F46) must appear starting at the next line in the same format as F22. (See Figure 10.10).

```
A NON-L.A. PUBLIC UTILITY CORPN. FUND (C)                    1                    5
HNW274     HNW374
        2          3          1          4          6          5
NIL. (PROPERTY IN SEPERATE FUND)
                0.30       0.0        0.70       0.0        0.0        0.0
15/ OF FUNDS TO SEPERATE PROPERTY ACCOUNT.
    590359     610503    1620870          0    2494305
   3733604     556839    1656177     512225    5081933
    422857     -55658     -87384          0
   2029043          0      -3719          0
    688747          0     484850     584867
INCOME EARNED                                NET
      4904       3129       2951          0          0
      4406       1686        673          0          0
     54787          0      32283          0     127900
31 71974      2874000     59.748      44.60     100.43      79.31      95.31
24 81974      2526000     57.377      42.63      91.98      71.55      92.90
18 91974      1146462     59.562      43.51      84.25      67.72      90.15
REPAID INCOME          SOME F27
          0          0          0          0          0
          0          0          0          0          0   }F46
          0          0          0          0     127900
     1.6755     2.3869
     1.6653     2.3225
     1.6527     2.3142
OPTIONS                         1     1     1          1
FINISH
END
```

FIGURE 10.10

Example of a Fund Data file with repaid income option "SOME"

Note that if income earned figures for a sector are net of tax, it is automatically assumed that repaid income figures for the same sector are also net of the same tax rate. It is also assumed by the software that if complete figures on income earned are NOT AVAILABLE (so that F18 is not blank) then the repaid income option F27 will always be ALL. In other words, it is assumed that arrangements are such that the fund manager either receives all the income of all sectors directly, or he received none at all. The consequences are that:

(i) If the fund manager knows details about how much income was earned, he must know how much, if any, was repaid to trustees.

(ii) If the fund manager does not know all details of income earned, then all income must have been repaid to trustees.

In other words, the situation where a manager receives income directly for some sectors, yet income for other sectors is sent directly to trustees is assumed to be impossible. This assumption was made for the sake of simplicity. If it does not hold for a particular fund, one has to treat the figures as if all income was repaid to trustees by adding the income received onto new money.

F28. Exchange rates $E^{p}_{t(i)}$ and $E^{o}_{t(i)}$ in the same format as M9. They refer to the rates as at the dates of new money flows and correspond line by line. If no rate appears for a month, the corresponding average (M9) is used by default. This option would be used if either, there was no new money this month, or its date F23 is unspecified, or there is no overseas sector in either the actual fund or any nominal fund. (Figure 10.9).

F29. "OPTIONS" indicates that the following fields are to specify which tables in the Fund Performance Report are to be excluded from the report. If no such options are wished to be exercised, this line is omitted altogether, as in Figure 10.7. Figure 10.9 illustrates a file for which it is present.

F30 and F38 specify the option. A non-zero number indicates that the associated tables are not to appear for this fund. The options are as follows. (The table numbers are as for the sample report in Figure 12.1).

F30. Tables concerning performance analysis (Tables 6,7 and, if F33 is exercised also, table 5).

F31. Performance components expressed as absolute amounts (Table 7).

F32. Overseas performance analysis (Table 8).

F33. Income performance analysis (Table 9).

F34. Tables of cummulative ROR's over past reviews (Tables 10, 11, 12).

F35. Tables of average annual ROR's over past reviews 13, 14, 15).

F36. Table of average component values over past reviews (Table 16).

F37. Accounting information concerning income earned, net purchases etc (Table 18 and 19).

F38. Risk measures. (Table 17).

In addition, if F30 is zero or blank, tables 12 and 15 (giving cumulative and average ROR's for the model fund) will not appear. The report derived from the file in Figure 10.9 will, for example, lack an income analysis, all historical tables and risk measures. These options, whether exercised or not, are checked for consistency with the rest of the Fund Data file. If there is inconsistency, the erroneous option is ignored and a warning message regarding it is printed within the report. For example, if no old history file (F4) is specified for the fund, yet not all of the options F34, F35, F36 and F38 are non-zero, a warning message will be printed.

F39. "FINISH" indicates the end of information for this fund.

F40. "END" indicates the end of the whole file.

Finally, it must be noted that all the above figures have referred only to the assets of a pension fund which are to be assessed. These assets combine to form the "Main Fund", which may differ from the fund as a whole because of excluded investments as specified in F9. Usually excluded investments are accounted for in separate accounts. If this is not the case however, the figures for excluded investments must be input so that they can be used to adjust the data for the Main Fund. Income and sales proceeds from an excluded sector are counted as new money into the Main Fund, while a positive level of net purchases is seen as a capital outflow from the Main Fund.

Data for the excluded sector is simply added on as an extra field, wherever appropriate. Thus F44 is excluded sector net purchases, while F45 is income earned, and F47 is that part of income earned in the excluded sector which was repaid to trustees. If, as in Figure 10.7, there is no excluded sector, the fields are simply left blank.

IV.4.1 FUND DATA FILE WITH MULTIPLE FUNDS

Items F1 to F39 are repeated in succession for every fund in the one batch run. At the very end of the file, END should appear. Figure 10.11 indicates the structure for a batch of three funds.

IV.4.2 EXAMPLES FOR PERIODS EITHER THAN ONE QUARTER

Figures 10.5 to 10.11 illustrate files applicable to a three month review period. Figure 10.12 applies to a one month review period, Figure 10.13 to a two month period, while Figure 10.14 is over one year, which is the maximum length of the review period for which the software can cater.

IV.5 DATA FILE CREATION USING AN INTERACTIVE PROGRAM

If it is intended that bank staff enter a fund's data on a real-time basis, a small interactive program could be made to receive data in a free-format form which matched the

(a)

```
A MANUFACTURING COMPANY'S STAFF FUND (D)                                  4                    5
HAS477    HAS178          2    4    6    8   10
          1          2          3          4          6          5
NIL. (PROPERTY IN SEPERATE FUND).
NO POLICY
   7464510    3007659    1038817     380970     750358
   7336577    3053395     981568     436198     839456
     35116     160000          0          0
     78663      48598          0          0
    -51016          0          0          0
INCOME EARNED          NOT AVAILABLE          NET          NOTIONAL  PARTIAL
1          5                                                          MONTHLY TOTALS
      3370
      2031
      3215
    130547      10243      37390

31 11978       139207     205.94     118.94       62.6       89.25      99.90
28 21978        77079     193.37     117.51       60.7       87.04     101.87
31 31978       143656     205.27     117.26       60.9       89.21     103.35
REPAID INCOME          ALL
    1.4857     1.9520
    1.3876     1.9364
    1.2698     1.8625
FINISH
A CONSUMER GOODS MANUF.'S PENSION FUND (A)                                2                    4
HH477     HH178          3    4    5    6    7
          1          4          2          6          3          5
NIL.
                1.00       0.0        0.0        0.0        0.0        0.0
TRUSTEES' WISH (NO GILTS OR OVERSEAS).
  1517590     324470     107250    1441492
  1494481     270696      96000    2121436
   -20356          0          0
   -63795          0          0
   196053          0      81970
INCOME EARNED          NOT AVAILABLE                    NOTIONAL  GRAND TOTAL
   208173
  0178        255763
  0278        237936
  0378        196076
REPAID INCOME          ALL
```

(b)

```
OPTIONS                    1
FINISH
A MANUF. COMPANY'S WORKMEN'S FUND (E)                                     5                    5
HAW477    HAW178          2    4    6    8   10
          1          2          3          4          6          5
NIL. (PROPERTY IN SEPERATE FUND).
NO POLICY
   3781309    1936952     315188     235765     629495
   3774703    2033963     238264     262025     870024
     15156     160000     -70547          0
     94361      48598          0          0
    -13336          0          0          0
INCOME EARNED          NOT AVAILABLE          NET          NOTIONAL  PARTIAL
1          5                                                          MONTHLY TOTALS
      2745
      2031
      4038
     69264       5158      28827

31 11978       176234     205.94     118.94       62.6       89.25      99.90
28 21978       215934     193.37     117.51       60.7       87.04     101.87
31 31978        82593     205.27     117.26       60.9       89.21     103.35
REPAID INCOME          ALL
    1.4857     1.9520
    1.3876     1.9364
    1.2698     1.8625
FINISH
```

(c)

FIGURE 10.11

Example of a Fund Data file for a batch run of 3 funds

```
A MANUF. COMPANY'S WORKMENS'S FUND (E)                          5                    4
HW176      HW276
          1          2          3          6          4          5
NIL. (PROPERTY IN SEPERATE FUND).
                   0.63       0.23       0.07        0.0       0.03       0.07
TRUSTEE WISH OF NO OVERSEAS INVESTMENT.
   2453963     501849     307638      79970
   2433877     488809     301158     202551
     64545       -468          0
     18445       -553          0
INCOME EARNED          NOT AVAILABLE          NET          NOTIONAL  PARTIAL
1          4                                                          MONTHLY TOTALS
       523
      1026
      1778      15651

28 21976        10768     167.12     103.63       53.6      90.71      87.24
31 31976       216735     164.61     104.78       49.5     132.77      87.59
REPAID INCOME          ALL
    1.3437     2.0253
    1.2660     1.9153
OPTIONS        1          1     1     1     1          1
FINISH
END
```

FIGURE 10.13

Example of a Fund Data file for a review period of two months

```
A MANUF. COMPANY'S WORKMEN'S FUND (E)                                   5                    5
HW1176     HW1276          2     5     8     9    13
          1          2          3          4          6          5
NIL. (PROPERTY IN SEPERATE FUND).
                   0.63       0.23       0.07        0.0       0.03       0.07
TRUSTEE WISH OF NO OVERSEAS INVESTMENT.
   2554599    1040771     277643      34561     341582
   2430684    1324111     234513      34862     122012
      5543     265139          0          0
INCOME EARNED          NOT AVAILABLE          NET          NOTIONAL  PARTIAL
1          5                                                          MONTHLY TOTALS
      2983
     10831

31121976        79111     132.06      91.88       46.7     107.46      84.63
REPAID INCOME          ALL
    1.1672     1.7028
OPTIONS   1     1          1
FINISH
END
```

FIGURE 10.12

Example of a Fund Data file for a review period of one month

```
A NON-L.A. PUBLIC UTILITY CORPN. FUND (C)                    1                    6
HNWY76     HNWY77
          2          3          1          4          5          6
NIL. (PROPERTY IN SEPERATE FUND)
                   0.30        0.0     0.6912        0.0     0.0088        0.0
15/ OF FUNDS TO SEPERATE PROPERTY ACCOUNT.
  13581226     422602   20617090    3541667     352009    1526587
  30664863     394072   20061964    7168410     369395     787139
   -359941          0     809456          0          0
  -4353688          0     597458          0          0
   4105609          0     584845     524753          0
  -3127000          0     777000     487000          0
   1081000          0    1227000     366000          0
   4722000     -36000     647000     590000          0
   1354759          0          0     929226          0
    598217          0    -305031    1060692          0
   4935556          0     -67879       6473          0
   2490588          0      19685          0          0
   -122021          0      -8696          0          0
   1631000     -105563     485397          0          0
INCOME EARNED                                   NET
     16250       5382      79163       4211          0       9529
    133522       2194      89178       3300          0      24291
     86175          0      63771       5732          0      62036
    226706          0     152776       9309          0      11213
         0          0      51120       4429          0      14552
         0       5384      31311       6903       9874     131144
     35841       5621      67740      13222          0      12284
    121434       2194     121774       9084          0      79998
         0          0      44559       5940          0      49936
    268125       1110     164247      19766          0      11435
         0          0      33122      11064          0       6351
     60840      10527      49566      17196          0      34213
14 41976     1405881     103.94      49.58     169.85     100.31     87.680
18 51976     1518335     105.25      52.14     167.54     101.26     88.535
14 61976      960327     103.07      51.62     157.84     101.95     88.990
16 71976     1712929     103.36      52.25     160.95     104.68     89.215
 8 81976     1739119     102.59      50.76     153.04     103.49     89.785
12 91976      741200     100.69      47.34     143.12     104.29     90.240
28101976     2912661      93.85      47.41     116.67     101.61     89.065
18111976     2729257      96.94      44.62     135.39     101.89     86.715
20121976     1132305      97.50      46.07     145.11     103.65     85.175
16 11977     1157348     103.69      49.37     155.69     103.73      85.18
19 21977     1048493     105.41      50.13     165.11     100.49      86.79
16 31977     1206902     110.53      53.98     175.24     102.17      87.30
REPAID INCOME          NONE
     1.2824     1.8548
     1.1646     1.8167
     1.1900     1.7724
     1.2374     1.7754
     1.3193     1.7889
     1.2051     1.7537
     1.1268     1.5860
     1.1825     1.6820
     1.1481     1.6797
     1.2020     1.7112
     1.2832     1.7048
     1.2308     1.7171
FINISH
END
```

FIGURE 10.14

Example of a Fund Data file for a review period of one year

organisation of bank records and so makes data input more convenient. The data could be re-organised by the program into the fixed format form outlined in IV.4 above. The data validity checks and modifications, plus even income estimation (all described below) could also be done by this program. This was not done in this study however because of the lack of generality of any such coding.

IV.6 INPUT DATA VALIDITY CHECKS

Checks on the consistency of some of the data in both the Market and Fund files are made in an attempt to avoid nonsense analysis, or in the case of errors in the Fund Data file, the abortion of a multiple-fund batch run just because the first fund had a minor data error. If an error is identified in the Market file, an error message is printed on a new page with a heading for that fund. The system then skips to the analysis of the next fund. Appendix 10-II gives a complete list of the error messages and what errors they indicate. Figure 10.15 gives some of the more important error messages. Message (c) is an example of the cessation of all anlysis because of nonsense data. Message (b) occurs if certain flags in the data (such as "REPAID INCOME") are not struck when they should be. Message (m) would be associated with a skip to the data of the next fund on the Fund Data file.

The only test for the arithmetic accuracy of the data is associated with message (l). The accuracy of the data is tested by checking that the final cash balance is consistent with the initial cash balance plus all moneys received, less all moneys spent during the period. The correct final cash balance, MV^S should be :

$$MV_n^S = MV_o^S + C + (I - R) - (P - P^S) \quad - (10.1)$$

Final balance	=	Initial balance	+	Moneys received (new money + retained income)	-	Moneys spent (net purchases in non-cash sectors)

In practice, small errors of accounting are common, so a tolerance of plus or minus £500 is allowed before any inequality is regarded as an error.

```
PERFORMANCE REPORT FOR SOCIETY OF INVESTMENT ANALYSTS' EXAMPLE.   OVER PERIOD   1  1 1977  TO   1  3 1977      PAGE  1
**********INPUT NUMBER OF SECTORS IS INVALID

************************************ END OF REPORT FOR SOCIETY OF INVESTMENT ANALYSTS' EXAMPLE.  ************************************

PERFORMANCE REPORT FOR A LOCAL AUTHORITY SUPERANNUATION FUND (B)  OVER PERIOD   1  4 1975  TO  30  6 1975      PAGE  1
**********INVALID INPUT OF    46.110 OR        -0 FOR MONTH  BAND SECTOR  6

************************************ END OF REPORT FOR A LOCAL AUTHORITY SUPERANNUATION FUND (B)  ************************************

PERFORMANCE REPORT FOR A NON-L.A. PUBLIC UTILITY CORPORATION (C)  OVER PERIOD   1  7 1976  TO  30  9 1976      PAGE  1
**********TOO MANY INPUT CARDS

************************************ END OF REPORT FOR A NON-L.A. PUBLIC UTILITY CORPORATION (C)  ************************************

**********CONFLICTING OR UNRECOGNISABLE INCOME OPTION INFORMATION AS FOLLOWS
    AVAILABILITY=NOT AV    NOTIONAL INCOME OPTION=          PARTIAL DATA OPTION=GRAND

PERFORMANCE REPORT FOR EXAMPLE TAKEN FROM KINGSTON'S ARTICLE (  ) OVER PERIOD   1  1 1974  TO  31  3 1974      PAGE  1
**********FUND DATA APPEARS INCONSISTENT AS FOLLOWS -
INITIAL CASH =    100000  NEW MONEY =    470000  TOTAL PURCHASES =    406000  RETAINED INCOME =     36700
    ,SO TOTAL FINAL CASH SHOULD BE    200700  NOT    200000

************************************ END OF REPORT FOR EXAMPLE TAKEN FROM KINGSTON'S ARTICLE (  ) ************************************

PERFORMANCE REPORT FOR EXAMPLE TAKEN FROM KINGSTON'S ARTICLE (  ) OVER PERIOD   1  1 1974  TO  31  3 1974      PAGE  1
**********INPUT INFORMATION DOES NOT AGREE WITH NUMBER OF SECTORS  3

************************************ END OF REPORT FOR EXAMPLE TAKEN FROM KINGSTON'S ARTICLE (  ) ************************************
```

FIGURE 10.15

Examples of error messages regarding invalid input data

V INPUT DATA MODIFICATION

The guiding criterion in the design of the input section of the system was to make the information required as easy and as convenient as possible to collect. This meant that several modifications have to be made to the data by the program before proper performance measurement and analysis can begin. These modifications are as follows.

V.1 MODIFICATIONS TO MARKET DATA

1. For each month, calculate the average premium penalty. For most months, the penalty will not have changed, but when it does, its time-weighted average during the month is calculated.

2. Calculate the effective (penalised) exchange rate for the exchange of the proceeds of the sale of overseas assets back into pounds.

   An effective rate of exchange for the sale of overseas assets is calculated by subtroutine EXCHNG.

$$E_t^e = \frac{1}{\dfrac{\alpha}{E_t^o} + \dfrac{1-\alpha}{E_t^p}} \qquad (10.2)$$

   where α = Premium penalty as a proportion (0.25).

3. Calcualte the total number of days in the review period.

4. For those sectors which give market income information M7 in the form of annual index yields, calcualte pure income index values using subroutine INCYLD.

1: If \$y are sold, \$ 0.75y must be changed at rate E_t^p and \$0.25y must be sold at rate E_t^o. Thus the proceeds in pounds, x, will be

$$£\,x = \frac{0.75y}{E_t^p} + \frac{0.25y}{E_t^o}$$

so the effective exchange rate of dollars per pound is y/x = (10.2) above.

If $\overline{Y}_t^s$ = average annualised income yield for month t for sector s, expressed as a percentage, the income index is given by

$$IX_t^s = \frac{\overline{Y}_t^s \quad \overline{X}_t^s}{1200} \qquad (10.3)$$

Appendix 10-III shows that (10.3) depends on an assumption of constant income yield throughout the month, and that it is no less accurate than to method recommended by Weaver(84, p167) which uses data which is not as freely available.

V.2 MODIFICATIONS TO FUND DATA

1. Estimation of unknown income figures.

   This is discussed in section VI to follow.

2. Augment Main Fund totals by excluded sector cash flows, as described in IV.4 under items F44 to F47.

3. Gross up any after-tax income.

   Although pension funds do not pay any income tax, some funds received dividends and other income with tax already deducted. They receive a tax refund later, perhaps as early as the next month[1]. It is necessary to gross up each income in order to calculate gross income yields and to ensure comparability with the model fund's simulated income earnings. If the indicator F19 is not blank, subroutine GROSS is called by PRFORM2 to gross up the income earned figures I_t^s by the tax rates set in a DATA statement as array INCTAX. Subroutine GROSS carries out the transformation.

1: Such tax refunds should be counted as new money, not income earned.

$$GI_t^s = \frac{I_t^s}{1 - INCTAX(s)} \qquad (10.4)$$

for s = 1 to S, plus excluded sector income. Repaid income is also grossed up as

$$GR_t^s = \frac{R_t^s}{1 - INCTAX(s)} \qquad (10.5)$$

4. Calculation of total gross repaid income

Total gross repaid income is that part of the total gross income of a sector, GI_t^s, which was repaid to either the trustees or as pre-paid tax.

$$GRT_t^s = GR_t^s + GI_t^s - I_t^s \qquad (10.6)$$

5. Compute the increase in Cash for each month.

This increse corresponds to "net purchases" in the cash sector, P_t^S, which of course is not kept on records.

$$P_t^S = C_t - \sum_{s=1}^{S-1} P_t^s \qquad (10.7)$$

6. Calculate the effective (penalised) new money exchange rates $E_{t(i)}^c$ according to (10.2) using $E_{t(i)}^p$ and $E_{t(i)}^o$ in subroutine EXCHNG.

7. Identify the "life" of each sector in the fund over the review period.

Any sector which is either wholly purchased or wholly sold during the review period needs have its life quantified for the purpose of ROR calulation. The purchase data, P_t^s, is examined in connection with initial and final market values to deduce the life of a sector as a decimal number of months in array LIFE, and to deduce the beginning and ending month numbers of the life as integers stored in array SECTEX.

8. Totals are taken over sectors and over time.

For example, total net purchases, initial market value and gross repaid income are:

$$P = \sum_{s=1}^{S} P^s \quad \text{where } P^s = \sum_{t=1}^{n} P_t^s \qquad (10.8)$$

$$MVo = \sum_{s=1}^{S} MV_o^s \qquad (10.9)$$

$$GRT = \sum_{s=1}^{S} GRT^s \quad \text{where } GRT^s = \sum_{t=1}^{n} GRT_t^s \qquad (10.10)$$

VI. ESTIMATION OF UNKNOWN INCOME FIGURES

VI.1 NEED FOR AN ESTIMATION FACILITY

The typically poor quality of existing income information is due to the fact that, for accounting purposes, there is no real need to keep track of income on a sector-by-sector basis, let alone keep monthly totals of it. In a fund whose income is received directly by the trustees, the fund manager may have little knowledge of income earned and may be hesitant to request the figures for fear of damaging good customer relations. Thus income must sometimes be estimated.

VI.2 METHODS OF ESTIMATION

A few methods of income estimation, in increasing order of sophistication, are as follows:

1. Assume a constant income yield for the total portfolio and divide income between sectors according to the initial split of the portfolio.

2. Assume a constant income yield for each sector separately.

3. For each sector, estimate income using the income index for that sector over the current review period.

4. As in point 3, but adjust the estimates for an

assumed Selection effect (i.e. Assume that the fund's actual income is always either above or below index income).

5. If past data is available, use this to either estimate income by extrapolation, or to estimate the Selection effect mentioned above by regressing actual income on market income.

Because past information is not likely to be available for a fund for which current information is not available, income must usually be estimated from current information only.

VI.3 METHOD USED IN THIS STUDY

The method built into the software of this study is a combination of the third and fourth methods mentioned above. Estimates based on income indices are adjusted linearly to be consistent with any known income figures for the current period. In general,

$$\text{Revised estimate} = \frac{\text{Known figure}}{\text{Estimated figure}} \times \text{Index estimate} \qquad (10.11)$$

Suppose an index simulation of a fund produces the the following estimates of income earned.

Equities	Gilts	Cash	Total
£50,000	£40,000	£10,000	£100,000

If no information was available on income earned by the fund, these would be used as the best estimates available. Suppose total income earned was known to be £90,000. The above figures are then adjusted by the -10% Selection factor on the assumption that each sector has the same Selection effect. The resulting estimates would be:

Equities	Gilts	Cash	Total
£50,000	£36,000	£ 9,000	£ 90,000

The assumption of equal Selection effects in each sector is patently unrealistic but is not always necessary since often total income is known for some sectors, in which case (10.11) is applied to each sector individually.

The software can estimate income in this manner using many different combinations of available income data, even though that data may be imcomplete. It can use sector totals, monthly totals, the total income over the whole period, or any of these in combination with known figures for up to S - 1 sectors of the fund. The following sub-section details the input features of this facility. Chapter 11 (section IV) outlines the routines responsible for generating the estimates, while Appendix 11-II discusses the accuracy of the method.

VI.4 INCOME DATA OPTIONS WHEN INCOME INFORMATION IS INCOMPLETE

There is a heirarchy of choices available in the specification of these options. The following four fields in the Fund Data file are involved in all cases of income estimation. Figures 10.16 to 10.25 illustrate the appearance of the various options using the Fund Data file of Figure 10.7.

1. NOT AVAILABLE (F18) should appear after F17 if complete income for every sector for every month is not available.

2. The tax indicator (F19) should be left blank unless some income information is available and all or part of it is net of tax.

3. The following field, F20, indicates whether the user wishes unknown income figures to be estimated or not. If this field is left blank and NOT AVAILABLE appears in F18, the fund's performance will be assessed on capital value only. An Example of this option is shown in Figure 10.16

   If "NOTIONAL" appears in F20, the program estimates income from index yields, using any available income data (as specified using the

```
A NON-L.A. PUBLIC UTILITY CORPORATION (C)                    1                    6
HNW276    HNW376          2    4    6    8    9
        2         3         1         4         5         6
NIL. (PROPERTY IN SEPERATE FUND)
                0.30        0.0    0.6919       0.0    0.0061       0.0
15/ TO PROPERTY FUND, + LANIT HOLDING.
  12645175    401376  21271924   4335294    350391   4088365
  14700303    359588  20627705   5992225    360346   2255432
  -3127000         0    777000    487000         0
   1081000         0   1227000    396000         0
   4722000    -36000    647000    505000         0
INCOME EARNED        NOT AVAILABLE
16 71976     2110535    103.36     50.25    160.95    104.68    89.215
 8 81976     1809120    102.59     50.36    153.04    103.49    89.705
12 91976      926412    100.09     47.34    143.12    104.29    90.240
REPAID INCOME        ALL
    1.2374    1.7754
    1.3190    1.7889
    1.2051    1.7537
FINISH
END
```

FIGURE 10.16

Example of a Fund Data file with the income data option of assessment on the basis of capital value only

```
A NON-L.A. PUBLIC UTILITY CORPORATION (C)                    1                    6
HNW276    HNW376          2    4    6    8    9
        2         3         1         4         5         6
NIL. (PROPERTY IN SEPERATE FUND)
                0.30        0.0    0.6919       0.0    0.0061       0.0
15/ TO PROPERTY FUND, + LANIT HOLDING.
  12645175    401376  21271924   4335294    350391   4088365
  14700303    359588  20627705   5992225    360346   2255432
  -3127000         0    777000    487000         0
   1081000         0   1227000    396000         0
   4722000    -36000    647000    505000         0
INCOME EARNED        NOT AVAILABLE          NET          NOTIONAL
16 71976     2110535    103.36     50.25    160.95    104.68    89.215
 8 81976     1809120    102.59     50.36    153.04    103.49    89.705
12 91976      926412    100.09     47.34    143.12    104.29    90.240
REPAID INCOME        ALL
    1.2374    1.7754
    1.3190    1.7889
    1.2051    1.7537
FINISH
END
```

FIGURE 10.17

Example of a Fund Data file with income data option "NOTIONAL"

options to follow) to adjust the estimates using (10.11).

4. The nature of the incomplete income data which is available is indicated by F21 according to one of several options as follows:

(i) Blank - This implies that no data is to be offered and the income estimates are to be taken as those calculated from index yields. This field must be blank if F20 is also blank, since incomplete data is of no use unless it is to be used to modify estimates. Refer Figure 10.17.

(ii) GRAND TOTAL - Used if the total income on the whole review period for the whole fund is known (refer Figure 10.18).

(iii) MONTHLY TOTALS - This indicates that figures are to follow on the total income earned by the fund from all sectors, split on a monthly basis (refer Figure 10.19).

(iv) SECTOR TOTALS - When figures are available for each sector on the total income earned by that sector over the whole review period, this option should be specified. Figure 10.20 shows this option.

(v) PARTIAL - This option allows any of the options above to be combined with complete monthly income figures which are known for one or more sectors of the fund. For example, because equities are the largest sector of a fund, complete income data may be available on this sector but not for others. Using the PARTIAL option, the known figures for equities can be used, while the income of other sectors is estimated in conjunction with any other income data which is available, such

```
A NON-L.A. PUBLIC UTILITY CORPORATION (C)                    1                    6
HNW276     HNW376          2     4     6     8     9
        2          3          1          4          5          6
NIL. (PROPERTY IN SEPERATE FUND)
                  0.30        0.0     0.6919        0.0     0.0081        0.0
15/ TO PROPERTY FUND, + LAMIT HOLDING.
  12645175     401376  21271924   4335294     350391   4088365
  14700303     359588  20627705   5992225     360346   2255432
  -3127000          0    777000    487000          0
   1081000          0   1227000    396000          0
   4722000     -36000    647000    505000          0
INCOME EARNED          NOT AVAILABLE          NET          NOTIONAL  GRAND TOTAL
F48  597936                F49
16 71976      2110535     103.36      50.25     160.95     104.68     89.215
 8 81976      1809120     102.59      50.36     153.04     103.49     89.705
12 91976       926412     100.09      47.34     143.12     104.29     90.240
REPAID INCOME          ALL
    1.2374     1.7754
    1.3190     1.7889
    1.2051     1.7537
FINISH
END
```

FIGURE 10.18

Example of a Fund Data file with income data option "GRAND TOTAL"

```
A NON-L.A. PUBLIC UTILITY CORPORATION (C)                    1                    6
HNW276     HNW376          2     4     6     8     9
        2          3          1          4          5          6
NIL. (PROPERTY IN SEPERATE FUND)
                  0.30        0.0     0.6919        0.0     0.0081        0.0
15/ TO PROPERTY FUND, + LAMIT HOLDING.
  12645175     401376  21271924   4335294     350391   4088365
  14700303     359588  20627705   5992225     360346   2255432
  -3127000          0    777000    487000          0
   1081000          0   1227000    396000          0
   4722000     -36000    647000    505000          0
INCOME EARNED          NOT AVAILABLE          NET          NOTIONAL  MONTHLY TOTALS
F50 393681      64943     139312
                           F51
16 71976      2110535     103.36      50.25     160.95     104.68     89.215
 8 81976      1809120     102.59      50.36     153.04     103.49     89.705
12 91976       926412     100.09      47.34     143.12     104.29     90.240
REPAID INCOME          ALL
    1.2374     1.7754
    1.3190     1.7889
    1.2051     1.7537
FINISH
END
```

FIGURE 10.19

Example of a Fund Data file with income data option "MONTHLY TOTALS"

```
A NON-L.A. PUBLIC UTILITY CORPORATION (C)                                  1                    6
HNW276     HNW376          2     4     6     8     9
        2          3          1          4          5          6
NIL. (PROPERTY IN SEPERATE FUND)
                  0.3          0.3     0.6919        0.0     0.0081        0.0
15/ TO PROPERTY FUND, + LAMIT HOLDING,
  12645175     401376   21271924    4335294     350391    4068365
  14700303     359568   20627705    5992225     360346    2255432
  -3127000          0     77[illegible]    4873[illegible]         0
   1081000          0    1227[illegible]    396[illegible]         0
   4722000     -36[illegible]     647[illegible]    505[illegible]         0
INCOME EARNED          NOT AVAILABLE          NET          NOTIONAL   SECTOR TOTALS
F52 - 226306      59[illegible]    27[illegible]    [illegible]641      [illegible]974     15[illegible]
16 71976      2110535     1[illegible].36      5[illegible].25     1[illegible].95     164.68      89.215
 8 81976      1809120     1[illegible].59      5[illegible].36     153.[illegible]4     1[illegible].49     89.705
12 91976       926412     1[illegible].09      47.34     1[illegible].12     1[illegible].29     90.240
REPAID INCOME          ALL
    1.2374     1.7754
    1.3190     1.7889
    1.2051     1.7537
FINISH
END
```

FIGURE 10.20

Example of a Fund Data file with income data option "SECTOR TOTALS"

```
A NON-L.A. PUBLIC UTILITY CORPORATION (C)                                  1                    6
HNW276     HNW376          2     4     6     8     9
        2          3          1          4          5          6
NIL. (PROPERTY IN SEPERATE FUND)
                  0.3          0.3     0.6919        0.0     0.0081        0.0
15/ TO PROPERTY FUND, + LAMIT HOLDING,
  12645175     401376   21271924    4335294     350391    4068365
  14700303     359568   20627705    5992225     360346    2255432
  -3127000          0     77[illegible]    48[illegible]         0
   1081000          0    1227[illegible]    396[illegible]         0
   4722000     -36[illegible]     647[illegible]    505[illegible]         0
INCOME EARNED          NOT AVAILABLE          NET          NOTIONAL   PARTIAL
F54 1          6                    F55
      11213
      14452
     131144
16 71976      2110535     1[illegible].36      5[illegible].25     1[illegible].95     164.68      89.215
 8 81976      1809120     1[illegible].59      5[illegible].36     153.[illegible]4     1[illegible].49     89.705
12 91976       926412     1[illegible].09      47.34     1[illegible].12     1[illegible].29     90.240
REPAID INCOME          ALL
    1.2374     1.7754
    1.3190     1.7889
    1.2051     1.7537
FINISH
END
```

FIGURE 10.21

Example of a Fund Data file with income data option "PARTIAL" to provide income data for one sector

as the grand total of income etc.

The lines in the Fund Data file following the options 1 to 4 above vary according to the option specified in F21. The variation is due to the differing amounts of data involved in each option. The format consequent upon the following options exercised in F21 are as follows:

1. Blank

   No income data is to be specified, so new money details appear immediately after, as in Figure 10.17.

2. GRAND TOTAL

   The next line displays the total income figure

$$I = \sum_{s=1}^{S} \sum_{t=1}^{n} I_t^s \qquad (10.12)$$

   for the Main Fund (F48) and the total excluded sector income over the whole period (F49).[1] In Figure 10.18, total gross income earned by all four sectors over the quarter is £597,936. There is no excluded sector.

3. MONTHLY TOTALS

   Two lines of information follow. The first gives the various monthly totals for the fund in chronological order (F50):

$$I_t = \sum_{s=1}^{S} I_t^s \quad \text{for } t = 1 \text{ to } n \qquad (10.13)$$

   The second line gives the chronologically ordered monthly income for the excluded sector (F51). Note that even if the fund has no excluded investments, a second line must appear, even if only blank. Figure 10.19 has monthly total incomes for the Main Fund of:
   January £393,681; February £64,943; March £139,312.

1: It is assumed throughout that whatever pattern of figures is known for the Main Fund is alos known for the excluded sector. If there is no excluded sector, the fields can be left blank.

There is no excluded sector.

4. SECTOR TOTALS

The sector totals

$$I^s = \sum_{t=1}^{n} I_t^s \quad \text{for } s = 1 \text{ to } S \qquad (10.14)$$

as listed on the one line (F52), on the order implied by the standard sector codes in F8. If there is an excluded sector, its total income (F53) appears after the last sector total. Figure 10.20 represents a fund whose gilt, equity, OFI, Overseas, property trust and cash sectors earned £226,306, £5,980 £233,209, £20,641, £9,874 and £156,809 respectively.

5. PARTIAL

The least simple of the options, it involves specifying three things:

(i) Number of sectors of the fund for which complete income data is to be offered (F54). This is followed on the same line by the numbers (F55) of these sectors as they appear in the <u>fund's</u> file. The funds in Figures 10.21 to 10.24 have complete data on their cash sectors only.

(ii) This first line ends with the specification (F56) of any of the income data options mentioned above except PARTIAL.

(iii) The remainder of this section of the Fund Data file then follows the pattern already discussed above, according to which option is specified in F56. Figures 10.21 to 10.24 illustrate the various formats of these options.

Income estimation using the PARTIAL option is acheived by applying (10.11) to unknown income figures only. For example, if total equity income in the example of VI.3 above

```
A NON-L.A. PUBLIC UTILITY CORPORATION (C)                    1                    6
HNW276    HNW376        2    4    6    8    9
        2         3         1         4         5         6
NIL. (PROPERTY IN SEPERATE FUND)
                0.30        0.0    0.6919       0.0    0.0081        0.0
15/ TO PROPERTY FUND, + LAMIT HOLDING.
  12645175    401376  21271924   4335294    350391   4088365
  14700303    359588  20627775   5992225    360346   2255432
  -3127000         0    777000    487000         0
   1081000         0   1227000    396000         0
   4722000    -36000    647000    505000         0
INCOME EARNED        NOT AVAILABLE        NET        NOTIONAL  PARTIAL
1         6                                                    GRAND TOTAL F56
     11213
     14452
    131144
    597936
16 71976      2110535     103.36      50.25     160.95     104.68     89.215
 8 81976      1809120     102.59      50.36     153.04     103.49     89.705
12 91976       926412     100.09      47.34     143.12     104.29     90.240
REPAID INCOME        ALL
    1.2374     1.7754
    1.3190     1.7889
    1.2051     1.7537
FINISH
END
```

FIGURE 10.22

Example of a Fund Data file with income data option "PARTIAL" to provide figures for one sector as well as the fund as a whole

```
A NON-L.A. PUBLIC UTILITY CORPORATION (C)                    1                    6
HNW276    HNW376        2    4    6    8    9
        2         3         1         4         5         6
NIL. (PROPERTY IN SEPERATE FUND)
                0.30        0.0    0.6919       0.0    0.0081        0.0
15/ TO PROPERTY FUND, + LAMIT HOLDING.
  12645175    401376  21271924   4335294    350391   4088365
  14700303    359588  20627775   5992225    360346   2255432
  -3127000         0    777000    487000         0
   1081000         0   1227000    396000         0
   4722000    -36000    647000    505000         0
INCOME EARNED        NOT AVAILABLE        NET        NOTIONAL  PARTIAL
1         6                                                    MONTHLY TOTALS
     11213
     14452
    131144
    393681      64943    139312
16 71976      2110535     103.36      50.25     160.95     104.68     89.215
 8 81976      1809120     102.59      50.36     153.04     103.49     89.705
12 91976       926412     100.09      47.34     143.12     104.29     90.240
REPAID INCOME        ALL
    1.2374     1.7754
    1.3190     1.7889
    1.2051     1.7537
FINISH
END
```

FIGURE 10.23

Example of a Fund Data file with income data option "PARTIAL" to provide figures for one sector as well as income for the whole fund by month

```
A NON-L.A. PUBLIC UTILITY CORPORATION (C)                    1                    6
HNW276    HNW376        2     4     6     8     9
          2         3         1         4         5         6
NIL. (PROPERTY IN SEPERATE FUND)
                  0.30        0.0    0.6913       0.0    0.0081        0.0
15/ TO PROPERTY FUND, + LAMIT HOLDING.
  12645175     401376  21271924   4335294    350391   4068365
  14700303     359588  20627705   5992225    363346   2295432
  -3127000          0    777000    487000         0
   1081000          0   1227000    396000         0
   4722000     -36000    647000    505000         0
INCOME EARNED        NOT AVAILABLE        NET        NOTIONAL  PARTIAL
3         1         3         5                                GRAND TOTAL
    226306     150778     11213
         0      51120     14452
         0      31311    131144
    597936
16 71976      2110535     103.36      50.25     160.95     104.68     89.215
 8 81976      1809120     102.59      50.36     153.04     103.49     89.705
12 91976       926412     100.09      47.34     143.12     104.29     90.240
REPAID INCOME        ALL
    1.2374     1.7754
    1.3190     1.7889
    1.2051     1.7537
FINISH
END
```

FIGURE 10.25

Example of a Fund Data file with income data option "PARTIAL" to provide figures for 3 sectors as well as income for the fund as a whole

```
A NON-L.A. PUBLIC UTILITY CORPORATION (C)                    1                    5
HNW276    HNW376        2     4     6     8     9
          2         3         1         4         5         6
NIL. (PROPERTY IN SEPERATE FUND)
                  0.30        0.0    0.6919       0.0    0.0081        0.0
15/ TO PROPERTY FUND, + LAMIT HOLDING.
  12645175     401376  21271924   4335294    350391   4068365
  14700303     359588  20627705   5992225    363346   2295432
  -3127000          0    777000    487000         0
   1081000          0   1227000    396000         0
   4722000     -36000    647000    505000         0
INCOME EARNED        NOT AVAILABLE        NET        NOTIONAL  PARTIAL
1         6                                                    SECTOR TOTALS
     11213
     14452
    131144
    226306     150778     11213     23641      9874    156809
16 71976      2110535     103.36      50.25     160.95     104.68     89.215
 8 81976      1809120     102.59      50.36     153.04     103.49     89.705
12 91976       926412     100.09      47.34     143.12     104.29     90.240
REPAID INCOME        ALL
    1.2374     1.7754
    1.3190     1.7889
    1.2051     1.7537
FINISH
END
```

FIGURE 10.24

Example of a Fund Data file with income data option "PARTIAL" to provide figures for one sector as well as total income for each sector in the fund

were known to be £55,000 in addition to the knowledge that grand total income was £90,000, the adjusted estimates would be

Equities	Gilts	Cash	Total
£55,000	£28,000	£7,000	£90,000

where the Gilts figure, for example, was calculated as

$$40{,}000 \times \frac{35{,}000}{50{,}000}$$

It is the PARTIAL option which is mainly responsible for the program's flexibility in using available income data. Virtually any combination of known and unknown figures can be catered for, except those combinations which would be unlikely given the constancy of data sources. For example, it is not possible to use known income figures for only two months out of a quarterly review period. Given that the user can obtain data for two months, it is assumed he can obtain it for all three. Figure 10.25 shows the incorporation of known figures for the gilt, equity and cash sectors in combination with a grand total of £597,936.

Whichever way the estimated figures are derived, they are treated in the rest of the analysis as if they were the known income figures GI_t^s.

VI.6 USE OF MONTHLY INCOME TOTALS

Although the package provides easy use of available monthly totals to constrain the estimation of income, it is not recommended that this option be used unless the accounting system from which the fund data is extracted is organised on an accrual basis. This should produce figures which are stable reflections of what the fund actually earned month by month. If, however, a cash accounting system is used, items are entered only as they are paid and received (and not as they fall due as in an accrual system). A monthly income total here is not a stable reflecttion of what the fund actually <u>earned</u> during the month, but only what it received. Receipts can be mixtures of only a fraction of

what was actually earned in the month plus various proportions of incomes earned in previous months, depending on how efficient the transmission process is. Appendix 11-II shows results generated from the various options shown in Figures 10.12 to 10.25 They show that the MONTHLY TOTALS option can lead to estimates which are less accurate that those obtained when no income data is provided. (The data on which Figures 10.16 to 10.25 are based was extracted from a cash accounting system).

CHAPTER 11

TECHNICAL SPECIFICATION OF METHODS

The generation of simulated investment returns forms the heart of the methods used in the software for both ROR estimation and performance analysis. Because of its importance, care was taken to ensure that simulation procedures reflected actual investment practice as closely as was practically possible. Sections I to V of this chapter document how this was done. Section VI details the ROR estimates used in the software, while the remainder of the chapter deals with the role played in the system by the internally generated history files.

I. SIA'S SIMULATION METHOD

I.1 DESCRIPTION

Figure 11.1 shows the flow chart of the relatively simple simulation method implicitly recommended by the SIA(76,App.I). The steps, numbered to correspond with Figure 11.1, are as follows:

STEP 1: The initial holding of index units is calculated for each sector as

$$XH_o^s = \frac{MV_o^s}{X_o^s} \qquad - (11.1)$$

STEP 2: The new money flow as index units is calculated as either:

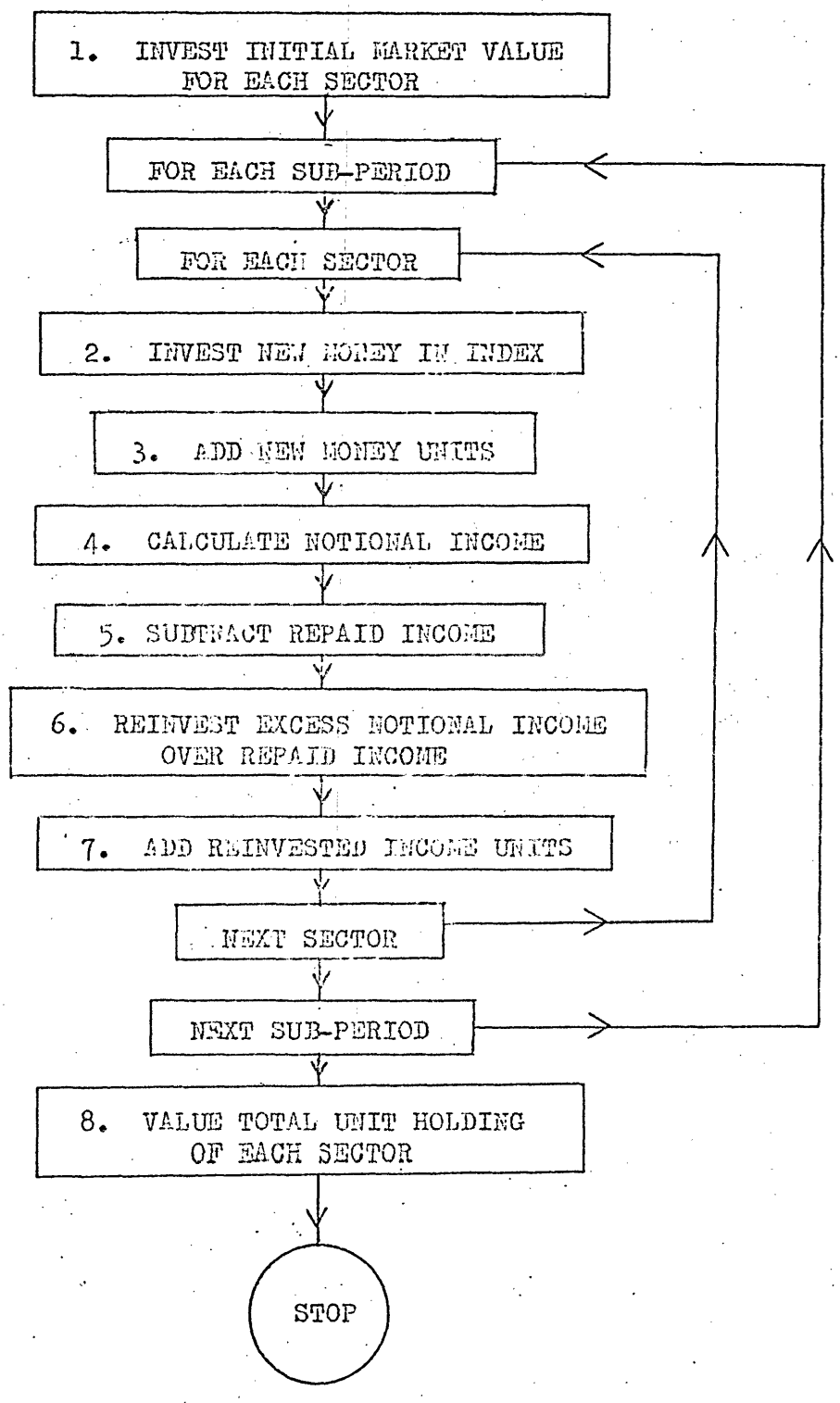
$$CX_{t(i)}^s = \frac{C_{t(i)}^s}{X_{t(i)}^s \ (1 + z_s)} \qquad - (11.2)$$

or

$$CX_t^s = \frac{P_t^s}{\bar{X}_t^s \ (1 + z_s)} \qquad - (11.3)$$

FIGURE 11.1

Flow chart of Society of Investment Analysts' simulation of a notional portfolio



where z_s = the relevant commission charge

$X^s_{t(i)}$ = the index level corresponding to the time, t(i), of the ith new money flow

$\bar{X}^s_t$ = the average index level for the sub-period t.

(11.2) is used for all notional portfolios except the simulated actual portfolio, $V(\pi_a)$, for which (11.3) is used to simulate the investment of actual new money (net purchases in sector s) with passive timing according to the average index level for the sub-period (e.g., month).

The SIA assumed that there is only one new money flow per month (so that i = 1 to n)

STEP 3: See Step 7 below.

STEP 4: Notional income is calculated by assuming that new money entered a sector halfway through the sub-period[1]

$$NI^s_t = IX^s_t \cdot XH^s_{t-1} + IX^s_t \frac{CX^s_{t(i)}}{2} \qquad - (11.4)$$

STEP 5: The SIA assumed that all income was repaid to trustees, giving excess notional income to be reinvested as

$$NI^s_t - GR^s_t \qquad - (11.5)$$

STEP 6: Excess notional income as index units is

$$\frac{NI^s_t - GR^s_t}{\bar{X}^s_t\,(1 + z_s)} \qquad - (11.6)$$

1: If there were more than one new money flow in a month (say f(t) flows), than the last term of (11.4) should be

$$IX^s_t = \frac{1}{2} \sum_{i=1}^{f(t)} CX^s_{t(i)} \qquad - (11.5)$$

assuming it is reinvested at the average index level for the sub-period.

STEP 7: The amount of index units held in the sth sector at the end of the tth sub-period is

$$XH_t^s = XH_{t-1}^s + CX_{t(i)}^s + \frac{NI_t^s - GR_t^s}{\bar{X}_t^s\ (1 + z_s)} \qquad - (11.7)$$

STEP 8: After steps 1 to 7 have been repeated for all sectors s=1 to S and all sub-periods t=1 to n, the simulated final market value of each sector is determined as:

$$V(\pi)^s = XH_n^s \cdot X_n^s \qquad - (11.8)$$

with a final market value of the total portfolio as

$$V(\pi) = \sum_s V(\pi)^s \qquad - (11.9)$$

I.2 IMPERFECTIONS IN THE SIA'S METHOD

The SIA's method was programmed in the early stages of this study and was found to have several shortcomings which, taken together, could lead to appreciable error. Many of these errors and omissions were corrected in the course of this study. They are listed below. Their remedies are discussed in the next section.

1. The SIA suggest that a notional portfolio can be charged for the dealing expense of realigning its profile back to its desired proportions.

   This suggestion was implemented in the software developed here for three reasons:

   (i) Its cumulative effect on performance statistics over a number of successive review periods may be significant. This was one of the objections raised to Holbrook's study (41,p75).

(ii) Evans(24) has shown that a mechanical trading rule, whereby a portfolio's split by market value between its securities is re-established to its original proportions at the end of every sub-period, leads to a higher ROR than a naive buy-and-hold strategy in which no such realignment is made. If this phenomenon holds as a general rule, a notional portfolio has a subtle advantage over a real portfolio, whose realignments cost money, unless notional realignments between review periods are also charged dealing expenses.

(iii) To ensure fair comparisons with trustee policy funds.

Without charging a policy fund which shifts rapidly in emphasis from sector to sector according to current expectations, the extra return from such large shifts (if correct) can easily make such a policy appear wise, when in reality the extra return may not cover the large dealing costs of such dramatic shifts between sectors.

2. The general method implied by the SIA's appendix breaks down when applied to a notional portfolio which does not include a sector which is represented in the actual fund.

The problem in such cases centres on the treatment of repaid income of the unrepresented sector. When actual repaid income is subtracted from the nil index unit holding in a notional portfolio (step 5 in Figure 11.1), a negative holding of index units results. Furthermore, it will grow to be more negative than actual repaid income from this sector since negative notional "income" will be earned on it and added to the holding.

Superficially, this seems harmless, the interpretation being that the notional portfolio "borrows" to pay the repaid income and pays a rate of interest equal to the index yield of the unrepresented sector. However the practice is suspect for two reasons. Firstly the relevant rate of interest would not in reality be the index yield, and secondly, negative final market values are nonsense to the layman.

3. The SIA's method breaks down when a sector is sold off completely during the review period.

During the simulation of $V(\pi_a)$, the complete sale of a sector will leave a balance of index units held in that sector, since the sale will usually have been at either a profit or loss. If it was at a loss, a positive index unit holding will remain, and, what is worse, will grow with the notional "income" earned on it after the sale takes place. If the sale made a profit, a negative index holding will result, leading to the problems described in the previous point.

4. The cash sector is not simulated with its own notional ROR.

The SIA assume that the market ROR for cash is the same as that actually earned by the fund. The need for this automatic equation is not clear. Admittedly, the local authority 7 day rate, or any other representative short term rate, is not a perfect index, but is at least a concrete standard of performance against which a manager's management of cash can be assessed. In any event, its contribution to the total Selection component is easily identified.

5. The SIA give no guide to the special procedures involved in the simulation of overseas investments.

   These centre on the rate of exchange problem, complicated by the dollar premium.

6. The SIA calculates notional income on the assumption of mid-month arrival of new money (see (11.4)).

7. The SIA's method of handling the reinvestment of excess notional income does not generalise to cases other than when all income is repaid to trustees.

   In reality, retained income is not automatically reinvested in the sector from which it came, but is deposited in cash and subsequently used along with any new money to finance the manager's strategy for the fund as a whole. In simulating the actual fund, it is only the excess of notional income over income earned (and not income repaid, as in (11.5)) which should be automatically reinvested in the same sector. The SIA's method, if generalised, would lead to all retained income being automatically reinvested in the same sector. To the extent that the notional return earned on that income differs from the actual return earned on it in practice by its deposit in cash and eventual redistribution, the Selection component will be incorrect. The accumulation of notional income in a sector in which actual income was in reality not reinvested will obscure the Selection component for that sector.

Some of these changes may appear to be only minor, but VI.1 of Chapter 12 will demonstrate that in some cases they can make a difference of 1% in quarterly excess return.

II. SIMULATION METHOD OF THIS STUDY

Figure 11.2 shows the flow chart of the simulation procedure used in the software to derive the investment

FIGURE 11.2

Flow chart of the simulation of a notional portfolio as it is done by software of this study

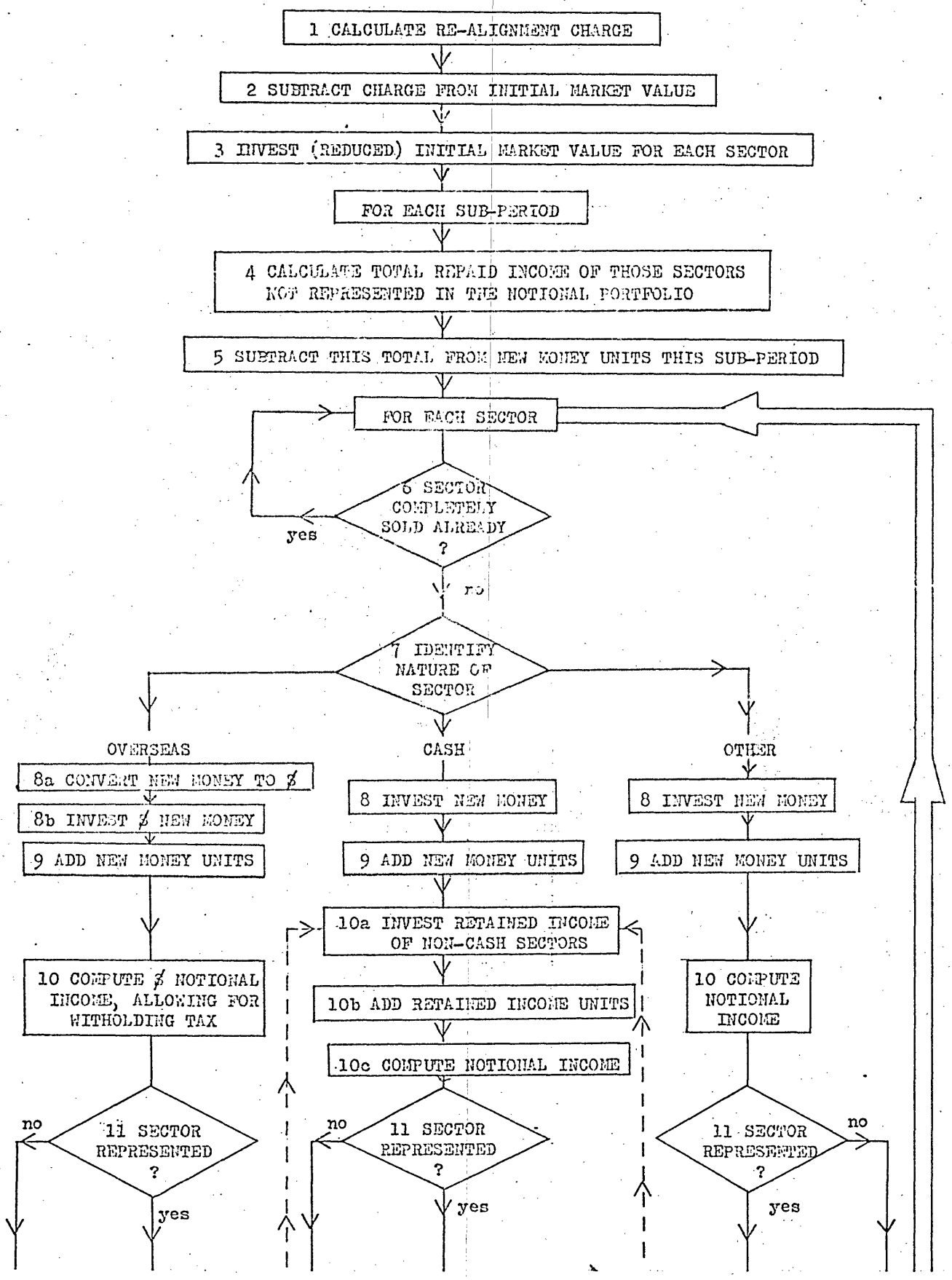
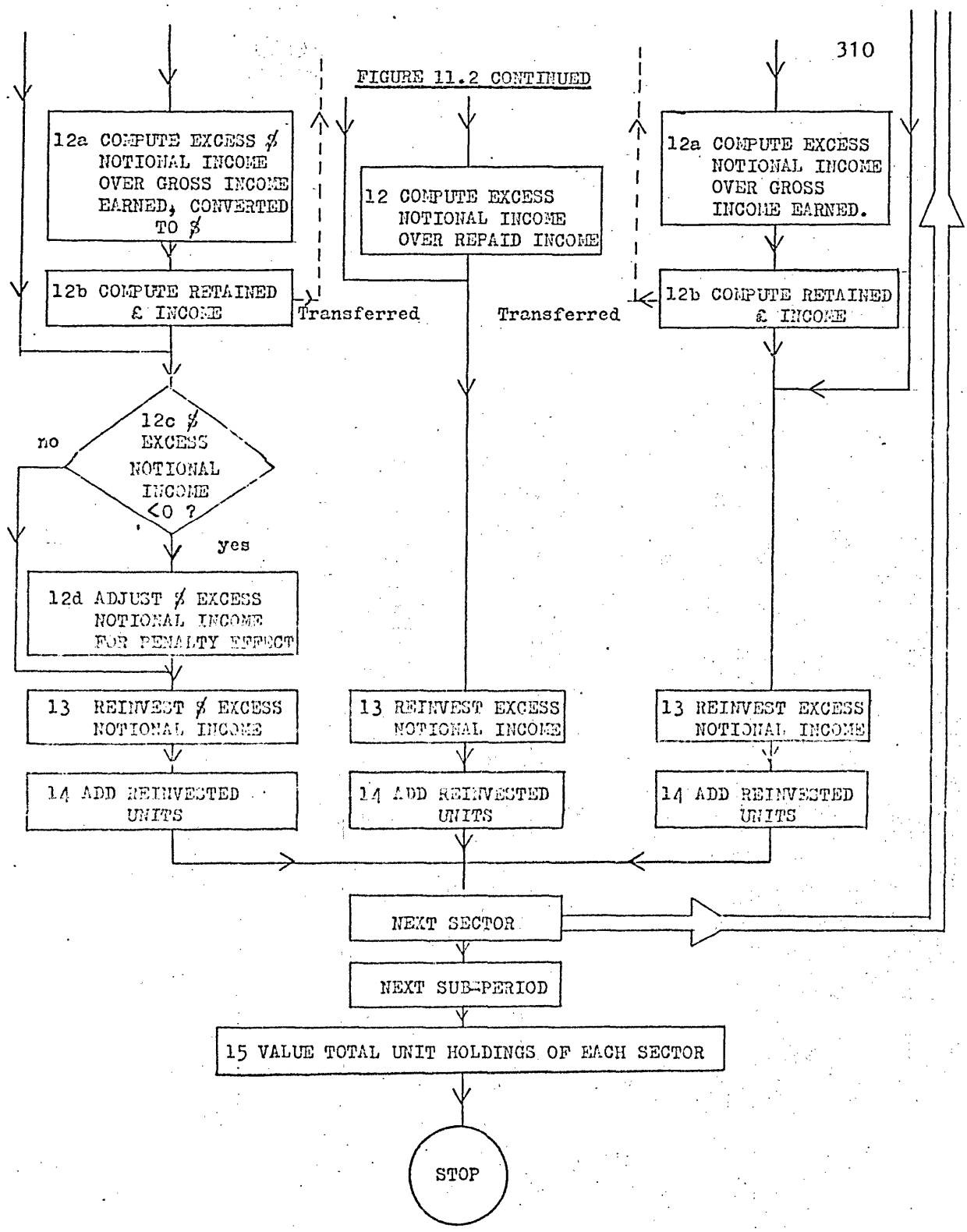


FIGURE 11.2 CONTINUED



performance of the notional portfolio $V(\pi_a)$. The procedure used to simulate the other notional portfolios (e.g., $V(\pi_m)$) differs slightly in the treatment of excess notional income, but is otherwise the same. The following sub-sections correspond in order to the numbered steps in Figure 11.2.

II.1 SIMULATED DEALING COSTS

II.1.1. APPROXIMATION

Dealing commissions for most sectors are set by self-regulating professional bodies at certain recommended levels. The Stock Exchange, for example, has a fixed sliding scale of charges according to the size of the deal and the type of security involved. The mathematical function used to represent charges for the purposes of simulation must be simple in view of the frequency with which it must be used. Charges are represented in the software developed here as purely linear functions of bargain size, where the slope chosen represents a dealing commission which in reality is relevant to the size of deal which would be most frequent for pension funds. Figure 11.3 shows the variation of the commission (i.e., slope) for dealing in registered shares on the London Stock Exchange as at mid - 1976[1]. The software uses a representative charge of 0.42%. This corresponds to a deal of a little over £0.5m. Although no detailed statistics are readily available on the sizes of bargains made by pension funds, it was thought that this level would be reasonably accurate for the simulation of both large-scale profile realignments and the usual transactions involved in the investment of new money. Half a million pounds is an adequate basis for the latter because funds are allowed to accumulate bargains over three months as a basis for the calculation of commission level. Its adequacy for the former purpose is less certain (it may over-estimate the cost) although it can be argued that the large deals involved in major profile realignments would necessitate many small placements with different brokers rather than one large placement.

1: Based on non-divisible charges, with no allowance for stamp duty

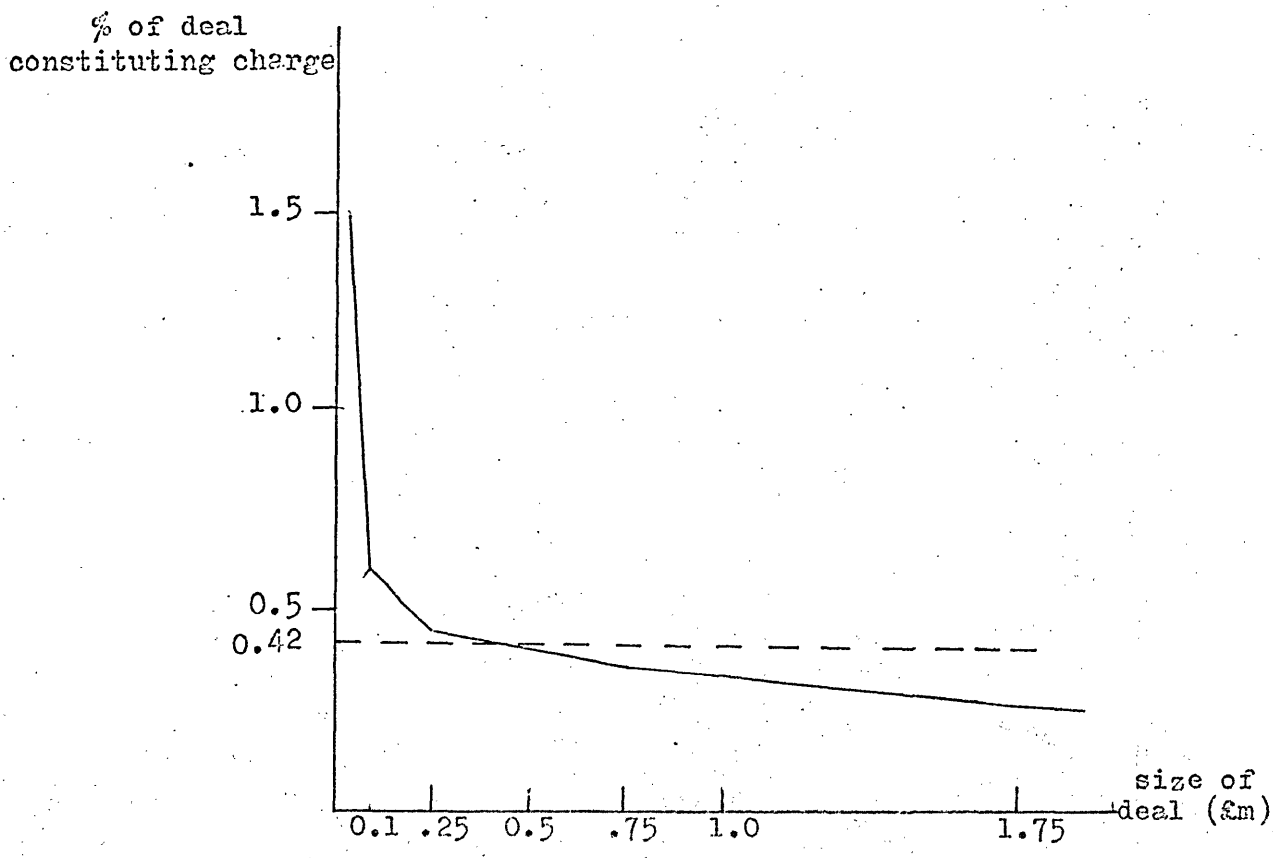


FIGURE 11.3

Actual and assumed average commission rates for dealing in registered shares at at mid 1976

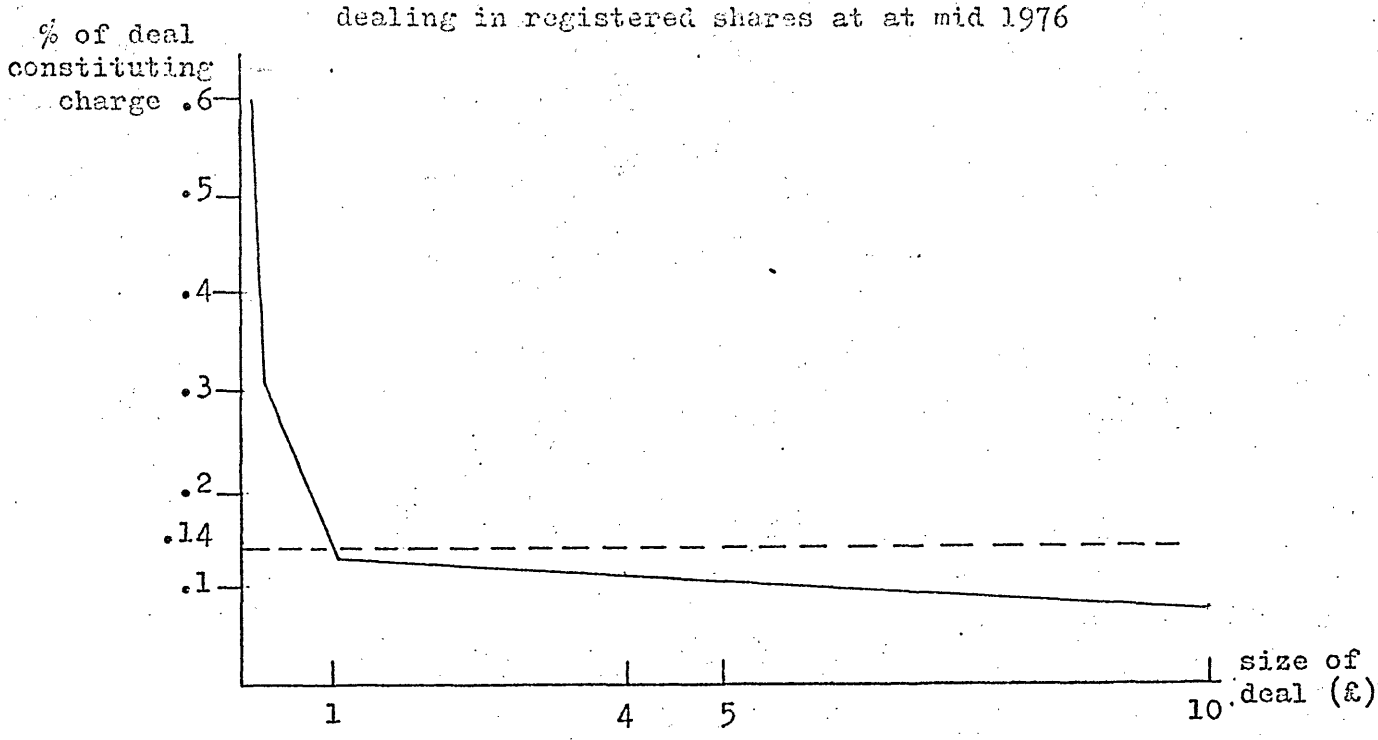


FIGURE 11.4

Actual and assumed average commission rates for dealing in gilts with greater than 10 years to maturity, as at mid 1976.

Figure 11.4, similar in structure to the previous figure, applies to dealings in gilts. Because of the typically larger size of bargains in this sector, the curve flattens out at a larger bargain size. The representative commission of 0.14% used in the software corresponds to a deal of a little under £1m. There is the additional complication with gilts that charges for dealing in shorter term bonds and new issues are lower. These were not used on the ground that the funds of this study (at least) dealt mostly in longer term existing securities.

II.1.2 CHARGES USED BY THE SOFTWARE

Table 11.1 shows the charges used for the evaluation of funds after April 1976.[1] Stamp duty is not chargeable on gilts, nor on most of the securities covered by "Other Fixed Interest". 1% is taken as half of the jobber's turn, since index values are based on middle market prices, while the actual fund must take bid or offer prices.

II.2 CALCULATION OF RE-ALIGNMENT CHARGE (STEPS 1 AND 2)

Call the profile at the end of the previous review period $\underset{\sim}{p}_e$ and at the beginning of the current review period $\underset{\sim}{p}_o$. The total market value of the fund at these two points of time will be MV_o. Further, let z_s denote the dealing cost (as a fraction) in sector s, as shown in Table 11.1 (Let z_s automatically imply any variation due to the buy/sell aspect).

If the total charges involved in the profile realignment are denoted by Z, the initial market value of sector s at the beginning of the current review period will be $p_o^s(MV_o - Z)$ and the net change in market value of the sth sector due to realignment will be

$$p_e^s \, MV_o - p_o^s \, (MV_o - Z) \qquad - (11.10)$$

1: Charges in previous years differed slightly.

TABLE 11.1

Charges used for investment simulation the software of this study

SECTOR	BUY/ SELL	TOTAL COMMISSION (%)	MADE UP OF (%) BROKER'S COMMISSION	JOBBER'S TURN	STAMP DUTY	RELEVANT AVERAGE TRANSACTION SIZE (APPROX £M)
EQUITIES	B	3.42	0.42	1.0	2.0	0.5
	S	1.42	0.42	1.0	0.0	
GILTS	B	0.25	0.15	0.1	0.0	1.0
	S	0.25	0.15	0.1	0.0	
OTHER FIXED INTEREST	B	0.3	0.3	0.0	0.0	0.25
	S	0.3	0.3	0.0	0.0	
OVERSEAS	B	3.314	0.314	1.0	2.0	0.25
	S	1.314	0.314	1.0	0.0	
PROPERTY TRUST	B	3.4	0.4	1.0	2.0	0.5
	S	1.4	0.4	1.0	0.0	
CASH	B	0.0	0.0	0.0	0.0	Any
	S	0.0	0.0	0.0	0.0	

TABLE 11.2

Example of the calculation of the realigment charge of a £6m portfolio

SECTOR	PROPORTIONS AS AT END OF PREVIOUS REVIEW (P^s_e)	DESIRED THIS REVIEW (P^s_o)	BUY/ SELL	RELEVANT CHARGE (Z_s) (ref. Table 11.1)	$Z_s\ P^s_e - P^s_o$ x 10^4	$Z_s\ P^s_o$ x 10^4
EQUITIES	.5786	.56	Sell	.0142	2.64	79.50
GILTS	.2519	.25	Sell	.0025	.05	6.25
O.F.I.	.0705	.07	Sell	.003	.02	2.10
O'SEAS	.0453	.06	Buy	.03314	4.87	19.88
PROPERTY	.0185	.02	Buy	.034	0.51	6.80
CASH	.0352	.04	Buy	0.0	0.0	0.0
					8.09	114.55

Total charge $= Z = \dfrac{Z_s\ P^s_e - P^s_o}{1 + Z_s\ P^s_o}\ MV_o$

$$= \frac{8.09 \times 10^{-4}}{1 + 114.55 \times 10^{-4}} \times 6 \times 10^6$$

$$= £4796$$

This will require an expenditure of

$$(1 + z_s) \left[p_e^s \, MV_o - p_o^s \, (MV_o - Z) \right] \qquad - (11.11)$$

where the charge for the necessary dealing in sector s is

$$z_s \left[p_e^s \, MV_o - p_o^s \, (MV_o - Z) \right] \qquad - (11.12)$$

Thus the total dealing costs of profile realignment will be

$$Z = \sum_s z_s \left[p_e^s \, MV_o - p_o^s \, (MV_o - Z) \right] \qquad - (11.13)$$

Solving (11.13) for Z yields

$$Z = \frac{\sum_s z_s \left| p_e^s - p_o^s \right|}{1 - \sum_s z_s \, p_o^s} \cdot MV_o \qquad - (11.14)$$

A deduction of Z from initial market value MV_o effectively spreads the burden of the realignment charge over sectors of the portfolio according to their relative importance in the portfolio by market value. An example of the calculation is given in Table 11.2. In this hypothetical example, total realignment charges amount to less than 1% of the initial value. Realignment charges for notional portfolios simulated during the quarterly assessment of the five funds in this study varied from 0% to just over 1% of initial market value. This is, as expected, quite small. However, as mentioned in I.2, it could become relevant over the long term.

The data from one fund (Fund C) was processed twice in this study, once with, and once without, realignment charges. The typical effect on the model fund's ROR was an absolute difference of $\frac{1}{4}$% per quarter when the fund was small to 0.1% per quarter when it was large. There were similar differences in the fund's excess return over the model fund. Over a period of 14 quarters, there was a difference of 5% in cumulative return of the model fund, or 0.8% p.a.

These results suggest that quarterly realignment charges could be either handled manually by an arbitrary deduction of 1% (or less for large funds) from initial market value. To ignore realignment charges over the long term could be more serious however. When the review period is longer (i.e., frequency of realignment is smaller), the effect of realignment charges decreases as short-run fluctuations cancel out. A similar comparison using Fund C over annual review periods yielded a 2% difference in cumulative return over 3 years, and a 0.5% p.a. difference in the model fund's average annual ROR.

The software calculates exact charges every review period, reading the old profile of a notional fund from the actual fund's old history file. Subroutine CHARG uses (11.14) to calculate the total charge. If a fund has no history files, no charges are deducted. The relevant routines are listed in appendix 11-V.

II.3 INVESTMENT OF INITIAL MARKET VALUE (STEP 3)

The software uses (11.1) where the numerator would be reduced by the sector's share of total realignment charges. No other transaction charges are made since the investment is a purely notional one.

An overseas sector is invested according to

$$XH_o^{os} = \frac{MV_o^{os} \quad E_o^e}{X_o^{os}} \qquad - (11.15)$$

where E_o^e is the penalised exchange rate according to (10.2) at the beginning of the review period. This should be the same rate that would have been used to value the portfolio at the end of the previous review period.

II.4 ALLOWANCE FOR REPAID INCOME OF UNREPRESENTED SECTORS

Repaid income of an unrepresented sector represents a capital outflow from the portfolio. Because it cannot be

sensibly simulated to come from the sector to which it in fact came from, the simulation method redistributes the outflow over the notional portfolio according to the notional policy, π, being simulated. Technically, the outflow should be simulated using average indices for the relevant sub-periods, but for the sake of simplicity it is merely subtracted from the in-coming new money that sub-period. The resultant error should be negligible in view of the small amounts typically involved.

II.5 TERMINATION OF SIMULATION OF SOLD SECTORS

The simulation algorithum checks in each sub-period (month) if a sector has been completely sold off during the previous sub-periods. The necessary information is generated automatically by the program (in the form of the array SECTEX) in the course of calculating the life of each sector, as outlined in V.2, Ch.10.

II.6 INVESTMENT OF NEW MONEY

This is done using (11.2) or (11.3), remembering that $C^s_{t(i)}$ may have been reduced by a share of the repaid income of unrepresented sectors. In applying (11.3) to the overseas sector, the new money is converted (Step 8a) at exchange rate $E^p_{t(i)}$ if the flow is positive or $E^e_{t(i)}$ if negative.

It was originally planned to cater for the investment of more than one new money flow per sub-period (month). This was not done however for three reasons:

1. It considerably complicates the data structures within the software.

2. The empirical results of the BAI study (1 ,p175) suggest that the improvement in accuracy to be gained from simulating cash flows even on a daily basis is minimal.

3. The use of more than one new money flow per month would entail a proportionally greater data collection burden on the user. Items F23, F24, F25 and F28 would have to be repeated for each flow.

Accordingly, the view was taken that the added complexity was not worth the likely gain.

II.7 COMPUTATION OF NOTIONAL INCOME (STEP 10)

It has already been noted that income is probably the most theoretically difficult aspect of investment simulation. Appendix 9-II shows that there are even problems in just deriving an index for income, let alone deciding how notional income should be reinvested.

In a minor modification to (11.4), notional income for non-cash sectors is generated in the software of this study as:

$$NI_t^s = IX_t^s \left[XH_{t-1}^s + w_t \quad CX_{t(i)}^s \right] \qquad - (11.16)$$

where w_t = A weight reflecting the influence of the new money flow on the performance of the portfolio during the tth sub-period.

$$= \frac{\text{No. of days in sub-period } t - \text{Date of flow}}{\text{No. of days in sub-period } t} \qquad - (11.17)$$

When simulating the actual portfolio, $V(\pi_a)$, transactions are assumed to be made at the middle of the sub-period (e.g., mid-month), so $w_t = 0.5$.

Because the income index for the overseas sector, XI_t^{os}, is expressed in dollars, (11.16) will produce dollar income. In addition, a provision for withholding tax of 15% on overseas income is made so that NI_t^{os} is 0.85 times the figure yielded by (11.16).

II.7.1. NOTIONAL INCOME OF THE CASH SECTOR

An allowance must be made in the cash sector for the extra income which would be earned through the investment of the total of all retained income earned in other (non-cash) sectors of the fund (refer II.8 below). Using the subscript c to denote cash, this net retained income will be

$$\sum_{s \neq c} (GI_t^s - GRT_t^s) \qquad - (11.18)$$

simplying that notional income for the cash sector is

$$NI_t^c = IX_t^c \left[XH_{t-1}^c + w_t \, CX_{t(i)}^c + 0.5 \, \frac{\sum_{s \neq c} (GI_t^s - GRT_t^s)}{\bar{X}_t^c} \right] \qquad - (11.19)$$

where the last term is retained income after reinvestment in cash (Steps 10a and 10b).

II.8 COMPUTATION OF EXCESS NOTIONAL INCOME

Notional portfolios other than $V(\pi_a)$ are simulated according to (11.5), since it is not intended that these simulate the actual transactions of the portfolio. In contrast to the SIA's approach however, when simulating the actual portfolio, the software of this study divides (11.5) for non-cash sectors into two parts:

$$\underbrace{NI_t^s - GI_t^s}_{\text{Excess notional income over income earned}} + \underbrace{GI_t^s - GRT_t^s}_{\text{Income retained by actual fund}} \qquad - (11.20)$$

The first part is the only part which is true excess income, in the sense that it must be ploughed back into the same sector in order to compound the Selection effect in this sector over successive sub-periods. The second part should not be reinvested in the same sector, since there is no guarantee that the same quantity was reinvested in this sector in reality. Retained income is deemed to be notionally invested in the cash sector according to the last term of (11.19). If in reality it was reinvested in the same sector as that in which it was earned, this will be reflected in the notional fund $V(\pi_a)$ via its appearance in the net purchases figure P_t^s. Retained income for the simulated actual fund is assumed to remain invested in cash until the end of the review period, to be redistributed amongst other sectors as part of the profile realignment process. The contribution to performance of any deliberate redistribution by the manager of retained income amongst non-cash sectors will be included in the Subseqent Strategy component, $V(\pi_a) - V(\pi_b)$.

Excess notional income of the cash sector is calculated using (11.5).

II.8.1 EXCESS NOTIONAL INCOME IN OVERSEAS SECTOR

For the purpose of application of (11.20) to the overseas sector, GRT_t^{os} is converted from pounds to dollars using the average ordinary rate, $\bar{E}_t^o$ for the month. This involves some approximation, in that income was probably remitted back at some other rate. The error was thought to be more tolerable than inputting the extra data on what rate was used, which may not be available anyway.

A complication arises with the reinvestment of excess overseas notional income which necessitates the increase of excess income if it is negative. In this case, part of the notional holding in the overseas sector must be sold in order to "pay" the amount of income which was repaid to the trustees.

(11.20) assumes that dollars raised from such a sale can be exchanged for sterling at the ordinary rate $\bar{E}^o_t$. Proceeds from the sale of overseas assets must be exchanged at the penalised rate $\bar{E}^e_t$ however, so the quantity of dollars needed to cover the deficiency of notional income in pounds will be

$$(NI^{os}_t - GI^s_t \ \bar{E}^{os}_t) \ \frac{\bar{E}^e_t}{\bar{E}^o_t} \qquad - (11.21)$$

The adjustement factor $\bar{E}^e_t/\bar{E}^o_t$ will decrease the amount of overseas assets which need to be sold, since the penalised rate buys more pounds to the dollars than the ordinary rate. This adjustment is shown as steps 12c and 12d in figure 11.2.

II.8.2 REINVESTMENT OF EXCESS NOTIONAL INCOME (STEP 13)

The index units gained from the reinvestment of excess notional income are obtained as

$$\frac{NI^s_t - GI^s_t}{\bar{X}^s_t \ (1 + z_s)} \qquad - (11.22)$$

with similar expressions for the cash and overseas sectors.

II.9 VALUATION OF THE FINAL PORTFOLIO

The total holding of index units in the sth sector at the end of a sub-period will be

$$XH^s_t = \underbrace{XH^s_{t-1}}_{\text{Holding at end of previous sub-period}} + \underbrace{CX^s_{t(i)}}_{\text{New Money}} + \underbrace{\frac{NI^s_t - GI^s_t}{\bar{X}^s_t \ (1 + z_s)}}_{\text{Excess notional income reinvested}} \qquad - (11.23)$$

with appropriate modifications for the overseas and cash sectors according to (11.21) and (11.5) respectively. (11.23)

constitutes steps 9, 10, 10a and 14 in figure 11.2.

After steps 4 to 14 have been carried out for all n sub-periods in the review period, the total notional portfolio is valued to get $V(\pi)$ as follows:

1. The overseas sector is valued as

$$V(\pi)^{os} = \frac{XH_n^{os} \cdot X_n^{os}}{E_n^e} \qquad - (11.24)$$

Use of the penalised rate of exchange yields realisable value.

2. All other sectors are valued according to (11.9), expecting the case where the actual portfolio is being valued and the sth sector has been completely sold off during the review period. In this case, the sector is valued at

$$V(\pi_a)^s = XH_{t'}^s \cdot \bar{X}_{t'}^s \qquad - (11.25)$$

where t' refers to the sub-period in which the last of the sector was sold off.

3. Total final value is summed up as (11.9).

III. ORGANISATION OF THE SIMULATION IN THE PROGRAM

Figure 11.2 is a very high level simplification of the logic used in PRFORM2 to simulate notional portfolios. The programming is organised in a heirarchy of sub-routines, as follows (refer Figure 10.4). The main program accesses the fund's old history file (if any) and reads the past proportions of the 4 notional portfolios associated with this fund ($V(\pi_m)$, $V(\pi_p)$, $V(\pi_b)$ and $V(\pi_a)$). If there is no history file, the logic skips to point 3 below.

Then each of these notional portfolios is simulated using the follow procedure:

1. The main program calls subroutine CHARGE to perform step 1 in Figure 11.2.

2. The main program subtracts the calculated charge from the initial market value (step 2).

3. Subroutine SIMUL is then called to conduct the entire simulation of this notional portfolio over the n sub-periods in the review period (e.g., 3 months in a quarter). This subroutine does the initial notional investment (step 3) and other preliminaries (steps 4 and 5). For each sub-period, it sets up the various parameters of new money, new money exchange rates and associated index levels which are relevant to the type of notional fund being simulated. (e.g., it applies π to the total new money $C_{t(i)}$ to produce the simulated $C^{s}_{t(i)}$.)

4. Subroutine INVEST is then called by SIMUL for each sub-period. INVEST carries out steps 6 to 14 for all sectors, calling special routines CSHINV and OSINV to execute steps 8 to 14 for the cash and overseas sectors respectively.

   All three routines (INVEST, CSHINV and OSINV) call on subroutine REVEST to reinvest excess notional income (step 13).

5. After SIMUL has called INVEST for all n sub-periods, the main program values the final portfolio (step 15).

The programming was done to make maximum use of commonly needed operations and so minimise the coding involved. Thus

the calculation of market returns is done with the use of the above routines, but after new money has been set to zero. Appendix 11-I includes a copy of the routines mentioned above with indications of which blocks of code perform the steps numbered in Figure 11.2.

IV. ESTIMATION OF INCOME DATA

If the NOTIONAL option (F20) is exercised, income is estimated by calling subroutine SIMUL an extra time before any of the other notional portfolios are simulated. The actual portfolio (according to Π_a) is simulated according to figure 11.2, except that no realignment charges are made (step 1 and 2) and no income is reinvested[1] (stepts 10a, 10b, 11, 12, 13 and 14 are skipped for each sub-period). The notional income is calculated according to (11.16) in steps 10 (and 10c in the case of cash, using (11.19) with a zero term for retained income in (11.18)). The calculated figure is specially noted as an element in the array SIMINC, which stores simulated income for each sector according to months. Appendix 11-II shows the routines involved in the adjustment of simulated income using known figures according to (10,11).

V. SIMULATION OF OVERSEAS PERFORMANCE

The components described in XIII, Ch.5 require the simulation of the actual transactions conducted in the overseas sector, but under varying conditions of exchange rates and premium penalty. The procedure within program PRFORM2 is as follows: The main program calls subroutine OVSEAS three times, each time to do a simulation under the assumed conditions represented by the parameters E and α in XIII, Ch.5. OVSEAS sets up the parameters E and α as appropriate to the particular assumptions being simulated. For each sub-period in the review period OVSEAS then calls routine OSINV, which, as

---

1: Since it is assumed that if complete income figures are not known, all income was repaid to the trustees.

has already been metioned, simulates the overseas sector. The parameters E and are passed to it by OVSEAS. After all sub-periods have been simulated in this manner, OVSEAS finally values the final index holding, again according to the assumptions of the current simulation. The main program then uses the various valuations to calculate the components of (5.22). Appendix 11-III lists the subroutine OVSEAS.

VI. CALCULATION OF RORs FOR THE WHOLE FUND

Figure 11.5(a) is a schemetic representation of the capital inflows and outflows to which the total portfolio is subjected over a review period consisting of an arbitrary 3 sub-periods. In addition to the new money flows C_t, some income is repaid to both the trustees and, in general, the tax man every sub-period. This is total gross repaid income, GRT_t, as defined by (10.6). It is a withdrawal of capital from the fund, because if it were not withdrawn, it would form part of the capital on which income during the next sub-period would be earned.

All the routines concerning ROR calculation are listed in Appendix 11-IV.

VI.1 TOTAL MONEY-WEIGHTED ROR

The direct application of (4.6) will produce erroneous results since it does not allow for repaid income. The SIA (76,p6) recommend the subtraction of repaid income from new money flows C_t. This is technically not strictly correct however (although it would introduce negligible error in practice). The error concerns the calculation of average new money, where the exact dates of new money flows should be used, while mid-month dates must usually be assumed for the repayment of income. Thus

$$\bar{C} = \sum_{t=1}^{n} W_t C_t \qquad - (11.26)$$

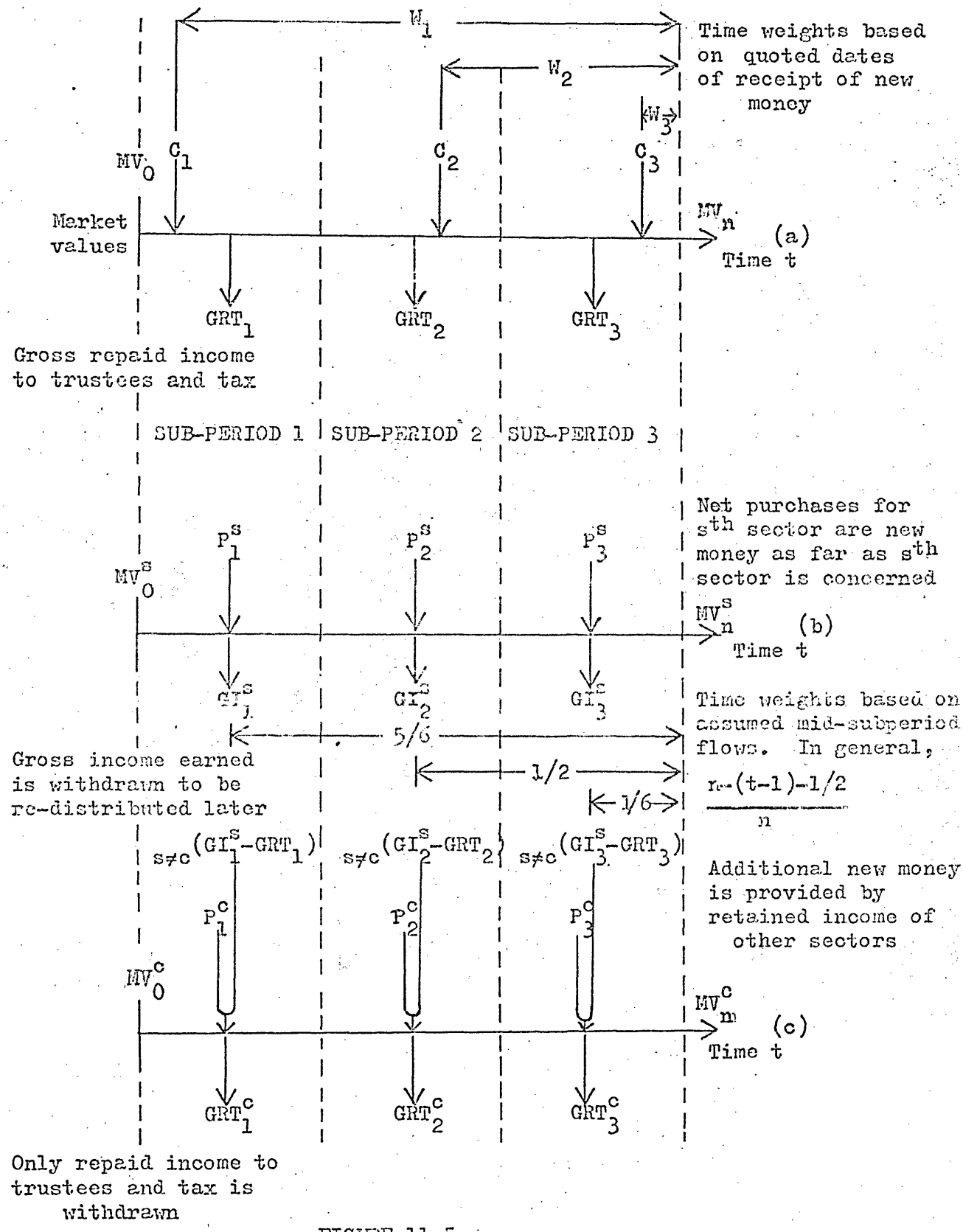


FIGURE 11.5

Schematic representation of variables relevant to the calculation of the rate of return of (a) the total fund, (b) any non-cash sector, and (c) the cash sector

where w_t is defined by (11.17)

and

$$\overline{GRT} = \sum_{t=1}^{n} \frac{n - (t - 1) - \frac{1}{2}}{n} \cdot GRT_t \qquad - (11.27)$$

A re-working of the derivation of (4.6) as given in I, Ch.4 will confirm that the appropriate MWR estimate is

$$MWR \doteqdot \frac{MV_n - MV_o - C + GRT}{MV_0 + \bar{C} - \overline{GRT}} \qquad - (11.28)$$

The program produces estimates (11.28) in the subroutine MWROR, which has as its parameters $\bar{C}$ and $\overline{GRT}$. $\bar{C}$ is calculated in the main program using (11.26) using weights w_t calculated via subroutine DAYWT. $\overline{GRT}$ is computed using a general subroutine AVFLOW which uses the weights (11.27) as a permanent feature.

VI.2 TOTAL TIME-WEIGHTED ROR

If (11.28) is used in the derivation of the SIA's TWR estimate (refer II.6.2, Ch. 4), the following is obtained as the TWR estimate for the total portfolio:

$$TWR = \frac{MV_n - \left[(C - GRT) - (\bar{C} - \overline{GRT})\right] \times (1 + TWN)}{V(\pi_b) + (1 + TWN)Z - \left[(C - GRT) - (\bar{C} - \overline{GRT})\right]} \qquad - (11.29)$$

where TWN is the TWR on a notional fund based on π_b but with no new money.[1]

As IV.1, Ch.4 explained, the relevant notional fund is that which mirrors the market ROR when it is exposed to the

---

1: If assessment is based on capital value only, this return must also be on capital value only.

same new money flows as the actual fund. This is $V(\pi_b)$ rather than $V(\pi_p)$ as the SIA's example implies.

(11.29) is used by subroutine TWROR to calculate the TWR on the Main Fund. $V(\pi_b)$ as it is calculated in the program will have been derived with realignment charges, Z, being deducted at the start of its simulation (refer II.2 above), whereas (11.29) requires a final value which is gross of these charges. The term (1 + TWN)Z is the required addition, being the initial loss due to charges blown up by the TWR in the market to give the total effective loss to final value.

VI.3 SECTOR RATES OF RETURN

VI.3.1 NON-CASH SECTORS

Figures 11.5(b) shows the variables relevant to the calculation of the ROR of a sector other than cash. New money as far as the sector is concerned is P^s_t, which may exist even though there was no new money C_t into the fund as a whole. As argued in II.8 above, the gross income earned by the sector must be considered as a withdrawal of capital from the sector. The weights applied to these inflows and outflows must be based on mid-month dates since, as was discussed in XII.2.1, Ch.5, it is impractical to note the date of individual transactions.

Defining average "new money" into the sector as

$$\bar{P}^s = \sum_{t=1}^{n} \frac{n - (t - 1) - \frac{1}{2}}{n} P^s_t \qquad - (11.30)$$

and average withdrawals as

$$\overline{GI}^s = \sum_{t=1}^{n} \frac{n - (t - 1) - \frac{1}{2}}{n} GI^s_t \qquad - (11.31)$$

the MWR estimate will be

$$MWR^s = \frac{MV_n^s - MV_o^s - P^s + GI^s}{MV_o^s + \bar{P}^s - \overline{GI}^s} \qquad - (11.32)$$

If all gross income was in fact reinvested in the sector, both MV_n^s and P^s will be increased by that amount and the numerator of (11.32) will remain constant. A similar argument applies to the averages. Subroutine MWROR employs (11.32).

The TWR estimate is

$$TWR^s = \frac{MV_n^s - \left[(P^s - GI^s) - (\bar{P}^s - \overline{GI}^s)\right]}{\left[V(\pi_a)^s + (1 + TWN^s)\ Zp_b^s\right] - \left[(P^s - GI^s) - (\bar{P}^s - \overline{GI}^s)\right]} \times (1 + TWN^s) \qquad - (11.33)$$

where TWN^s is as defined for (11.29) but applies to the sth sector only. It was emphasisied in IV.1, Ch.4 that the appropriate notional fund for the estimation of sector TWRs was that which simulated the actual transactions of the fund. Once again, $V(\pi_a)$ must be corrected for the realignment charges, Z, which were deducted from this notional portfolio at the beginning of its simulation. These were borne by the sth sector according to the proportion of the initial fund, p_b^s, made up by that sector.

Subroutine TWROR uses (11.33) to calculate the TWR of all sectors except cash. ((11.30) and (11.31) are evaluated by subroutine AVFLOW.)

VI.3.2 CASH SECTOR

As Figure 11.5(c) shows, the cash sector has the additional "new money" of all retained income earned by the non-cash sectors. Taking this into account,

$$MWR^c = \frac{MV_n^c - MV_o^c - P^c + GRT^c}{MV_o^c + \bar{P}^c - \overline{GRT}^c} \qquad - (11.34)$$

where $$\overline{GRT}^c = \sum_{t=1}^{n} \frac{n - (t-1) - \frac{1}{2}}{n} \; GRT_t^c \qquad - (11.35)$$

is the average level of withdrawals of repaid cash income and $\bar{P}^c$ is calculated according to (11.30)

The TWR estimate is:

$$TWR^c = \frac{MV_n^c - \left[(C^c - GRT^c) - (\bar{C}^c - \overline{GRT}^c)\right]}{\left[V(\pi_a)^c + (1 + TWN^c)\; Zp_b^c\right]\left[(C^c - GRT^c) - (\bar{C}^c - \overline{GRT}^c)\right]} \times (1 + TWN^c) \qquad - (11.36)$$

where $$C^c = P^c + \sum_{s \neq c} (GI^s - GRT^s) \qquad - (11.37)$$

is total "new money" into the cash sector

and $$\bar{C}^c = \sum_{t=1}^{n} \frac{n - (t-1) - \frac{1}{2}}{n} \left[P_t^c + \sum_{s \neq c} (GI_t^s - GRT_t^s)\right] \qquad - (11.38)$$

as average "new money" into the sector

Subroutine AVFLOW calculates (11.35) and (11.38) in preparation for subroutines MWROR and TWROR to use them in (11.34) and (11.36) respectively.

VI.3.3 COMPLETE PURCHASE AND SALE OF A SECTOR DURING REVIEW PERIOD

The wholesale purchase or sale of a fund's complete holdings in a sector causes difficulty for the calculation of RORs. The MWR of the sector theoretically exists and can be calculated by the normal application of (11.32). Because the

purchase cost or sales proceeds will be counted as a new money flow P^s, the profit over the period is still computed by the numerator. Further, provided n in (11.30) is modified to reflect the shorter life of the sector, P^s will reflect the average capital employed.

The TWR does not theoretically exist however if the sector temporarily disappears during a review period, since (3.9) will at some stage involve division by zero. To tailor (11.33) to the shortened life of a sector would require special modifications to $V(\pi_a)^s$ and TWN^s, all of which were considered to be too complex in view of the relative rarity with which they would be required. Hence the feature was introduced of automatically equating TWR with MWR for any sector whose life was less than the length of the review period. This procedure cannot, however, correctly handle a sector which is both completely bought and sold within the review period, as the average new money calculation (11.30) will not be valid.

VII. CONTENTS AND ORGANISATION OF HISTORY FILES

Several tables towards the end of a Fund Performance Report, and all of a Fund Comparison Report, are derived from information which is stored on a fund's history file. This section summarises the structure of this file (more specific details can be found in Appendix 10-I). It is convenient to note at this stage that all RORs and profile proportions on history files are stored as decimals (not percentages) and are always in the standard order of sectors as discussed in IV.2, Ch.10.

VII.1 MODEL HISTORY FILES

One file like that shown in Figure 11.6 is kept (and named seperately) for each type of model fund. The indicated fields contain the following information:

```
31 12 1977   MH1
 .53877    .27320    .05306    .05152    .03214    .09121   MH2
MH3  914
 1 10 1977      92
 -.03213   -.00026    .04857    .02008    .05857    .01171   -.01272
 1  7 1977      92
  .19237    .16275    .16296   -.12359    .06524    .01644    .15325
 1  4 1977      91
  .09507   -.01147    .02636    .03634    .04243    .01916    .05270
 1  1 1977      90
  .17044    .18425    .22136   -.11179    .05532    .02987    .14153
 1 10 1976      92
  .15336    .03274   MH5 .04150   -.00441   -.04049    .03584    .05925
MH4
 1  7 1976      92
MH6
 -.11608   -.02374   -.04226    .10433    .06100    .02722   -.05979   MH7
 1  4 1976      91
 -.04325    .01309    .05594    .06310    .03302    .02457   -.01160
 1  1 1976      90
  .05452    .07093    .03513    .13924    .02375    .02277    .05956
 1 10 1975      92
  .16766   -.00164    .06814    .14635    .02560    .02765    .07955
 1  7 1975      92
  .14547    .04931    .05097   -.12060    .03043    .02426    .09119
 0  0    0      0
-1.00000   -1.00000   -1.00000   -1.00000   -1.00000   -1.00000   -1.00000
 0  0    0      0
-1.00000   -1.00000   -1.00000   -1.00000   -1.00000   -1.00000   -1.00000
MH8  10
      92    .09119   MH9  92   .07952   MH10  90    .05956      91   -.01160
      92   -.05979      92    .06925         90    .14153      91    .05270
      92    .15325      92   -.01272
MH11  0
```

FIGURE 11.6

Example of a Model History file updated to the end of 1977

MH1. Date up to which the file has been updated.

This will be the ending date (M2 in IV.1, Ch.10) of the last review period for which the file was updated.

MH2. Profile proportions as at the end of the last review period.

For example, using the standard sector codes listed in IV.2, Ch.10, the file in Figure 11.6 indicates that 53.9% of the model fund was invested in equities at the end of the review period ending 31/12/77.

MH3. Total number of days covered by all the review periods whose results are recorded on the file. (This should equal the sum of the fields MH5, described below).

Hereafter on the file is repeated the following set of information, once for every past review period up to a maximum of 12 reviews.[1]

MH4. Beginning date of the review period (as it appeared as item M1 on the market file).

MH5. Length in days of the review period (as calculated by the program PRFORM2).

MH6. The RORs earned by the various sectors during the review period.

These are the rates as derived from the simulation of the market using SIMUL in PRFORM2. They are calculated as

---

1: In theory, this maximum can of course be increased to any size within the limits of available file space. For a system designed to conduct regular monthly reviews (not necessary except under very extreme new money flows), the limit would have to be 36 to enable the summary of the past 3 year's results.

$$R_m^s = \frac{V(\pi_m)^s}{MV_o^s} - 1 \qquad - (11.39)$$

derived from (3.7)

since there is no new money involved. They are based on monthly compounding of income. It is important to note that these RORs are unaffected by the realignment charge, Z, made to the model fund, since charges are deducted at the end of the simulation using (11.40) below.

MH7. ROR on the whole model fund.

This is derived as a function of the sector RORs, the initial model fund profile P_m and the realignment charge Z made on the model fund[1].:

$$R_m = (1 - \frac{Z}{MV_o}) \sum_s P_m^s R_m^s \qquad - (11.40)$$

If the fund has been reviewed less than 12 times since its history file was created, the surplus fields are occupied by dummy data as indicated in Figure 11.6. Dates and lengths are represented as zeros, while all RORs are set to minus one.

After the information corresponding to 12 review periods, data which enables the calculation of a risk measure for the

---

1: The ROR derived is $V(\pi_m)/MV_o$ where $V(\pi_m)$ is the final value of the model fund after the initial deduction of Z.

But $V(\pi_m) = \sum_s (1 + R_m^s)\ p_m^s\ (MV_o - Z)$

So $\frac{V(\pi_m)}{MV_o} = \sum_s p_m^s\ (1 + R_m^s) - \frac{Z}{MV_o} \sum p_m^s\ (1 + R_m^s)$

which simplifies to (11.40) above

model fund as a whole is stored.

MH8. Number of review periods for which a total ROR figure is to appear in the next lines

The next two fields are repeated, four pairs to a line, for the number of times indicated in MH8.

MH9. Number of days which the review period covered.

MH10. ROR earned by the model fund (net of realignment charges) over this period. It is identical to that described as MH7.

This information is kept seperately even though it is to some extent repetitive of items MH5 and MH7. For the first 12 reviews, this data will add nothing to the rest of the file. Beyond 12 reviews, it stores total fund returns which would otherwise be wiped from the file. It was viewed as more important to provide a complete history of returns for the calculation of a risk measure of the fund, since total ROR, rather than individual sector returns, is likely to be the focus of any historical study. In addition, it enables total ROR to be modified for the purpose of risk calculations without affecting cumulative and average ROR calculations. This situation could arise if, for example, it was not desired that the risk estimate of a fund be affected by a wild deviation of return which was due to exceptional circumstances, such as unusual Trustee policy. Total ROR will be stored on a history file in this manner without limit to the number of past review periods.

MH11. This is an end-of-file marker, produced automatically by the software.

As successive reviews are done and the history file updated each time, the results of a given review period are "pushed down" the file until, if it is the 13th review into the past, it no longer appears.

VII.2 FUND HISTORY FILE

A fund's history fund, an example of which appears in Figure 11.7, has a broadly similar structure. The items as labelled in the figure are as follows:

FH1. Fund identifying code (numerical)

This must match the identifier F2 on this fund's Fund Data file.

FH2. Date up to which the file has been updated (similar to MH1).

FH3. Ending profile of the model fund against which the fund was compared in the last review period

These will not necessarily be the same as MH2, since the manager may have used option F41 to specify his own model fund. If a manager oscillates between the common model fund and his own, the model fund will be charged with the simulating dealing expenses implied by the changes of profile. These proportions, and those of FH4, FH5 and FH6 are in standard sector order and enable the calculation of (11.14) by providing the p_e^s data.

FH4. Ending profile of the policy notional fund used last period.

FH5. Ending profile of the notional fund aligned according to the initial profile π_b last period.

FH6. Ending profile of the simulated actual fund according to π_a last period.

FH7. Similar to MH3.

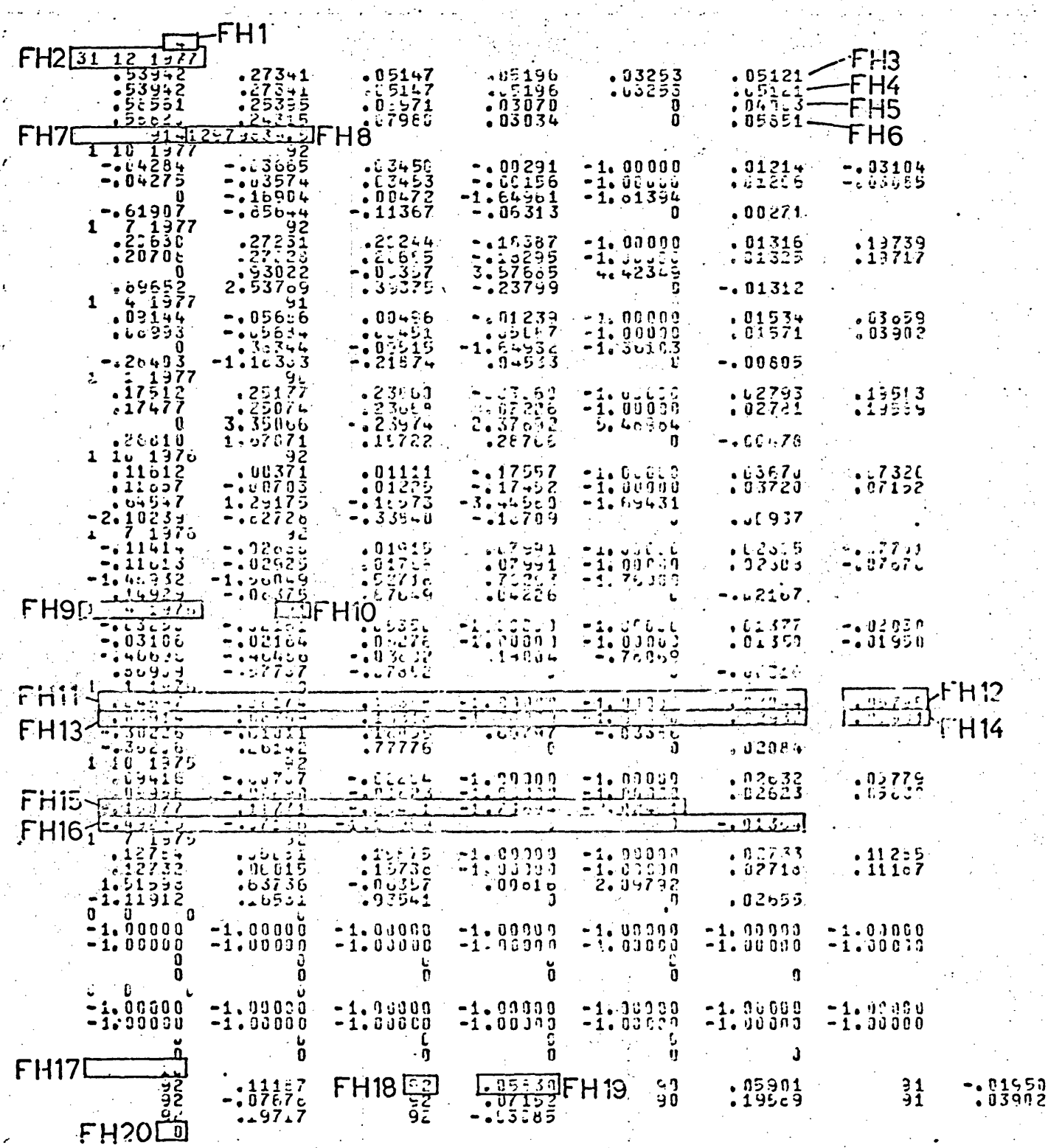


FIGURE 11.7

Example of a Fund History file updated to the end of 1977 and carrying 10 past reviews

FH8. Average size of the Main Fund during the last review period. This will be

$$MV_o + \overline{C} - \overline{GRT} \qquad - (11.41)$$

If income data was estimated using any of the options in VI.4, Ch.10, the estimates are used to form $\overline{GRT}$.

The next 5 lines are repeated once for each of 12 past review periods.

FH9. Similar to MH4.

FH10. Similar to MH5.

FH11. Money-weighted RORs for the sectors of the fund during the review period. Similar in format to MH6, but calculated according to (11.32).

FH12. MWR of the total fund, calculated according to (11.28).

FH13. Time-weighted RORs for the sectors of the fund during the review period. Similar in format to MH6, but calculated according to (11.33).

FH14. TWR of the total fund, calculated according to (11.29).

FH15. Components of the fund's performance during the review period.

Expressed as percentages, they are in the order of Policy, Initial Strategy, Subsequent Strategy, Selection and Excess Return as defined in System I, Table 6.4.

FH16. Selection components of individual sectors.

Expressed as percentages and in standard sector order, they should add to give the Selection figure in FH15.

"Unfilled" review periods are indicated by zeros and minus ones as before. Note also that if a fund was not invested in a sector during a certain review period, the RORs for that sector are indicated as minus ones to distinguish them from a sector which earned a zero ROR. The fund in Figure 11.7 has not invested overseas (standard sector code 4) for any part of its history.

After 12 review periods of information, a complete time series of the total fund's TWR is kept in exactly the same format as a model history file. Items FH17, FH18, and FH19 correspond to MH8, MH9 and MH10.

FH20. End-of-file market produced automatically.

VII.2.1 STRUCTURE FOR MULTIPLE FUNDS

As II, Ch.10 indicated, history file data, as listed above, for different funds can be stacked onto the one master history file. Under this arrangement, items FH1 to FH19 are repeated over and over, with FH20 appearing at the very end.

VIII. ORGANISATION OF FILES AND FUND REVIEWS

The file handling procedures within the software are such that the history files may be used in any one of three ways:

1. Each fund has its own history file, its own seperate model history file and its own Market Data file, all for the use of that fund alone.

2. Each fund has its own history file but uses a model history file and Market Data file in common with other funds which use the same model type (private, local authority etc.).

3. All funds which use the same model type have their historical information stored on the one master history file, and they all use a common model history file and Market Data file.

These alternative arrangements are listed above in decreasing order of complexity as far as file manipulation and creation goes. This will be illustrated in the following paragraphs using the example of an institution which manages 40 funds which must be regularly reviewed, and which number 15, 10 and 15 by model type.

The first arrangement would have maximum flexibility. Each fund manager could review his fund whenever he liked and use his own unique model specification, Market Data file and review period times. For the institution however, it would involve the maintainence of 160 files, half of which would be history files and the remainder data files for either the market or the fund. This is clearly wasteful.

The second approach economises on the use of Market Data files and model history files. The institution must now maintain only 43 history files on a permanent basis and 41 temporary data files. Fund managers can still review their funds whenever they like, provided they use a common review period. The first manager to review a fund of a model type whose history file is not yet updated will cause that model history file to be updated. Subsequent reviews of funds with the same model type and Market Data file will read the model fund results for the current review period off the new model history file created by the first manager. Their fund reports will be based on the same current market returns but cumulative and average RORs for the market in their Fund Performance Reports will be based on the past 11 reviews of the model fund,

while the first manager's report will be based on the past 12 reviews.[1]

The third approach is the most economical on file administration but the least flexible, in the sense that it demands a batch mode of operation. All funds on the one master history file must be reviewed in the same run. This is because only those funds which are reviewed have their history data copied from the old master file to the new master file.[2] Using this approach, the institution would have to maintain only 4 files on a permanent basis.

The software does one complete search of a master history file, rewinding it if need be, and stopping where it last finished reading for the previously reviewed fund. If a match between F2 and FH1 is not achieved by the end of this search, analysis continues and as much of a Fund Performance Report is produced as is possible without the fund's historical data. An error message is printed to indicate the inability to locate the fund's history data on the master file. If the manager still wants the historical figures, he can re-run his fund with a "NO UPDATE" option (F4). Because the search on a master file is complete, the funds on it need be in no particular order, and the numerical identifier FH1 need follow no particular pattern from fund to fund.

1: The software automatically compensates for this difference by the appropriate adjustment of the pattern of accumulation (F6) on the Fund's Data file. The automatic compensation leads to the same dates along the tops of Tables 10 to 15, with the possible exception of the last column if the 12th review period was specified.

2: The same will apply if a fund is included in a run but is not analysed because of imperfect data (refer IV.6, Ch.10). Both these problems could be overcome with a simple "housekeeping" program to search the old master file and copy the data of any unreviewed funds. This was not done in the course of this study however.

Appendix 11-VI lists the various routines involved in the manipulation and analysis of historical results. Whichever of the above three systems is used, there is no practical difficulty if history files are tampered with to, for example, delete the results of one review period which is regarded as being non-representative. The logic of the software does not demand that review periods be continuous over time, although the missing periods will not be highlighted in the reports.

IX. MISCELLANEOUS STATISTICS

IX.1 CUMULATIVE AND AVERAGE PAST RORs

RORs are annualised by subroutine ANULIS using

$$(1 + r)^{365/D} \qquad - (11.42)$$

where D is the number of days to which the ROR r applies. Past RORs are compounded over N past periods by subroutine CMPND using

$$\prod_{i=1}^{N} (1 + r_i) \qquad - (11.43)$$

while subroutine CMPNOW finds the cumulative ROR right up to the current review period by multiplying (11.43) by one plus the current ROR, r_o, to give

$$(1 + r_o) \prod_{i=1}^{N} (1 + r_i) \qquad - (11.44)$$

Annualised averages over the past N periods are taken by CMPANU as

$$\bar{r} = \left[\prod_{i=1}^{N} (1 + r_i) \right]^{365/\sum_{i=1}^{N} D_i} - 1 \qquad - (11.45)$$

where D_i is the length in days of the ith past review period.

All of the above quantities are calculated with careful attention to the occurrence of sectors for which no return is recorded. (the test being $r_i = -1$).

IX.2 AVERAGE PAST COMPONENT VALUES

As highlighted in VIII.4, Ch.5, time-weighted arithmetic averages are taken in an attempt to indicate how current values of a component compare with past achievements on the same component. A component K is averaged over N past review periods as

$$\bar{K} = \frac{1}{\sum_{i=1}^{N} D_i} \sum_{i=1}^{N} D_i K_i \qquad - (11.46)$$

where D_i is as defined in (11.45).

IX.3 RISK MEASURES

The risk measures appearing in Table 17 of a Fund Performance Report are weighted mean deviations. For the sth sector,

$$MAD^s = \frac{1}{\sum_{i=1}^{N} D_i} \sum_{i=1}^{N} D_i \left| a_i^s - \bar{a}^s \right| \qquad - (11.47)$$

where D_i is as defined in (11.45)

a_i^s is the annualised ROR over the ith past review period

$\bar{a}^s$ = the arithmetic weighted average of past annualised returns, a_i, according to (11.46)

N = Either 12 or the number of past reviews for which data is available, whichever is the less.

A similar estimate is made for the total fund except that N is unlimited. If a fund was not invested in the sth sector during the ith review period, that review period is ignored by (11.47).

As indicated in III.3, Ch.7, no theory exists on how to handle unequal review period lengths in the formation of a risk estimate. The annualisation of returns before taking their deviation was the most practical solution which could be found to this problem. The annualisation can unfortunately introduce some distortion into the risk measure under extreme circumstances. If the return for one very short period is a quite large deviation from average past return, that deviation is "blown up" by the exponential process implicit in its annualisation. The absolute amount by which it is increased exceeds the extent to which it is cut down again by the linear weight $D_i/\sum D_i$, so some upward bias is introduced. The amount of bias introduced into the ratio of risk measures (fund to market) would be less however if the market also experienced a similar wide deviation of return over the same period. Subroutine RISK (Appendix 11-VI) does the necessary calculations.

One of the disadvantages of this, or any other risk measure based on past returns, is the need to accumulate about 30 observations before any confidence can be held in an estimate from a statistical point of view. Figure 11.8 shows the changes in a measure of risk relative to the market for each of the 5 funds in this study as more observations become available. The measure is the ratio of MADs as in Table 17 of a Fund Performance Report (refer next chapter). The estimates are "stable" only in the sense that they rarely transgress bands on 0.5 in width, enabling at least a rough early indication of the broad riskiness of a fund relative to the market.

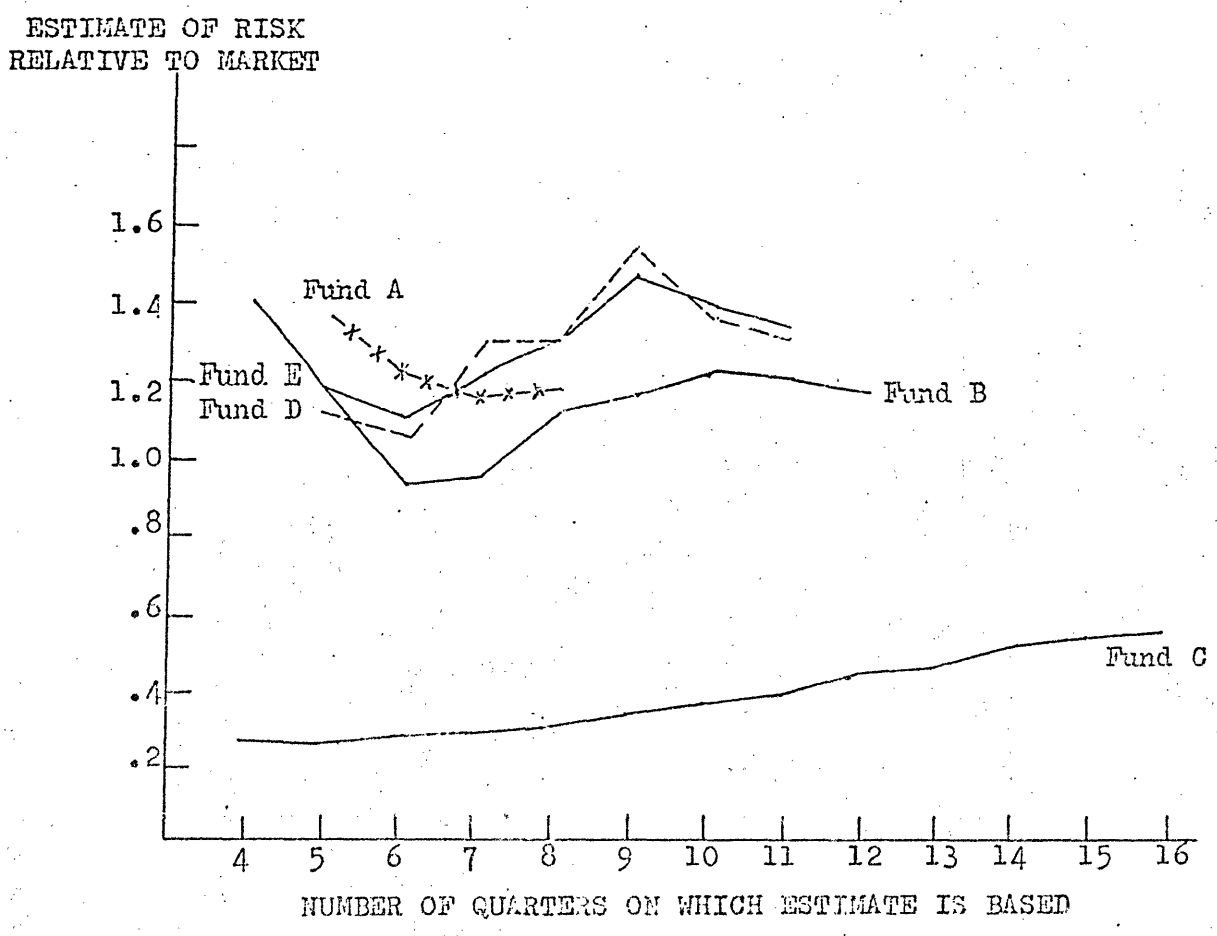


FIGURE 11.8

Variation of estimates of risk relative to the market (ratio of M.A.D.'s) as number of observations grows

IX.4 INCOME ANALYSIS

IX.4.1 QUALITY OF RETURN

The gross gain made by the fund in sector s is reported as

$$MV_n^s - MV_o^s - P^s + GI^s \qquad - (11.48)$$

or

$$MV_n^c - MV_o^c - C^c + GRT^c \qquad - (11.49)$$

in the case of the cash sector, where C^c is as defined in (11.37). If income data is unavailable, the GI^s term is set to zero for the purpose of the calculation even if it was estimated using the NOTIONAL option. Gross gain for the total fund is:

$$MV_n - MV_o - C + GRT \qquad - (11.50)$$

An annualised gross income yield

$$\left[1 + \frac{GI^s}{MV_o + P^s - GI^s}\right]^{365/D_o} - 1 \qquad - (11.51)$$

is quoted for each sector, with appropriate modifications to the denominator for the cash sector. For the total fund, annualised gross income yield is

$$\left[1 + \frac{GI}{MV_o + C - GRT}\right]^{365/D_o} - 1 \qquad - (11.52)$$

The "quality" of return in each sector (refer XII.7, Ch.5) is measured as the percentage of gross gain (11.48) which was made up of gross income:

$$\frac{GI^s}{MV_n^s - MV_o^s - P^s + GI^s} \times 100\% \qquad - (11.53)$$

with similar expressions for the total fund and cash sector. Because this ratio leads to nonsensical results if a loss, or only a small profit, was made during the period, it is not always reported.

None of the above statistics are reported if sufficient income data for their calculation was not provided. For example, under the MONTHLY TOTALS option, only figures relating to the total fund are given.

IX.4.2 COMPONENTS OF INCOME PERFORMANCE

The components of income performance relative to the model fund (refer (5.20)) do not appear disaggregated by sector completely as it was felt that the income indices of sectors other than gilts and equities were not reliable enough to warrant highlighting.

CHAPTER 12

FUND PERFORMANCE REPORT

A quarterly performance report for one of the funds analysed is used in this chapter to illustrate the interpretation of a Fund Performance Report as produced by the software of this study. The results obtained from the application of this software to five pension funds over extended periods are also presented and interpreted. Finally, results of the application of the software to some artificial problems are also presented.

I. FORMAT OF A REPORT

Figure 12.1 displays a Fund Performance Report of maximum length for a fund which was reviewed over the third quarter of 1976. It is based on the files shown in Figure 10.7 and 10.5, and uses a model fund based on the average profile of U.K. "other public sector" pensions funds. It must be emphasised that this report is the longest possible, and in reality would be reduced to some extent depending on the preferences of the user.

Sector information in the report usually appears in the order in which sectors were specified in the Fund Data file (F8). Table 17 is an exception, where they always appear in standard order. Sector names (EQUITIES, GILTS etc.) as well as the titles MAIN FUND and MODEL FUND may be easily varied from run to run by changing the appropriate DATA statements in WRITER.

The interpretation of performance falls neatly into two categories: that of short run performance (over the current review period only) and long run performance (assessing performance to date in the light of both past and recent

FIGURE 12.1

Example of a Fund Performance Report with all tables included

PERFORMANCE REPORT FOR A NON-L.A. PUBLIC UTILITY CORPORATION (C) OVER PERIOD 1 7 1976 TO 30 9 1976 PAGE 1

SUMMARY OF PERFORMANCE THIS PERIOD

1. GROWTH OF MAIN FUND

SOURCE OF GROWTH	ACTUAL FUND AMOUNT ($000)	ACTUAL FUND % OF INITIAL FUND	MODEL FUND AMOUNT ($000)	MODEL FUND % OF INITIAL FUND
INITIAL MAIN FUND	43092.53	100.00	43092.53	100.00
NET NEW MONEY	4193.25	9.73	4193.25	9.73
(INCOME EARNED **)	(919.97)	2.13	(851.77)	1.98
(INCOME WITHDRAWN)	(-267.36)	-.62	(-267.58)	-.62
REINVESTED INCOME	652.62	1.51	584.69	1.36
APPRECIATION	-3642.99	-8.45	-4096.05	-9.51
FINAL MAIN FUND	44295.66	102.79	43774.41	101.58

** BECAUSE INCOME WAS REPORTED ON AN AFTER TAX BASIS, INCOME OF ACTUAL FUND HAS BEEN GROSSED UP TO A BEFORE-TAX FIGURE IN ADVANCE OF TAX REFUNDS. THIS MAKES IT DIRECTLY COMPARABLE TO THE GROSS INCOME OF THE MODEL FUND. 'INCOME WITHDRAWN' INCLUDES TAX PAID THIS PERIOD.

- THIS REPORT DOES NOT ASSESS THE FOLLOWING INVESTMENTS: NIL. (PROPERTY IN SEPERATE FUND)

2. ANNUALISED RATE OF RETURN OVER THIS PERIOD (%P.A.)

TYPE OF RATE OF RETURN MEASURE	SECTORS OF MAIN FUND: GILTS	OTH FIXD INT	EQUITIES	OVERSEAS	PROPRTY TST	CASH	TOTAL MAIN FUND
ACHIEVED ORDINARY RATE OF RETURN (AFFECTED BY TIMING OF NEW MONEY)	-9.42	3.49	-42.74	26.04	31.90	10.60	-21.73
ACHIEVED TIME WEIGHTED RETURN (NOT AFFECTED BY TIMING OF NEW MONEY)	-7.10	2.98	-40.98	33.96	31.47	10.60	-20.42
HISTORICAL MARKET RATE OF RETURN ACCORDING TO INDEX	-9.09	-15.74	-39.26	42.25	12.80	11.20	(MODEL FUND) -24.04

3. ANALYSIS OF RETURN RELATIVE TO MODEL FUND

RELATIVE RETURN FROM LONG-RUN INVESTMENT POLICY	+	RELATIVE RETURN FROM CURRENT STRATEGY	=	TOTAL RELATIVE RETURN FROM SECTOR SELECTION	: +	TOTAL RELATIVE RETURN FROM SECURITY SELECTION	=	TOTAL RELATIVE RETURN ON MAIN FUND
-2.25%	+	3.91%	=	1.56%	: +	-.41%	=	1.15%

PERFORMANCE REPORT FOR A NON-L.A. PUBLIC UTILITY CORPORATION (C) OVER PERIOD 1 7 1976 TO 30 9 1976 PAGE 2

4. ACHIEVED RATE OF RETURN (R.O.R.) FOR EACH SECTOR OVER THIS REVIEW PERIOD (/)

SECTOR	HISTORICAL MARKET R.O.R.	ACHIEVED MONEY-WEIGHTED R.O.R. (SEE NOTE 1 BELOW)	ACHIEVED TIME-WEIGHTED R.O.R. (SEE NOTE 2 BELOW)	DIFFERENCE (MONEY- LESS TIME-WEIGHTED. SEE NOTE 3) -	GROSS GAIN (LOSS) (NET OF NEW MONEY)*	GROSS INCOME YIELD (/P.A.)*	PERCENTAGE OF GAIN WHICH WAS INCOME*
TOTAL MAIN FUND	-6.69 (MODEL FUND)	-5.99	-5.59	-.40	-2723.10	8.27	NOT APPLICABLE
GILTS	-2.37	-2.46	-1.84	-.62	-272.71	13.06	NOT APPLICABLE
OTH FIXD INT	-4.23	[illegible]	.74	.13	3.41	9.59	262.64
EQUITIES	-11.81	-13.11	-12.44	-.67	-2936.44	6.51	NOT APPLICABLE
OVERSEAS	10.43	6.01	7.65	-1.64	300.58	2.54	10.56
PROPTY TST	3.10	7.23	7.14	.09	25.14	18.49	60.41
CASH	2.71	2.57	2.57	0	156.81	10.60	100.00

NOTE 1: MONEY-WEIGHTED RATE OF RETURN IS AFFECTED BY THE TIMING OF NEW MONEY AND SECTOR SWITCHES DURING THE PERIOD. IT IS THE ORDINARY RATE OF RETURN, MEASURING INCREASE IN WEALTH.

NOTE 2: TIME-WEIGHTED RATE OF RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR. IT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BETWEEN DIFFERENT PORTFOLIOS.

NOTE 3: IN THE CASE OF AN INDIVIDUAL SECTOR, A LARGE POSITIVE DIFFERENCE (E.G. 1/ OR GREATER) INDICATES THAT SWITCHES INTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN THIS SECTOR WERE TIMED WELL. A LARGE POSITIVE DIFFERENCE FOR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOURABLE TO PERFORMANCE.

* ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP INCOME, SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET OF TAX.

FIGURE 12.1 CONTINUED

Table 4

A N A L Y S I S O F P E R F O R M A N C E R E L A T I V E T O M O D E L F U N D

E. COMPOSITION OF FUNDS USED IN ANALYSIS

SECTOR	% OF MTN FUND HYPOTHETICALLY INVESTED IN SECTORS IN THE CASE OF- MODEL FUND *	POLICY FUND **	INITIAL STRATEGY (AS AT 1 7 1976)	COMPOSITION OF FINAL FUND (AS AT 30 9 1976)
GILTS	22.00	30.00	29.74	33.19
OTH FIXD INT	9.00	0	.03	.81
EQUITIES	56.00	60.19	49.76	46.57
OVERSEAS	7.00	0	10.06	13.53
PROPTY TST	2.00	.81	.91	.81
CASH	4.00	0	9.49	5.39

* BASIS FOR MODEL FUND PROFILE: AVERAGE PROFILE OF NON-L.A. PUBLIC FUNDS.

** BASIS FOR POLICY FUND PROFILE: 15% TO PROPERTY FUND, + LIMIT HOLDING.

FIGURE 12.1 CONTINUED

Table 5

6. ANALYSIS OF RETURN RELATIVE TO MODEL FUND (PERCENTAGES*)

SOURCE OF RELATIVE RETURN	SECTORS OF MAIN FUND: GILTS	OTH FIXED INT	EQUITIES	OVERSEAS	PROPTY TST	CASH	TOTAL MAIN FUND
POLICY RETURN (FROM LONG-RUN INVESTMENT POLICY)	9.12	-8.95	12.06	-7.34	-1.27	-4.27	-2.25
INITIAL STRATEGIC RETURN (FROM COMPOSITION OF INITIAL FUND)	-.56	.02	-13.11	11.43	.05	10.12	3.72
SUBSEQUENT STRATEGIC RETURN (FROM ACTION THIS PERIOD)	2.68	-.17	.78	2.15	-.10	-5.14	.19
TOTAL STRATEGIC RETURN (FROM CURRENT DEVIATION FROM POLICY)	2.03	.75	-17.37	13.48	-.09	4.98	3.81
TOTAL RELATIVE RETURN FROM SELECTION OF SECTORS (POLICY + STRATEGIC)	10.14	-8.20	-5.27	5.54	-1.36	.71	1.56
TOTAL RELATIVE RETURN FROM SELECTION OF SECURITIES	.15	.04	-.30	-.30	.03	-.02	-.41
TOTAL RELATIVE RETURN (SECTOR SELECTION + SECURITY SELECTION)	10.29	-8.16	-5.57	5.24	-1.33	.70	1.15

* AS A PERCENTAGE OF AN AVERAGE MAIN FUND SIZE DURING THIS REVIEW PERIOD OF £45461267.

FIGURE 12.1 CONTINUED : Table 6

7. ANALYSIS OF ABSOLUTE GAINS RELATIVE TO MODEL FUND (£ '000'S))

SOURCE OF RELATIVE PROFIT	SECTORS OF MAIN FUND: GILTS	OTH FIXD INT	EQUITIES	OVERSEAS	PROPRTY TST	CASH	TOTAL MAIN FUND
POLICY PROFIT (FROM LONG-RUN INVESTMENT POLICY)	7698.24	-4068.32	5462.53	-7510.67	-577.44	-1939.37	-1324.03
INITIAL STRATEGIC PROFIT (FROM COMPOSITION OF INITIAL FUND)	-297.54	418.50	-3231.61	5198.32	1.65	4601.82	1691.14
SUBSEQUENT STRATEGIC PROFIT (FROM ACTION THIS PERIOD)	1218.84	-78.58	352.41	930.30	-43.27	-2338.60	41.11
TOTAL STRATEGIC PROFIT (FROM CURRENT DEVIATION FROM POLICY)	921.30	339.92	-7879.21	6128.62	-41.63	2263.23	1732.24
TOTAL RELATIVE PROFIT FROM SELECTION OF SECTORS (POLICY + STRATEGIC)	4611.54	-3729.40	-2306.67	2517.95	-619.06	323.86	708.22
TOTAL RELATIVE PROFIT FROM SELECTION OF SECURITIES	61.11	19.67	-137.75	-136.40	14.13	-7.79	-187.03
TOTAL RELATIVE PROFIT (SECTOR SELECTION + SECURITY SELECTION)	4672.65	-3709.73	-2594.42	2381.56	-604.93	316.06	521.19

FIGURE 12.1 CONTINUED

Table 7

8. PERFORMANCE OF OVERSEAS SECTOR

SOURCE OF PERFORMANCE	AMOUNT OF GAIN (£000) (NET OF NEW MONEY)	MONEY-WEIGHTED * RATE OF RETURN (%)
STRATEGY (RETURN FROM INDEX - AT OLD EXCH RATE + PENALTY)	-131.6	-2.03
SELECTION OF SECURITIES (RETURN IN EXCESS OF INDEX -AT OLD EXCH RATES + PENALTY)	-137.3	-2.74
CHANGE IN PREMIUM EXCHANGE RATE (FROM £1=1.23 TO £1= 1.13 - AT OLD PREMIUM PENALTY)	507.6	10.14
TOTAL PROFIT SINCE BEGINNING OF REVIEW PERIOD	266.9	5.37

* AS A PERCENTAGE OF AN AVERAGE INVESTMENT IN THIS SECTOR DURING THE REVIEW PERIOD OF £5006183. THE ABOVE GAINS AND RETURNS DO NOT INCLUDE ANY UN-REINVESTED INCOME.

FIGURE 12.1

CONTINUED

Tables 8 & 9

9. GROSS INCOME PERFORMANCE RELATIVE TO MODEL FUND (PERCENTAGES*)

SOURCE OF RELATIVE INCOME	SECTORS OF MAIN FUND: GILTS	EQUITIES	OTHER (INCL CASH)	TOTAL MAIN FUND
POLICY INCOME (FROM LONG-RUN INVESTMENT POLICY)	.19	.20	-.50	-.12
STRATEGIC INCOME (FROM CURRENT DEVIATION FROM POLICY)	-.15	-.30	.45	.01
TOTAL RELATIVE INCOME FROM SELECTION OF SECTORS (POLICY + STRATEGIC)	.04	-.10	-.05	-.11
TOTAL RELATIVE INCOME FROM SELECTION OF SECURITIES	.22	.04	.00	.26
TOTAL RELATIVE INCOME (SECTOR SELECTION + SECURITY SELECTION)	.26	-.06	-.05	.15

* AS A PERCENT OF OF AN AVERAGE MAIN FUND SIZE DURING THIS REVIEW PERIOD OF £45401267.

CURRENT COMPARED TO PAST RESULTS

10. ACHIEVED CUMULATIVE MONEY WEIGHTED RATE OF RETURN (%)

(NOTE: MONEY WEIGHTED RETURN IS AFFECTED BY THE TIMING OF NEW MONEY OP, IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR.)

SECTOR	CUMULATIVE RETURN OVER PREVIOUS PERIODS (TO 30 9 1976)				
	SINCE 1 1 1976	SINCE 1 7 1975	SINCE 1 1 1975	SINCE 1 7 1974	SINCE 1 4 1974
MAIN FUND	-1.36	9.63	27.81	24.44	21.46
GILTS	4.59	7.11	12.14	11.71	30.45
OTH FIXD INT	3.76	3[illegible].48	100.14	107.37	76.51
EQUITIES	-13.52	3.47	53.15	.01	-8.26
OVERSEAS	35.05	34.76	74.08	98.97	96.97
PROPTY TST	13.06	24.17	26.95	26.59	26.59
CASH	12.60	21.92	31.77	39.87	41.53

11. ACHIEVED CUMULATIVE TIME WEIGHTED RATE OF RETURN (%)

(NOTE: TIME WEIGHTED RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY OP, IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR.)

SECTOR	CUMULATIVE RETURN OVER PREVIOUS PERIODS (TO 30 9 1976)				
	SINCE 1 1 1976	SINCE 1 7 1975	SINCE 1 1 1975	SINCE 1 7 1974	SINCE 1 4 1974
MAIN FUND	.01	12.14	32.65	32.75	32.95
GILTS	5.57	8.19	15.00	13.39	29.9[illegible]
OTH FIXD INT	3.46	18.13	95.04	103.78	71.66
EQUITIES	-12.19	6.[illegible]9	31.47	29.35	18.32
OVERSEAS	41.12	44.79	151.03	180.86	180.86
PROPTY TST	12.68	23.86	26.57	26.21	26.21
CASH	12.45	21.78	31.59	39.68	41.34

FIGURE 12.1 CONTINUED : Tables 10 & 11

12. MODEL FUND CUMULATIVE TIME WEIGHTED RATE OF RETURN (%)

(NOTE: TIME WEIGHTED RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY OR, IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR.)

SECTOR	CUMULATIVE RETURN OVER PREVIOUS PERIODS (TO 30 9 1976)				
	SINCE 1 1 1976	SINCE 1 7 1975	SINCE 1 1 1975	SINCE 1 7 1974	SINCE 1 4 1974
MAIN FUND	-2.65	14.58	71.09	47.66	38.74
GILTS	5.92	10.36	29.65	38.77	41.52
OTH FIXD INT	5.03	22.45	64.07	52.93	49.39
EQUITIES	-11.03	12.39	123.72	48.79	34.50
OVERSEAS	33.75	33.91	194.54	105.40	97.23
PROPTY TST	9.03	15.26	14.30	7.75	-2.70
CASH	7.63	13.29	19.23	26.02	29.89

13. ACHIEVED AVERAGE ANNUAL MONEY WEIGHTED RATE OF RETURN (%P.A.)

(NOTE: MONEY WEIGHTED RETURN IS AFFECTED BY THE TIMING OF NEW MONEY OR, IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR.)

SECTOR	VALUE THIS PERIOD	CUMULATIVE ANNUALISED AVERAGE RETURN BASED ON OVER PREVIOUS PERIODS (TO 1 7 1976)				
		SINCE 1 1 1976	SINCE 1 7 1975	SINCE 1 1 1975	SINCE 1 7 1974	SINCE 1 4 1974
MAIN FUND	-21.73	10.18	16.52	22.79	15.05	12.07
GILTS	-9.42	14.91	9.31	9.77	7.02	13.80
OTH FIXD INT	3.48	5.87	17.46	58.13	43.38	28.25
EQUITIES	-42.74	-.95	19.03	46.06	7.28	2.45
OVERSEAS	26.04	62.96	27.12	39.32	34.22	34.22
PROPTY TST	31.90	11.27	15.89	11.95	9.96	9.96
CASH	13.60	20.69	18.86	18.23	16.77	15.39

FIGURE 12.1 CONTINUED : tables 12 & 13

14. ACHIEVED AVERAGE ANNUAL TIME WEIGHTED RATE OF RETURN (%P.A.)

(NOTE: TIME WEIGHTED RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY OR, IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR.)

SECTOR	VALUE THIS PERIOD	ANNUALISED AVERAGE RETURN BASED ON CUMULATIVE RETURN OVER PREVIOUS PERIODS (TO 1 7 1976) SINCE 1 1 1976	SINCE 1 7 1975	SINCE 1 1 1975	SINCE 1 7 1974	SINCE 1 4 1974
MAIN FUND	-2[illegible].42	12.34	1[illegible].79	25.53	18.58	16.44
GILTS	-7.10	15.81	10.22	11.16	7.48	12.87
OTH FIXD INT	2.98	5.51	17.25	55.52	41.52	26.74
EQUITIES	-40.98	.59	21.[illegible]6	68.72	21.54	14.32
OVERSEAS	33.96	72.62	34.13	76.12	61.53	61.53
PROPTY TST	31.47	11.10	15.51	11.79	9.83	9.83
CASH	10.60	20.37	18.73	18.12	16.70	15.32

15. MODEL FUND AVERAGE ANNUAL TIME WEIGHTED RATE OF RETURN (%P.A.)

(NOTE: TIME WEIGHTED RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY OR, IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR.)

SECTOR	VALUE THIS PERIOD	ANNUALISED AVERAGE RETURN BASED ON CUMULATIVE RETURN OVER PREVIOUS PERIODS (TO 1 7 1976) SINCE 1 1 1976	SINCE 1 7 1975	SINCE 1 1 1975	SINCE 1 7 1974	SINCE 1 4 1974
MAIN FUND	-2[illegible].[illegible]4	8.94	22.80	4[illegible].98	25.80	19.29
GILTS	-9.09	17.87	13.66	20.86	19.22	17.95
OTH FIXD INT	-15.74	2[illegible].56	2[illegible].[illegible]5	43.31	26.36	21.85
EQUITIES	-39.26	1.81	2[illegible].[illegible]1	[illegible]5.32	2[illegible].[illegible]9	20.64
OVERSEAS	43.25	47.15	21.26	50.99	36.38	29.41
PROPTY TST	12.88	11.95	11.80	7.14	2.23	-2.54
CASH	11.20	9.89	10.30	17.49	1[illegible].77	11.00

FIGURE 12.1 CONTINUED : Tables 14 & 15

16. COMPONENTS OF RETURN RELATIVE TO MODEL FUND (PERCENTAGES)

COMPONENT	VALUE THIS PERIOD	AVERAGE OVER PREVIOUS PERIODS (TO 1 7 1976) SINCE 1 1 1976	SINCE 1 7 1975	SINCE 1 1 1975	SINCE 1 7 1974	SINCE 1 4 1974
POLICY RETURN	-2.25	-.57	.21	2.86	.77	.67
INITIAL STRATEGIC RETURN	3.72	.76	-1.1[illegible]	-7.48	-2.98	-2.50
SUBSEQUENT STRATEGIC RETURN	.09	.44	.45	.34	.92	1.27
TOTAL STRATEGIC RETURN	3.81	1.20	-.58	-7.14	-2.06	-1.22
TOTAL RETURN FROM SECTOR SELECTION	1.56	.67	-.47	-4.28	-1.29	-.55
TOTAL RETURN FROM SECURITY SELECTION BY SECTOR -	-.41	.11	-.38	-.97	-.70	-.53
GILTS	.13	-.03	-.13	.12	.13	-.15
OTH FIXD INT	.04	-.16	-.58	-.92	-.64	-.51
EQUITIES	-.36	-.09	-.21	-.65	-.66	-.26
OVERSEAS	-.30	.37	.24	.32	.29	.29
PROPTY TST	.07	.05	.11	.02	.03	.03
CASH	-.02	.03	.08	.15	.15	.12
TOTAL EXCESS RETURN OVER MODEL FUND	1.15	.78	-.96	-5.25	-1.99	-1.08

FIGURE 12.1 CONTINUED

Table 16

17. RISK MEASURES (/P.A.)

RISK IS MEASURED AS THE VARIABILITY OF TIME-WEIGHTED RATE OF RETURN ABOUT THE AVERAGE RETURN OVER THE PAST 12 OR LESS REVIEWS PLUS THIS ONE. A RISK MEASURE OF 15.0%, FOR EXAMPLE, IMPLIES THAT, ON AVERAGE, PAST ANNUALISED TIME-WEIGHTED RATES OF RETURN HAVE DEVIATED FROM THEIR AVERAGE BY PLUS OR MINUS 15 PER CENT

SECTOR	RISK MEASURES (/P.A.) FUNDS INVESTMENTS	MARKET (ACCORDING TO INDEX)	RATIO: FUND TO MARKET RISK*
MAIN FUND	2[illegible].36	57.88 (MODEL FUND)	.36
EQUITIES	117.02	176.31	.67
GILTS	22.17	19.18	1.16
OTH FIXD INT	115.15	51.94	2.22
OVERSEAS	101.59	56.88	1.79
PROPTY TST	11.51	14.74	.80
CASH	5.57	.86	6.45

* A RISK MEASURE LOWER THAN THAT OF THE MARKET (I.E. A RATIO LESS THAN 1.0) INDICATES SUPERIOR RISK PERFORMANCE. INFERIOR RISK PERFORMANCE, IF LARGE ENOUGH, MAY COMPENSATE FOR INFERIOR RATE OF RETURN PERFORMANCE RELATIVE TO THE MARKET. THIS IS ON THE RATIONALE THAT A LOWER, MORE SECURE RETURN IS PREFERABLE TO A HIGHER BUT MORE VARIABLE (AND HENCE LESS SECURE) RETURN.

FIGURE 12.1 CONTINUED

Table 17

RECEIPTS AND ALLOCATIONS DURING REVIEW PERIOD

18. RECEIPTS AND ALLOCATIONS BY SECTOR

RECEIPTS

SOURCE	AMOUNT (£)		% OF INITIAL FUND
NET CONTRIBUTIONS		4193248	9.73
INVESTMENT INCOME-			
GILTS	226376		.53
OTH FIXD INT	5987		.01
EQUITIES	233279		.54
OVERSEAS	27641		.06
PROPTY TST	9474		.02
CASH	156889		.36
TOTAL INCOME (MAIN FUND)	652819		1.51
EXCLUDED SECTOR	0		0
TOTAL INCOME		652819	1.51
TOTAL RECEIPTS		4846067	11.25

ALLOCATIONS

SOURCE	AMOUNT (£)		% OF INITIAL FUND
NET PURCHASES -			
GILTS	2676000		6.21
OTH FIXD INT	-36000		-.08
EQUITIES	2651000		6.15
OVERSEAS	1388000		3.22
PROPTY TST	0		0
TOTAL PURCHASES (MAIN FUND)	6679000		15.50
EXCLUDED SECTOR	0		0
TOTAL PURCHASES		6679000	15.50
INCREASE IN CASH		-1832933	-4.25
PAYMENTS TO TRUSTEES		0	0
TOTAL ALLOCATIONS		4846067	11.25

19. RECEIPTS AND ALLOCATIONS BY TIME

MONTH	RECEIPTS				ALLOCATIONS				
	NET CONTRIBUTIONS	INVESTMENT INCOME (NET OF ANY EXPATR)	TOTAL (£)	TOTAL AS % OF INITIAL FUND	NET PURCHASES (MAIN FUND)	INCREASE IN CASH	NET PURCHASES IN EXCLUDED SECTOR	TOTAL (£)	TOTAL AS % OF INITIAL FUND
JUL	1712929	397606	2110535	4.90	-1563000	3673535	-0	2110535	4.90
AUG	1731119	78001	1809120	4.20	2774000	-965880	-0	1809120	4.20
SEP	741200	185212	926412	2.15	5367000	-4491588	-0	926412	2.15
TOTALS	4193248	652819	4846067	11.25	6679000	-1832933	0	4846067	11.25

********** END OF REPORT FOR A NON-L.A. PUBLIC UTILITY CORPORATION (C) **********

FIGURE 12.1 CONTINUED : Tables 18 & 19

statistics). These two categories are discussed seperately in this chapter.

II. INTERPRETATION OF CURRENT PERFORMANCE RESULTS

Performance this period is covered in the report by tables 1 to 4, which constitute a summary of current performance, and tables 5 to 9, which give further details to some of the figures appearing in the summary. In addition, tables 18 and 19 provide accounting information for the current period. Tables 1 to 4 constitute the minumum length of a report. All other tables may be vetoed using input options.

II.1 TABLE 1 - "GROWTH OF MAIN FUND"

This is designed to be the simplest explanation of current performance in the report. All other information in the report can ultimately be related to the figures in this table. Table 1 compares the growth in market values of the actual fund and its associated model fund against which all performance assessment in the report is made. Various sources of growth of the two funds are quoted as follows:-

1. Both commence with the same initial value, MV_0, and are subjected to the same new money and income withdrawals. These identical cash flows make the two funds directly comparable.

2. The actual income earned by Fund C is compared to the simulated income earned by the model fund. The difference between these two is the first source of different rates of return over the period.

3. The other source of difference in return is the capital appreciation of the funds.

Thus Fund C over this period earned more income than the average U.K. pension fund of the same type as Fund C. Fund C earned £919,900 while the model fund earned only £851,770. After the £267,080 income which was actually repaid to trustees during the review period was withdrawn from both funds, the model fund consequently had less to reinvest. The market generally declined during the review period, as the average fund lost over £4m during the period. Fund C did not do as badly however, losing only £3,642,990. Consequently, as a result of both this smaller capital loss and greater income generation, Fund C ended the period with a greater final market value than the model fund. Its final value is 2.79% higher than its initial value, whereas the average pension fund managed only 1.58%. Fund C outperformed the average fund of the same type by an extra 1.21%.[1]

Table 1 is designed for the complete layman who, while he may not completely comprehend the components of performance or rates of return in the rest of the report, can at least understand the differences in the growth of absolute sizes of the two funds, and appreciate their sources of income versus capital appreciation.

A message is always given underneath table 1 concerning investments which have been excluded from the analysis. Additional messages may appear depending on the nature of the income earned figures appearing in the table. They refer to the facts that income was grossed up to compensate for pre-paid tax, and / or that some income figures were estimated from index yields. These messages can be seen in various combinations in Appendix 11-II

1: This difference will in general be fairly close to the "relative return" figure in Table 3. The difference is due to the fact that relative return is a more accurate measure of excess return since it is based on average capital employed, whereas 1.21% is based on just initial value, MV_0.

II.2 TABLE 2 - "ANNUALISED RATES OF RETURN"

Both money-weighted (top line) and time-weighted rates of return are quoted on an annualised basis. They are the returns which would be obtained if the experience of the fund were repeated for the next three quarters. Annual returns have an appeal for some trustees who like to make comparisons with well-known annual rates in the market, such as the bank rate. The bottom line gives annualised market returns (on a monthly compounding of income[1]). These are strung together according to the model profile relevant to this fund to produce an overall market return. Note that this return is net of realignment charges for the model portfolio at the beginning of the current review period.[2]

II.3 TABLE 3 - "ANALYSIS OF RETURN RELATIVE TO MODEL FUND"

Table 3 gives a basic analysis of the causes of the difference in performance between Fund C and the model fund which was foreshadowed by tables 1 and 2. Fund C earned 1.15% more during the quarter than did the model fund. Fund C earned a MWR during the current review period of -5.99% (refer table 4), while the market, when exposed to the same money flows as those experienced by Fund C, earned 1.15% less, or -7.15%. This difference is unaffected by the new money to which Fund C was exposed because the model fund was exposed to the same cash flows, as table 1 showed.

Just from this one line of figures, several deductions can be drawn:

1. The trustees' policy was potentially very damaging to the fund during this review period. If it had

---

1: If the fund was assessed on capital value only (option F20), these returns and those of Table 4 will nevertheless include income.

2: Technically, the compounding of 4 identical quarterly returns to get the annualised return implicitly assumes that realignment charges at the end of each quarter would be the same as those actually deducted at the beginning of the current quarter. Any inaccuracy introduced by this assumption would be minute.

been pursued to the letter, if would have earned a return for the fund which was $2\frac{1}{4}\%$ below the average return.

2. The fund manager should be congratulated for departing from this policy. His actions resulted in above average return which more than compensated for the potentially adverse effects of trustee policy. Thanks to this action, the fund earned over $1\frac{1}{2}\%$ in excess of the average fund just due to decisions concerning its distribution between sectors.

3. Excess return would have stayed as $1\frac{1}{2}\%$ if the fund had been composed of better quality securities. The fund's securites in fact earned an average of 0.41% less than market return over the review period. To the extent that the fund manager is responsible for security selection (as a manager usually is), this is an adverse comment on his skill as far as this very short term review is concerned.

4. Interpreting these components from a CAPM point of view[1], Fund C has, on a risk adjusted basis, actually <u>under</u>-performed the market.

A quick reference to table 17 will confirm that the risk level for this fund as at the end of this quarter is less than half that of the market. Because the market has declined, this would normally imply that Fund C's return should decline to a less extent than the market. This it has done, as indicated by the positive sector selection figure. This is the extra return one would expect from the lower risk level of the fund. The fact that actual return was not in fact this high (as reflected by Security Selection) indicates that Fund C under-performed the market on a risk-adjusted basis. This argument is summarised by Figure 12.2. The use of the fund's MAD as an estimate of its risk in this

1: Refer V, Ch. 8

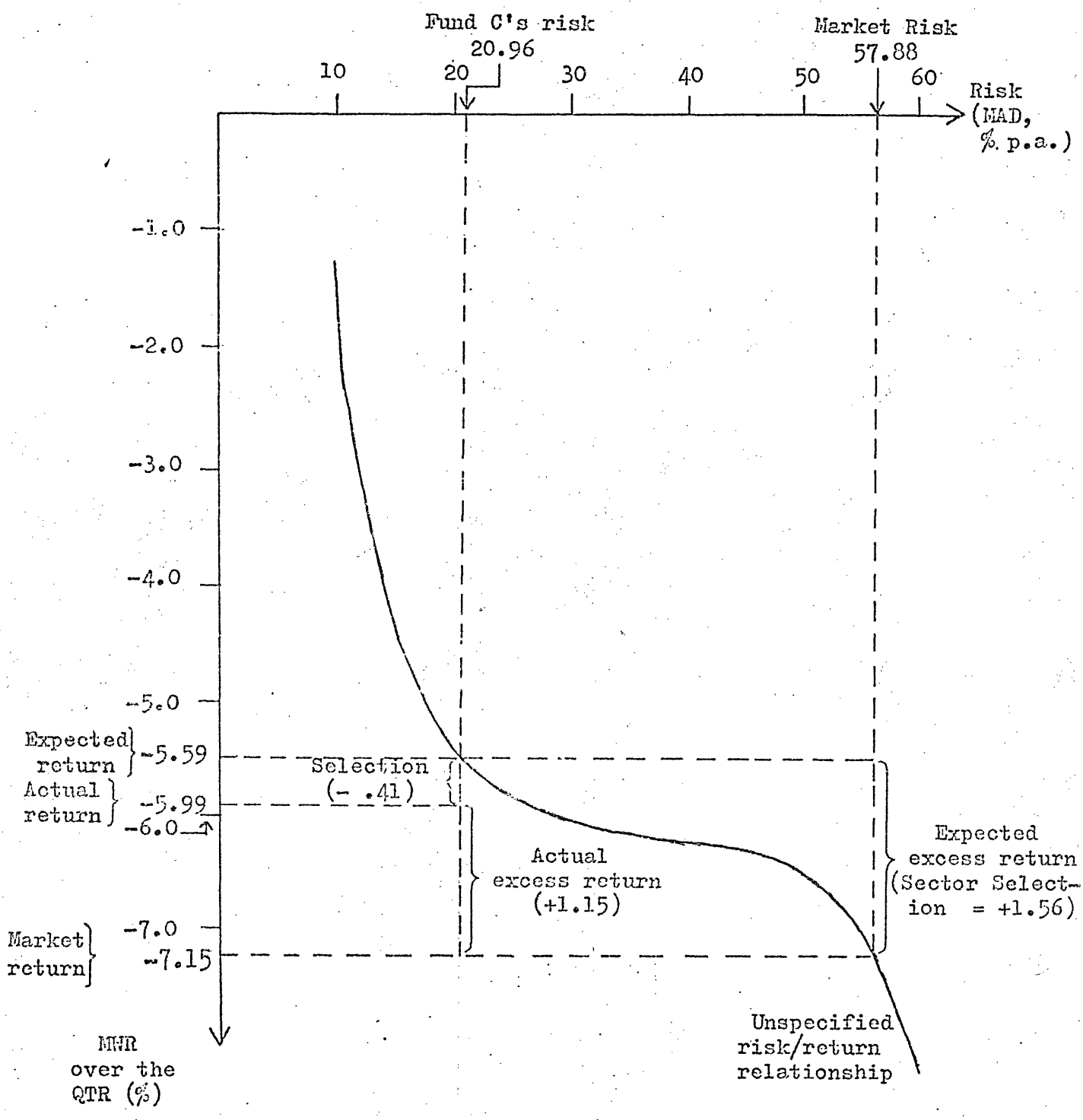


FIGURE 12.2

Components of performance of Fund C shown in terms of CAPM theory, assuming that MAD is a measure of systematic risk only (i.e. that Fund C is perfectly diversified).

diagram assumes that the fund is perfectly diversified, as discussed in XI.3.1, Ch.8.

II.4. TABLE 4 - "ACHIEVED ROR FOR EACH SECTOR"

The first three columns of figures give essentially the same information as table 3, except that the returns are not annualised. The difference between the TWR and MWR is quoted as an indication of the timing of the investment decisions (refer XII.2.2, Chapter 5). A threshold of 1% is given in order to produce conservative conclusions. It is thought that the MWR and TWR estimates are both accurate to within this margin for most reasonable market movements and amounts of new money.[1]

Fund C's new investments in the overseas sector are indicated to be have been badly timed on this basis. Reference to Figure 10.7 will confirm that investment in this sector was substantial each month during the quarter, with a decrease of about 20% in the middle of the month. Referring to the Market Data file in Figure 10.5, this is also the month in which the market bottomed out during the quarter and the premium rate for dollars peaked. Both of these factors would have combined to produce the greatest potential return in the middle of the quarter, yet investment in the sector was least during the middle month, indicating some degree of bad timing.

Two points must be noted about these ROR differences:

1. Timing may be indicated to have been bad for each sector individually, yet the fund as a whole may have benefited from the switches involved.

2. A large negative difference for the Main Fund does not reflect badly on the fund manager, since timing of total new money into the fund is not within his control.

3. As Chapter 5 foreshadowed, they are very blunt measures of timing performance.

1: See Appendix 4-I and VII.2 this chapter

The mid-month dates at which transactions are assumed to be carried out are not capable of yielding discriminating measures unless the review period is very long (say a year), or market movements are very sharp. An example of the latter case is provided by Figure 12.3, which shows table 4 for the report on Fund C over the first quarter of 1975, during which most sectors enjoyed a sharp boom. The associated data files are shown in Figure 12.4. The timing of equity purchases is rightly indicated to have been very unfortunate, for as the Fund Data file shows, purchases in this sector followed the market. Sales were made when the market was at its low, and increasingly high purchases were made in the next two months. Nearly £1.5m net purchases were made at the market's peak! A contrasting picture is provided by the overseas and OFI sectors. Overseas purchases were made at a low level in the market and most of this sector was sold off at the market's peak in the third month, while other fixed interest securities were continually sold as the market continually climbed.

Timing measures for a review period of one full year may be seen in Appendix 12-I.

The last column is designed to be a measure of the "quality" of return, as outlined in IX.4.1, Ch.11 and XII.7, Ch.5. A figure other than 100.0 under this heading for Cash indicates that some of the figures relating to purchases, income or new money on which the results are based are imperfect but still fall within the limit of inaccuracy described in IV.6, Ch.10.

All the figures in table 4 are based on grossed-up income. If income data was not available for any particular sector, the last two columns will have "NOT AVAILABLE" displayed, while Gross Gain will be based on capital appreciation only. Examples of these in various combination can be found in Appendix 12-I.

PERFORMANCE REPORT FOR A NON-L.A. PUBLIC UTILITY CORPN. FUND (C) OVER PERIOD 1 1 1975 TO 31 3 1975 PAGE 2

4. ACHIEVED RATE OF RETURN (R.O.R.) FOR EACH SECTOR OVER THIS REVIEW PERIOD (/)

SECTOR	HISTORICAL MARKET R.O.R.	ACHIEVED MONEY-WEIGHTED R.O.R. (SEE NOTE 1 BELOW)	ACHIEVED TIME-WEIGHTED R.O.R. (SEE NOTE 2 BELOW)	DIFFERENCE (MONEY- LESS TIME-WEIGHTED, SEE NOTE 3)	GROSS GAIN (£000'S) (NET OF NEW MONEY)*	GROSS INCOME YIELD (/P.A.)*	PERCENTAGE OF GAIN WHICH WAS INCOME*
TOTAL MAIN FUND	40.87 (MODEL FUND)	14.96	15.99	-1.03	2181.21	8.70	13.88
GILTS	16.86	7.43	8.80	-1.37	315.51	.88	2.91
OTH FIXD INT	39.79	68.32	64.51	3.81	273.19	15.26	5.22
EQUITIES	80.29	45.09	64.84	-19.75	1328.37	8.87	4.69
OVERSEAS	21.29	15.32	12.01	3.31	58.34	5.09	8.05
PROPTY TST	-4.07	.31	.26	.05	1.01	9.73	751.68
CASH	2.78	3.18	3.17	.01	214.78	13.54	100.00

NOTE 1: MONEY-WEIGHTED RATE OF RETURN IS AFFECTED BY THE TIMING OF NEW MONEY AND SECTOR SWITCHES DURING THE PERIOD. IT IS THE ORDINARY RATE OF RETURN, MEASURING INCREASE IN WEALTH.

NOTE 2: TIME-WEIGHTED RATE OF RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR. IT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BETWEEN DIFFERENT PORTFOLIOS.

NOTE 3: IN THE CASE OF AN INDIVIDUAL SECTOR, A LARGE POSITIVE DIFFERENCE (E.G. 1/ OR GREATER) INDICATES THAT SWITCHES INTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN THIS SECTOR WERE TIMED WELL. A LARGE POSITIVE DIFFERENCE FOR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOURABLE TO PERFORMANCE.

* ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP INCOME, SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET OF TAX.

FIGURE 12.3

Extract from a Fund Performance Report over a review period with sharp market movements, showing significant timing measures

```
1 11975   31 31975   3
     66.89      58.292       37.2      68.53      88.37
         1       77.72     59.398      79.08      72.56     87.530
         2      112.36     63.268      44.75      80.10     85.851
         3      124.48     66.291      49.07      83.78     84.216
    118.32      66.059       49.9      83.36      83.42
     10.40       0.661      18.51       5.07       6.51      11.00
       7.0       0.646      16.41       4.61       6.68      11.75
      6.34       0.640      15.08       4.42       6.78      10.25
    1.3807      2.3495       0.25
    1.4669      2.3626
    1.4169      2.3948
    1.3833      2.4194
    1.3955      2.4026       0.25
```

FIGURE 12.4

Market and Fund Data files associated with

Figure 12.3

```
A NON-L.A. PUBLIC UTILITY CORPN. FUND (C)                    1                    6
HNW474     HNW175        1     2     3     4     5
        2          3          1          4          5          6
NIL. (PROPERTY IN SEPERATE FUND)
                  0.30        0.0     0.6750        0.0     0.0250        0.0
15/ OF FUNDS TO SEPERATE PROPERTY ACCOUNT.
    195548     466234    2306530     557976     329861    9328212
   6448788     492277    5899530      62304     323266    5572633
   4121334          0     -50750    -149673          0
    949438     -75000     951575      59695          0
    876123    -157903    1417069    -450544          0
INCOME EARNED                                NET
         0        139      15917        940          0      88568
         0          0       6302       1840          0       9390
      5959       9124      18312        272       4945     106821
20 11975       787100     59.469      37.44      73.58      71.08      87.53
21 21975      1413525     63.879      39.86     111.99      82.62     85.851
17 31975      1258025     67.093      45.63     124.96      86.01      83.42
REPAID INCOME          NONE
    1.5282     2.3684
    1.4087     2.4025
    1.3639     2.4195
FINISH
END
```

II.5 TABLE 5 - "COMPOSITION OF FUNDS"

Appearing only if any further performance analysis in addition to table 3 is to appear in the rest of the report, this table gives the profiles of the various notional funds involved in the analysis. The initial and final profile of the actual fund is also given. If there is NO POLICY (F11) connected with the fund, the column under "POLICY FUND" is left blank.

II.6 TABLE 6 - "ANALYSIS OF RETURN RELATIVE TO MODEL FUND."

This table gives the analysis of table 3 with greater detail. The greater detail relates to the split of Strategy into Initial and Subsequent Strategy components, and the split of each component over the sectors of the fund.

The manager's superior strategy this review period was primarily due to the structure of the fund as it was at the beginning of the review period, although his subsequent investments between sectors did make a positive, but small, contribution to overall performance.[1] The largest contribution to Fund C's performance came from its gilt sector (+10.28%), and most of this was due to holding more gilts than the average UK pension fund. (Sector Selection for gilts = 10.14%). Most of this benefit can be attributed to trustee policy in this area, which the manager initially contravened (Initial Strategy = -.65%) but during the period supported and extended (Subsequent Strategy = 2.68%). Going back to the basic data, table 5 showed that initially the fund was invested to just under the extent of 30% implied by policy, but during the period gilts were increased to over 33% of the fund. The manager should be further commended for his selection of the particular gilts held in the portfolio, which

---

1: This component quite naturally tends to become smaller over time if the fund continuously grows. It seems that a manager can only do so much in a quarter in the way of sector switches (perhaps due to marketability constraints) and the absolute profit from this activity becomes a smaller proportion of the total fund size as the fund grows. Thus this component cannot be compared between funds of different sizes.

performed better than the market to produce an extra profit which contributed 0.13% to the total excess of the fund's MWR over model fund return.

The interpretation of the figures for other sectors is similar. Trustee policy would have scored heavily on equities because it implied holding more of them than the average pension fund. The manager's strategy was to hold less throughout the period, so a net loss was made on the weighting of equities as a sector in the portfolio. To make matters worse, the individual share held earned on average a return below that of the FTA All-Share index.

The overseas and cash sectors made positive contributions to the overall rate of return on the fund even though trustee policy ignored them. In each case, the manager's decision to hold some of this sector paid off, although it would have been even more profitable if it were not for poor Selection.

It must be emphasised that with the exception of Selection figures, the figures for individual sectors for a particular component are very much inter-dependent, so that a figure cannot be completely interpreted in isolation from the figures for the same component for other sectors. For example, the net loss made on equities is not necessarily a bad result which should be regretted. It may be that such a loss was necessary in order to invest more heavily in other more profitable sectors of the market. The fact that total excess return was positive indicates that this is so. The loss in equities stems primarily from a negative Strategic contribution. Given that the manager wanted to invest the fund heavily in gilts however, the money had to come from somewhere, in this case from equities. A positive total Strategy component for the fund as a whole indicates that this was a wise move and that the negative Strategic figure for equities was simply an opportunity cost of the process. As table 4 shows, equities were where the heaviest losses were to be made in the market, so it was beneficial to get out of this sector.

Similarly, a positive figure is not necessarily good if the total of the corresponding component is negative. The gain is indicated to have been at great expense in this case.

These comments do not apply to the split of Security Selection over sectors. Here a negative figure does reflect badly on a manager, as far as this short review period goes. However, the Selection figure for a sector is weighted by the importance of that sector in the make-up of the total fund. So quite spectacular Selection in a very small sector can yield a figure which is less than good, but less spectacular, Selection in a large sector. Comparison of the Selection figures for the overseas sector between tables 6, 7 and 8 will illustrate this point.

II.7 TABLE 7 - "ANALYSIS OF ABSOLUTE GAINS RELATIVE TO MODEL FUND"

These are the absolute profits and losses corresponding to the percentages in table 5. Some people may be more impressed by the realisation that, for example, £187,030 was lost over the review period due to poor selection. This is a little more dramatic than quoting -0.41%, but of course cannot be validly compared with a fund of a different size, as can a percentage.

II.8 TABLE 8 - "PERFORMANCE OF OVERSEAS SECTOR"

This decomposition shows that unless the manager claims responsibility for timing overseas investments to coincide with exchange rate movements, he should take no credit for the positive return in this sector. The American market actually declined over this quarter (Strategy) and to aggravate that loss, the particular U.S. shares held by the fund declined even further than the market (Selection). The only cause of the satisfactory overseas return was extremely beneficial exchange rate movements over the quarter (+10.14%). The premium exchange rate declined, implying that the sterling value of dollar assets increased.

Note that the total MWR decomposed in this table will always be less than the MWR quoted in table 4. The latter allows for unreinvested income, whereas becuase the analysis of table 8 confines itself to only the actual transactions carried out in the overseas sector, it cannot allow for income which is not reflected in those transactions.

Figure 12.5 presents table 8 for a different fund over another quarter in which rates moved in the opposite direction. A superficial analysis would conclude that because the net return was about the same as the market return in the U.S., the manager's selections have just been able to keep up with the market. In truth however, his Selection was very good but was more than offset by losses due to a sharp rise in the premium rate.

II.9 TABLE 9 - "GROSS INCOME PERFORMANCE RELATIVE TO MODEL FUND"

The interpretation of these figures should be very similar to that of tables 6 and 3. Fund C earned more income than the relevant average UK pension fund. The extra income accounted for an amount of 0.15% in the total excess return of 1.15%, implying that an excess return of 1.0% was earned through greater capital appreciation. Recall that these figures were pre-empted by table 1. All of the excess income was earned through superior selection of securities. Fund C was invested in high income yielding sectors to a less extent than the model fund (negative Sector Selection) but what high yielding assets it held did so much better than the market that they compensated for the loss due to sector choice. Further, most of this superior income performance was concentrated in equities. This fact, combined with the knowledge obtained from table 17 that the equity sector of this fund is much less risky than the equity market as a whole, suggests that Fund C's holdings are primarily "defensive" shares, with high income and low price volatility.

8. PERFORMANCE OF OVERSEAS SECTOR

SOURCE OF PERFORMANCE	AMOUNT OF GAIN (£000) (NET OF NEW MONEY)	MONEY-WEIGHTED RATE OF RETURN (%) *
STRATEGY (RETURN FROM INDEX - AT OLD EXCH RATE + PENALTY)	-13.0	-4.02
SELECTION OF SECURITIES (RETURN IN EXCESS OF INDEX -AT OLD EXCH RATES + PENALTY)	27.3	8.44
CHANGE IN PREMIUM EXCHANGE RATE (FROM £1=1.21 TO £1=1.31 - AT OLD PREMIUM PENALTY)	-31.8	-9.84
TOTAL PROFIT SINCE BEGINNING OF REVIEW PERIOD	-17.5	-5.42

* AS A PERCENTAGE OF AN AVERAGE INVESTMENT IN THIS SECTOR DURING THE REVIEW PERIOD OF £ 323109. THE ABOVE GAINS AND RETURNS DO NOT INCLUDE ANY UN-REINVESTED INCOME.

FIGURE 12.5

Extract form a Fund Performance Report showing analysis of overseas sector performance under conditions of adverse exchange rate movements

Table 9 will not appear if income data was not provided at least on a SECTOR TOTALS level (refer VI.4, Ch.10).

II.10 TABLE 18 - "RECEIPTS AND ALLOCATIONS BY SECTOR"

This is accounting information only, which can be obtained for record purposes or to confirm that the data on which the preceeding analysis was based is correct. The "investment income" is what was actually received net of any tax which was pre-paid. The two totals should of course always balance.

II.11 TABLE 19 - "RECEIPTS AND ALLOCATION BY TIME"

Totals appearing in table 18 are here split by the sub-periods making up the review period.

The two total columns should agree for each sub-period.

The line appearing in Figure 12.1 beneath table 19 appears at the end of a report on a fund. In a batch run of more than one fund, the report for the next fund would start on the next page after this line, when the page number count (top right hand corner) also recommences at one.

III. FUNDS ANALYSED IN THIS STUDY

Data on five pension funds was extracted from the records of a City merchant bank. The records were organised on a cash accounting basis and took slightly different forms for different funds. All data was extracted on a quarterly basis for valuations and on a monthly basis for all other data.

Table 12.2 lists the funds, giving details relevant to their analysis. All three types of fund are represented with a range of available income data. Policy restrictions on the funds also differ widely, from none at all to the quite severe restriction of 100% investment in the equity sector.

TABLE 12.2

CHARACTERISTICS OF THE 5 PENSION FUNDS USED TO TEST AND VALIDATE THE DEVELOPED SOFTWARE

FUND	TITLE	SIZE (£M AT MAR '78)	No. OF QTRS EXTRACTED (to 31-3-78)	INCOME DATA AVAILABLE	INCOME DATA USUALLY REPAID TO TRUSTEES	INCOME DATA GROSS FIGURES AVAILABLE	TRUSTEE POLICY	MODEL TYPE*	MANAGER
A	CONSUMER GOODS MANUFACTURER'S PENSION FUND	17.4	8	Grand total only	All	Grand total	No gilts or overseas investments: 100% equities	P	2
B	LOCAL AUTHORITY SUPERANNUATION FUND	27.6	12	Sector totals	All	Sector totals	No overseas investment	LA	2
C	NON-LOCAL AUTHORITY PUBLIC UTILITY CORPORATION FUND	87.1	16	All	None	Cash	(i) Restrictions consequent upon 15% to Direct Property (ii) Holding of units in a certain Property Unit Trust	OPS	3
D	MANUFACTURING COMPANY'S STAFF FUND	12.6	11	Monthly totals plus Cash	All	Cash	Until 1977: No overseas investment 1977 and after : No policy	P	1
E	MANUFACTURING COMPANY'S WORKMENS' FUND	7.2	11	Monthly total plus Cash	All	Cash	As for Fund D	P	1

* P = Private sector; LA = Local Authority; OPS = Other Public Sector

III.1 TRUSTEE POLICIES

Fund A had been with this bank for only a relatively short time. Its trustees had had a bad experience with the firm previously engaged to manage the fund. They produced heavy losses for the fund through mismanagement of gilt investments, making the trustees "once burnt, twice shy" of this sector. Coupled with a disbelief in a need for overseas investment and a basic faith in equities, they insist on all their investments being in the equity sector. This case is therefore an example of a trustee policy which translates neatly into a single-point restriction (refer IV.1, Ch.9).

The trustees of funds D and E were at first reticent to support a policy of investment overseas but came around to the manager's point of view after only six months trial investment there.

Fund C's restrictions are interesting in that they are a consequence of the legal restrictions on public pension funds, even though the fund is being compared to a model fund reflecting these same restrictions. The added policy restraints are necessary because the trustees of this fund made the conscious decision to allocate 15% of the total pension fund of their organisation to direct holdings in property. A special account was set up and 15% of the fund plus 15% of all new money goes to this account. The account is managed as a seperate fund (by another management team) and retains its own uninvested cash. That is, it is run completely independently of the rest of the fund, labelled here as the Main Fund. Because the organisation's fund as a whole is subject to a maximum of 25% of its total as investments in property and overseas assets jointly (refer IV.2.1, Ch.9), the decision to allocate 15% to property effectively limits the Main Fund's overseas holdings to 10% of the total fund, which is equivalent to 12% (10%/85%) of the Main Fund. It also effectively limits the proportion of the Main Fund made up by wider range securities (including overseas investments) to 70% of its total ((75-15)/85 %). In addition to these effects, the trustees insisted on the Main Fund holding units in a certain Property Unit Trust for

what to them were "political" reasons. The trustees also frowned on overseas investment as a long-term policy.

Putting all these factors together, the Main Fund was therefore limited to a maximum of 70% investment in wider-range securities, of which a certain percentage had to be Property Unit Trust units. The remaining 30% was treated as gilt investment. Returning to figure 12.1, table 5 shows that the policy for the quarter involved holding 0.8% of the fund in the Property Trust sector. Because this was the actual proportion in the initial fund, the manager's Initial Strategy component (table 6) was not affected by this restriction (although his Subsequent Strategy component was slightly affected because he did not allocate 0.8% of new money to this sector).

This policy and the "no overseas" policy of the other funds are good examples of one-sided restrictions, and were handled as representative single-point restrictions as discussed in IV.1.1, Ch.9.

III.2 MANAGERS

The five funds, between them, are under the charge of three managers, as indicated in the last column of Table 12.2. Each manager has a notably different style. Manager 1 trades very little while Manager 2 is well known in the office for what is viewed by some others as excessive dealing. Manager 3 represents a combination. Fund C in its early days (1974/75) was managed by personnel now no longer directly connected with the fund in recent times, when it has been managed by Manager 2. It will be seen in the next section that to some extent, the stamp of these individual managers on their funds is revealed by an analysis of the fund's results over the long term.

IV. PERFORMANCE OF THE FIVE FUNDS

The performance of the five funds over the entire period for which their data was collected is discussed here to

indicate the sort of performance statistics which are helpful in such long term analysis. The rationale for the structure of the section of a Fund Performance Report which deals with long term results will in this way become apparent.

Table 12.3 summarises the results of the application of the software package developed in this study to the five funds. Because the funds were reviewed over time periods of different lengths, some of the statistics in the table are not strictly comparable between funds. As a check on this effect, the statistics for Fund C were re-computed for a period extending over only the past two years instead of its full history of four years. The results are broadly similar, lending confidence to comparisons between the funds. Additional support is given by the Fund Comparison Report in figure 13.3 of the next chapter. This ranks the funds on the basis of average performance over only the past two years and, with the exception of an interchange of funds B and E, confirms the ranking of Table 12.3. The risk measures in Table 12.3 are as at 31st March 1978.

Taking the results as a whole, the CAPM dictum of greater return only in reward for greater risk is supported by these five funds. The funds with above average returns (A, D and E) have above-average risk levels. Using the reasoning of V and VI, Ch.8, it can be stated that funds A and D almost certainly beat the market on a risk-adjusted basis, while funds C and E probably under-performed the market on a risk-adjusted basis. The position of Fund B is less clear however. Depending on whether or not one is willing to ignore the element of risk in this fund which is due to lack of complete diversification, Fund B has either out-performed or under-performed the market on a risk-adjusted basis. The funds are listed in the table in order of decreasing superiority of performance, assuming that lack of diversification concerning Fund B should be counted.

IV.1 LENGTH OF LONG TERM REVIEW PERIOD

Most writers agree that firm conclusions about a manager's or a fund's performance cannot be drawn from figures which

TABLE 12.3

PERFORMANCE STATISTICS RELATING TO THE "MARKET" OF THE 5 FUNDS REVIEWED IN THIS STUDY

All figures relate to excesses (or ratios) relative to the same measure on the appropriate model fund (or part of it)

FUND	FIRST QTR OF SAMPLE PERIOD (TO 1st QTR '78)	EXCESS AV* ANNUAL TWR	EXCESS CUMULATIVE TWR (%)	MAIN COMPONENTS (% PER QTR)			SECTOR SELECTION (% PER QTR)			AV. SECURITY SELECTION BY SECTOR (% PER QTR)					
				AV. EXCESS RETURN PER QTR	AV. SECTOR SELECTION	AV. SECURITY SELECTION	AV. POLICY	AV. STRATEGY		EQ.	GILTS	OFI	OS	P.T.	CASH
								AV. TOTAL	AV. SUBSET						
A	2nd QTR '76	4.09	9.72	1.00	0.03	0.98	0.62	-0.60	-0.23	0.71	0.07	-	0.03	-	0.18
D	3rd QTR '75	0.85	3.31	0.33	0.28	0.05	-0.01	0.30	-0.02	-0.14	0.08	0.10	0.0	-	0.0
E	3rd QTR '75	0.17	0.68	0.21	0.30	-0.08	-0.18	0.30	-0.02	-0.18	0.13	0.0	-0.07	-	-0.01
B	2nd QTR '75	-2.78	-11.86	-0.52	-0.72	0.20	0.34	-1.06	0.02	-0.21	-0.26	0.0	-	0.05	0.08
C	2nd QTR '74	-3.70	-24.36	-1.09	-0.75	-0.33	0.61	-1.37	0.67	-0.52	-0.01	-0.05	0.17	0.02	0.09
	2nd QTR '76	-3.95	-9.11	-0.92	-0.84	-0.08	0.30	-1.15	-0.05	-0.44	0.24	0.04	0.06	0.0	0.03

* Geometric average. All other averages are arithmetic (weighted by length of the quarter).

TABLE 12.3 CONTINUED

FUND	RISK (RATIO RELATIVE TO THAT OF MKT)							AVERAGE INCOME COMPONENTS			RISK ADJ. MEASURE (8.21)
	TOTAL FUND	EQ.	GILTS	OFI	OS	P.T.	CASH	TOTAL EXCESS INCOME	SECTOR SELECTION	SECURITY SELECTION	
A	1.16	0.88	19.46	-	1.20	-	2.80		NOT AVAILABLE		0.11
D	1.29	0.93	1.77	1.46	1.14	-	1.39		NOT AVAILABLE		0.03
E	1.30	0.94	1.84	1.66	1.08	-	1.36		NOT AVAILABLE		0.005
B	1.16	0.94	1.46	1.04	-	2.60	4.50	0.18	0.03	0.15	-0.10
C	0.55	0.70	1.19	4.45	1.61	1.35	3.28	-0.09 0.115	0.02 -0.03	-0.11 0.15	-0.13 -0.14

cover less than 2 years', and desirably 3 years', experience. The basic reasoning is that performance should be assessed through at least one market cycle in order to produce a balanced assessment. It is well acknowledged within the fund management industry that some portfolios tend to do better in "bull" than "bear" markets and vice-versa. This phenomenon is due of course to inflexibility in the risk levels of funds, being limited by marketability or by ignorance of impending turns in the market to adjust their profiles to suit prevailing conditions.[1] The performance of pension funds has been empirically verified to be generally inconsistent from year to year for this reason.[2]

IV.2 FUND A

This fund was the "star performer" of the group, earning an average of an extra 4% p.a. over the average private U.K. pension fund. Most of the average excess return of 1% per quarter was due to superior selection of securities, much to the credit of Manager 2. His talent seems to have been spread over all sectors. Further, although his equity holdings earned above-average returns, they are less risky than the market. This enhances the credit which should go to the manager.

Sector Selection contributed very little (0.03%) to overall performance. The trustees' policy of 100% investment in equities was potentially very beneficial to the fund over the two years of this assessment (0.62%). However, the fund manager almost completely negated this potential benefit by differing from this policy (-0.60%). His actions during a review period as far as choice of sector is concerned were on the average detrimental to the fund's performance (-0.23%).

1: Pension World(64) and Holbrook(41) both confirm that performance can be correlated with the importance of the equity sector in a pension fund portfolio.

2: Holbrook(41) has verified this for a sample of around 100 British funds. The same inconsistency in American pension fund performance is reported in (80).

These results suggest that Manager 2's strength lies in security selection, while he is weak on sector decisions. This is confirmed by the results of his other fund.

The risk level for this fund is above that of the market (1.16), as one would expect from CAPM theory. The conclusion that Fund A has outperformed the market on a risk-adjusted basis is made on the basis of two pieces of evidence. Its Selection component is positive, and the very crude risk-adjusted measure quoted in Chatper 8 (equation (8.21)) also indicates superior performance. Without resorting to risk adjustment, it can be concluded that Fund A has performed better than funds B, D and E. (assuming that the differences in review periods have not greatly affected the results). As figure 12.6 shows, A dominates these funds, having greater excess return relative to the market at a smaller risk level relative to the market.

IV.3 FUND D

This fund managed to stay just ahead of the market, earning an average of just under 1% p.a. excess return. Most of the excess return was due to superior sector selection (0.28%), reflecting the fact that Fund D's risk adjusted performance is only very marginally ahead of the market. Its average Security Selection component, as a risk-adjusted measure of performance, reflects the fact that D's slightly greater return was earned with the assumption of a greater level of risk than the market (1.29). The risk-adjusted measure in the last column of table 12.3 confirms that D just managed to keep up with and exceed market performance on a risk-adjusted basis.

Manager 1, who managed this fund, can be seen to be strong in strategy but weaker than Manager 2 in security selection. Even though trustee policy for this fund was short-lived it had a potentially damaging effect while it lasted

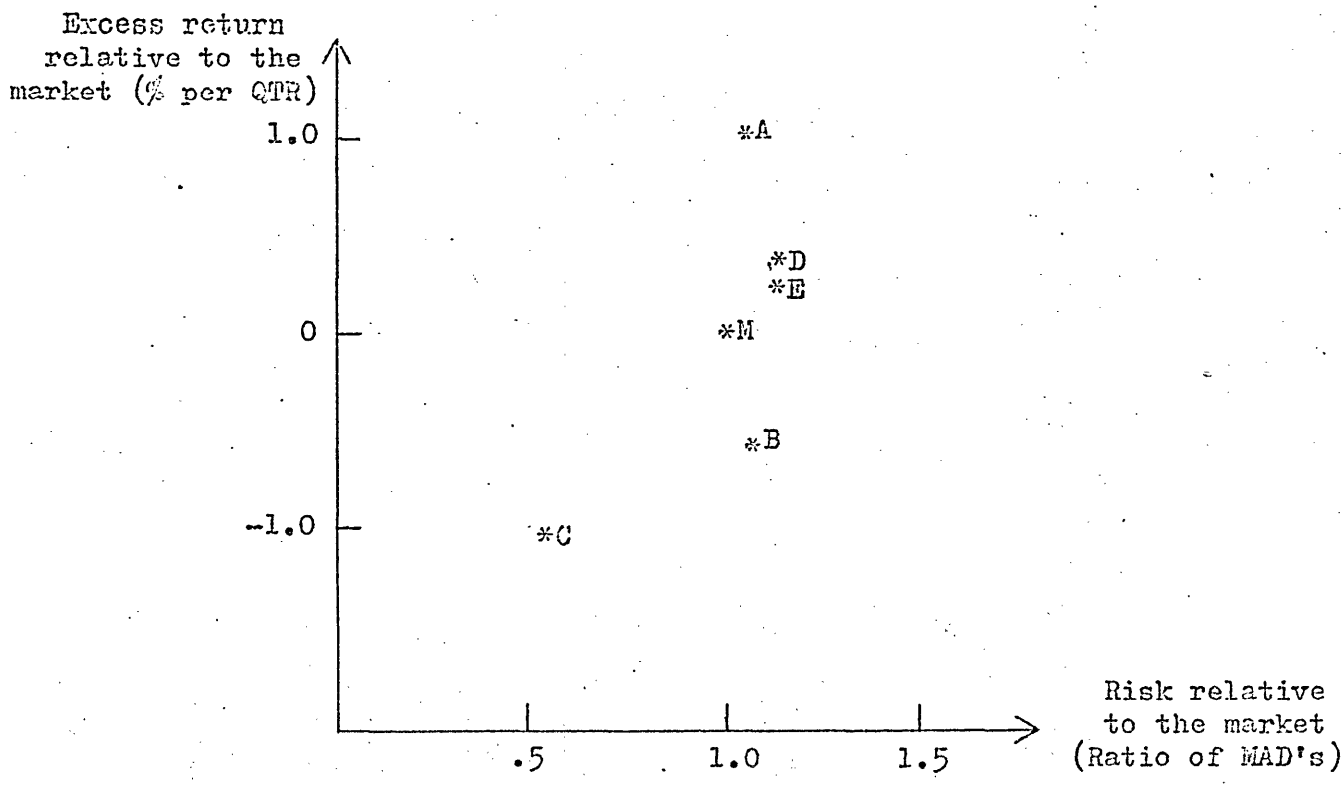


FIGURE 12.6

Performance of funds A to E in risk/return space scaled according to the market's risk and return.

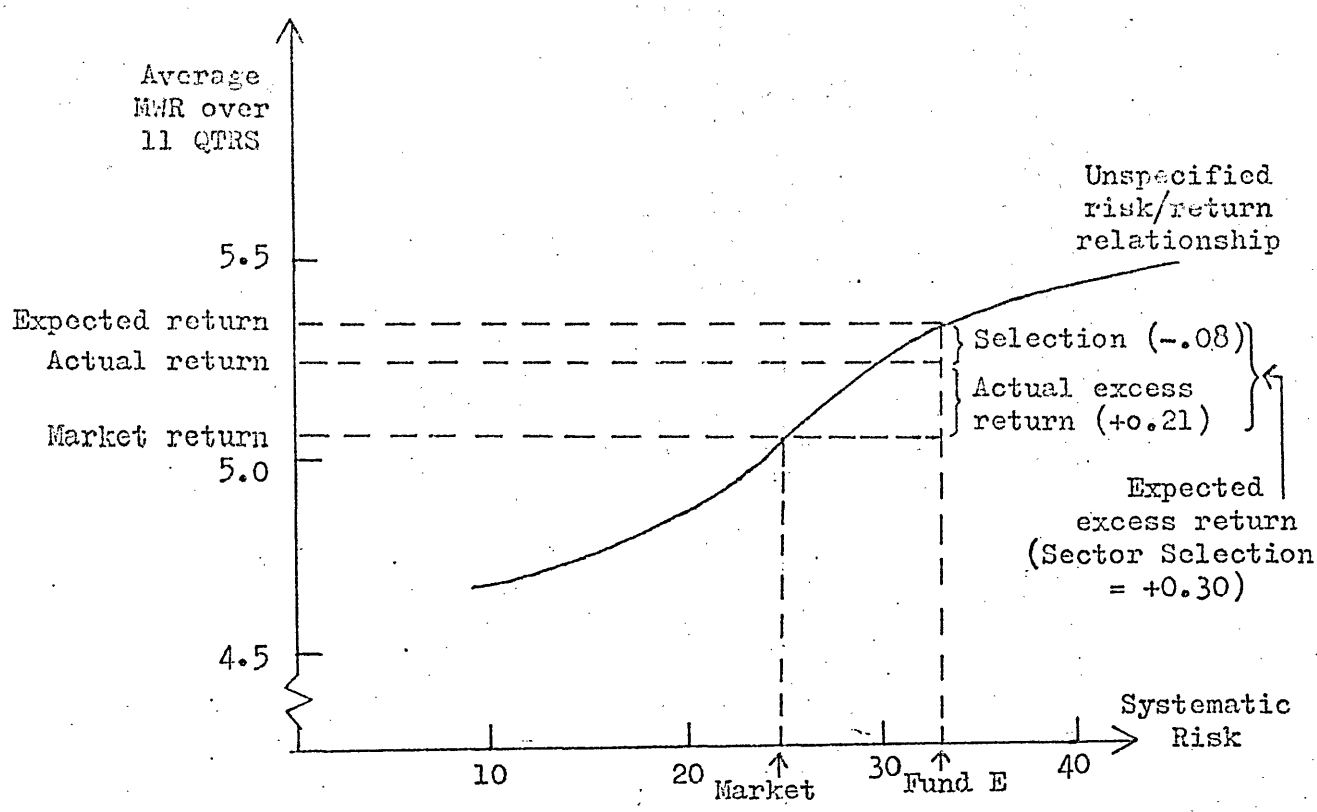


FIGURE 12.7

Components of performance of Fund E in terms of CAPM theory

(-0.02%). Manager 1 should be congratulated for deviating from this policy. His strategy accounted for most of the average excess return earned by the fund. His skill at security selection in the equity sector was on average lacking however (-0.14%) and just managed to match market return in the overseas and cash sectors. Superior returns were earned in gilts and other fixed interest, but both were associated with greater risk in these sectors (1.77 and 1.46). Equally, his poor equity Selection performance is to some extent excused by a risk level of equity holdings which is slightly less than that of the equity market (0.93).

IV.4 FUND E

Also managed by Manager 1, this fund displays trends very similar to those of Fund D. Fund E's performance (over the same period as Fund D) was marginally inferior to that of Fund D. It possessed the same risk level as Fund D (1.30) yet earned a marginally lower excess return. The negative Security Selection component indicates that this fund very slightly under-performed the market on a risk-adjusted basis. As figure 12.7 indicates, all of the excess return earned by Fund E was due to its above-average level of risk. Even then, its actual return was slightly less than that expected from this risk, as indicated by the negative Selection figure of -0.08%.

Manager 1's style as revealed through Fund D's results is repeated with Fund E. His security selection is once again weak in equities and strong in gilts. Once again, these are excused to some degree by compensating risk levels relative to the market. The contribution of his Strategy regarding sector selection was, as before, his major strength.

IV.5 FUND B

This fund is interesting because it fails to conform to the neat risk/return pattern which has been observed for the other four funds. On the one hand, the fund earned a return which was below that of the market by an average of a little

over ½% per quarter, yet its risk level exceeds that of the market (1.16). This would suggest that the fund has seriously under-performed the market. This is also indicated by the risk-adjusted measure of -0.10. On the other hand however, its risk-adjusted performance, as indicated by its Security Selection component, is better than the market. These seemingly conflicting results can be reconciled by realising that Selection is a risk-adjusted measure based on the fund's systematic risk only. It ignores any unsystematic risk, as shown in VI.1, Ch.8. It assumes that a fund is perfectly diversified. To the extent that it is not, the riskiness of the fund on which Selection is based is under-estimated, so its risk-adjusted performance is over-estimated. This appears to be the case here.[1] The MAD of this fund has been inflated by the effects of under-diversification of the fund. The situation is represented diagramtically by figure 12.8.

The pattern of an adverse contribution of Strategy combined with an overall positive Selection effect reflects the style of Manager 2 who managed this fund. Equity selection was weak while gilt selection was strong, but both these are offset to some extent by compensating risk levels relative to the market. The trustee policy of no overseas investment produced on the average a potentially beneficial effect (0.34%) which was more than negated by the manager's strategy of some overseas investment and other deviations from the average profile of UK local authority funds. Income performance relative to the market was on the average favourable (0.18%) and stemmed mainly from selection of securities with higher than average income yields.

1: It is probably also the case with the other 4 funds. The MAD in each case is no doubt inflated to some extent by non-diversification. If notional funds $V(\pi)$ were constructed to reflect risk including diversification (similar to Fama's $r(\sigma)$ portfolio of V.1, Ch.8), the observed Selection effects would be less favourable for all funds. The effect is just more noticeable with Fund B because the market risk level is between the fund's systematic risk and its total risk measure, MAD.

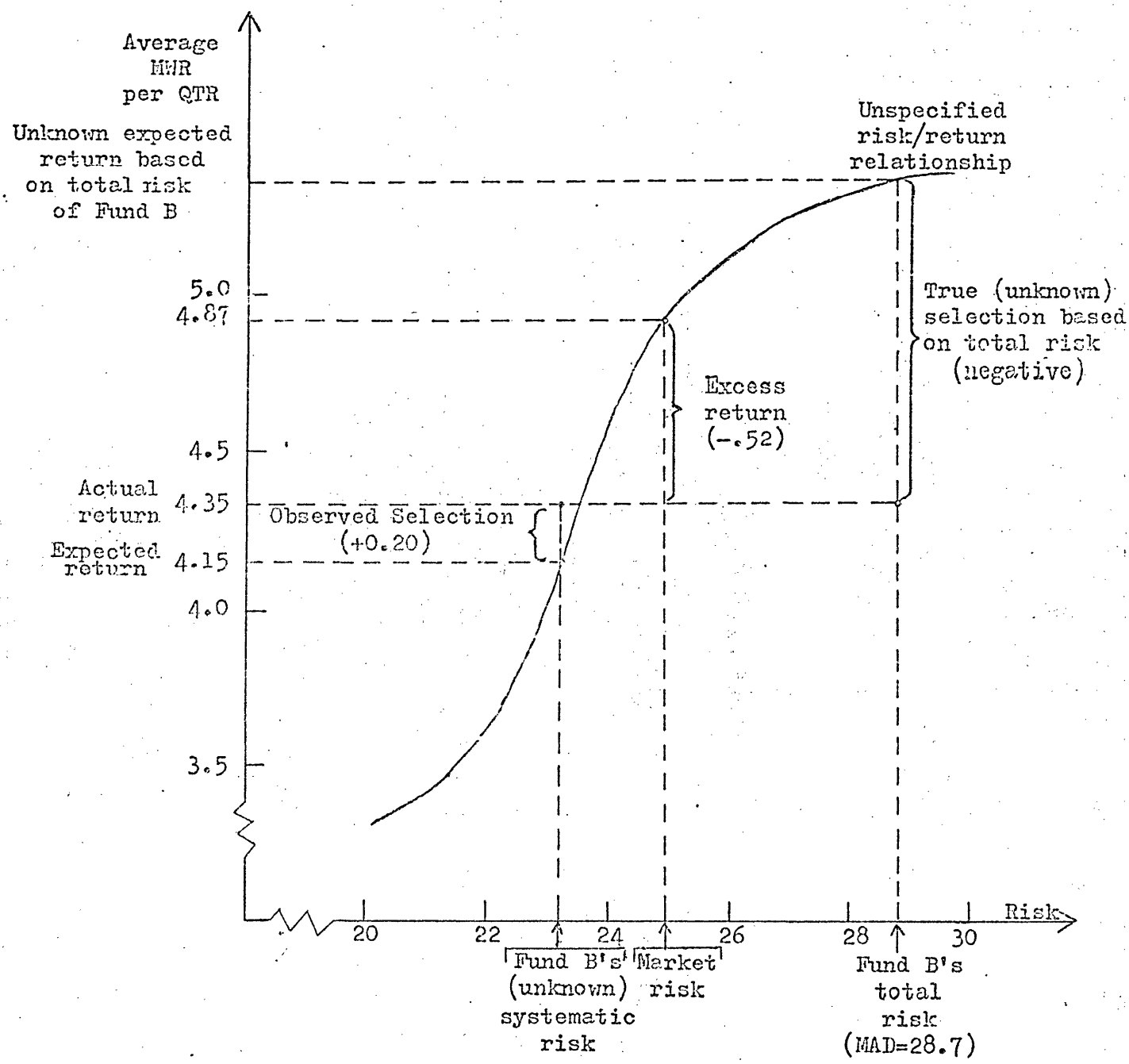


FIGURE 12.8

Components of performance of Fund B in terms of CAPM theory, showing the effect of non-diversification.

IV.6 FUND C

Fund C stands out as the fund with the worst performance relative to the market, even after adjustment for its exceptionally low risk level. Its average annual TWR over the last four years was nearly $3\frac{1}{4}$% p.a. below that of the market. Its average under-performance of 1.09% per quarter was due to both its risklessness relative to the market (0.55, - 0.75%) and due to poor average Security Selection (-0.33%). The latter figure indicates under-performance on a risk-adjusted basis, as does a crude risk-adjusted measure of -0.13. That the poor performance is not due to its much greater period of review (4 years) is confirmed by the broadly similar results obtained over a review period extending back only half this time.

Trustee policy was potentially beneficial to the fund but was more than doubly wiped out by the manager's strategy, although it must be stated that actions concerning the selection of sectors taken during a review period were on average of benefit to the fund (0.67%).

Security Selection was weak in equities but strong in the overseas sector, although the respective risk levels of these sectors were correspondingly lower and higher than the market. Income performance of the fund was also unfavourable (-0.09%), mostly due to Security Selection once again.

Thus neither the trustees nor the manager of Fund C have much to be happy about. The fund has under-performed the market by a not insignificant margin, and all of the under-performance can be attributed to poor management of the fund. The effects of trustee policy constitutes no excuse for the manager, as this is shown to have been potentially beneficial to the fund.[1]

1: When a statement like this is made, it is implied that trustees would recommend a profile consistent with that which results from the representation of any one-sided restrictions as single-point restrictions. Whether they would do this or not in reality is not really relevant. The relevant fact is that the manager's strategy differed from this sector choice and was not beneficial.

IV.7 CONCLUSIONS REGARDING MANAGEMENT'S PERFORMANCE

Taken as a whole, the above results imply the following:-

1. If Manager 2 was restrained from implementing his own desired strategy with Fund A, Manager 1 may be said to be a generally more skillful manager than Manager 2.

   The analysis showed that Fund A performed well primarily due to security selection, while its Sector Selection was just about neutral. Manager 2's strategy cancelled the potentially beneficial effects of trustee policy, suggesting that perhaps if the policy had not existed, Manager 2 may have implemented a strategy which was just as adverse to performance as it was for his other fund, Fund B. If this is true, it can be concluded that Fund A's above-average performance was primarily due to the restraining influence of trustee policy. If it were absent, the gains from Manager 2's skillful security selection may have been swamped by losses due to sector selection, as was the case with Fund B. Given this, it is apparent that Manager 1 is a generally more skillful manager. He has a generally more successful record of strategic decisions. Even though his Security Selection is not nearly as good as that of Manager 2, he is the better performer because it is sector decisions which generally contribute more to a fund's return than do security decisions (refer III, Ch.10).

2. The bank concerned should encourage Manager 2 to improve his sector strategy, while Manager 1 should concentrate more on security selection.

3. The trustees of Fund C would be justified in complaining that their fund could have been managed with more skill over the past four years.

These are of course bold conclusions on the basis of only 5 funds and on the basis of heterogeneous review periods. The analysis at least illustrates the sort of conclusions that can be made from a similar analysis of performance of a greater number of funds however. It will be shown later that program REPORT provides many of the statistics necessary to a study similar to that above of the performance of managers as distinct from their funds.

V. INTERPRETATION OF CURRENT VERSUS PAST PERFORMANCE RESULTS

Tables 10 to 17 of a Fund Performance Report are devoted to the contrast in various ways of current performance to past performance. All tables are entirely optional and aim to enable the sort of analysis represented by Table 12.3. Returning to figure 12.1, the following sub-sections explain the tables in turn.

V.1 TABLES 10 to 12 - "CUMULATIVE RATES OF RETURN"

These tables present the cumulative return earned by the fund since several dates up to the end of the present review period. The ith commencement date is the beginning date on the fund's history file for the review period which was the nth before this one, where the integer "n" was specified as the ith integer in Fund Data File item F6.

Table 10 gives the cumulative money-weighted rates of return earned by the fund, while Table 11 quotes cumulative time-weighted rates of return. Depending on how much new money the fund has had, and, in the case of individual sectors, how much sector switching has been conducted, these two cumulative returns will differ. In the case of Fund C, it is a substantial difference on average, as figure 12.1 shows (21.48% versus 32.95% for the total fund over the last 10 quarter).

A standard of comparison for the assessment of cumulative performance is provided by table 12, which does exactly the same analysis for the fund's appropriate model fund. Since the

model fund had no new money, these returns are both MWRs and TWRs, but have been labelled as TWR in table 12 to ensure that they are properly compared with the fund's cumulative TWRs. Comparison with the fund's MWRs would be inappropriate as these have been affected by new money.

Note that the commencement dates of past periods appearing in table 12 are a function of the pattern of accumulation specified in the Market Data file (T5). They will automatically match if the default option is used on F6. However, if, for example, a fund in a batch run is only new to the institution, its own individual pattern may be specified to avoid the situation where rates of return are attempted to be accumulated well beyond the beginning of the fund's history. A similar approach can be taken if a fund has an exceptionally long history. Figure 12.9 shows the appearance of tables 11 and 12 for a case where the patterns differed. Table 12 in this figure also shows what happens if rates are attempted to be accumulated beyond the beginning of a fund's recorded history. The cumulative returns for the last column are simply repeated.

These tables enable the statistics in column 2 of Table 12.3 to be calculated for up to 5 past periods. Looking at figure 12.2, there is already evidence (32.95% versus 38.74% since 1/7/74) of the wide gap in cumulative return revealed for Fund C in Table 12.3.

V.2 TABLES 13 to 15 - "AVERAGE ANNUAL RATES OF RETURN"

In a similar format to tables 10 to 12, these tables present average annual rates of return calculated over the five specified periods, but this time up to only the end of the immediately <u>previous</u> review period. The averages are geometric average annual returns, allowing for the possibly different lengths of the past review periods involved. They do not embrace the return on the fund over the current review period. This fact enables their direct comparison with current returns, to reveal how the fund has performed this period relative to its average performance over the past. By comparing tables 14 and 15, the statistic shown in column 1 of table

11. ACHIEVED CUMULATIVE TIME WEIGHTED RATE OF RETURN (%)

(NOTE: TIME WEIGHTED RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY OR, IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR.)

SECTOR	CUMULATIVE RETURN OVER PREVIOUS PERIODS (TO 30 9 1976) SINCE 1 4 1976	SINCE 1 1 1976	SINCE 1 10 1975	SINCE 1 7 1975	SINCE 1 4 1975
MAIN FUND	-5.58	-2.51	2.43	8.66	10.06
GILTS	-1.79	5.32	7.47	12.13	12.11
EQUITIES	-16.98	-11.59	-2.41	7.99	20.64
OTH FIXD INT	3.67	24.38	28.37	36.20	34.09
PROPTY TST	7.41	11.45	25.63	40.63	56.35
CASH	8.20	23.19	28.23	32.05	33.96

PERFORMANCE REPORT FOR A LOCAL AUTHORITY SUPERANNUATION FUND (3) OVER PERIOD 1 7 1976 TO 30 9 1976 PAGE 8

12. MODEL FUND CUMULATIVE TIME WEIGHTED RATE OF RETURN (%)

(NOTE: TIME WEIGHTED RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY OR, IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR.)

SECTOR	CUMULATIVE RETURN OVER PREVIOUS PERIODS (TO 30 9 1976) SINCE 1 1 1976	SINCE 1 10 1975	SINCE 1 7 1975	SINCE 1 4 1975	SINCE 0 0 0
MAIN FUND	-2.63	3.57	12.61	17.84	17.84
GILTS	5.92	5.75	10.96	10.94	10.94
EQUITIES	-11.02	-1.44	12.89	24.09	24.09
OTH FIXD INT	5.08	12.24	22.45	17.37	17.37
PROPTY TST	9.03	11.56	15.26	19.16	19.16
CASH	7.63	10.61	13.79	16.01	16.01
OVERSEAS	33.75	53.32	33.91	68.64	68.64

FIGURE 12.9 : Example of cumulative ROR tables where model and fund patterns of accumulation differ

12.3 may be calculated (although it will not include the current review period's results). Note that it is really not strictly valid to compare the current and past money-weighted rates of return in table 13 because of the possibility of differing new money flows. The comparison of TWRs in the next table is valid however.

Figure 12.1 indicates that Fund C has done worse this period than in the past as a fund as a whole and in all sectors with the exception of Property Trust, in which it has done relatively well this period. Reference to table 15 shows that the situation is roughly the same for the average UK pension fund except for the Overseas, Property Trust and Cash sectors. Overseas seems to have performed better this period, while the other two sectors appear to have done as well this period as in the past.

These tables therefore enable trends in performance to be identified, both over time and relative to the market.

V.3 TABLE 16 - "COMPONENTS OF RETURN"

This table permits the analysis shown in Table 12.3 in columns 3 to 14. Components are averaged over the specified five past periods, weighting the observations by the lengths of the relevant review periods. The averages are over a period extending from the shown commencement date to the end of the previous review period. They do not include the components of current performance. They therefore allow the identification of trends in components and the comparison of present components to average levels of the same component in the past.

Referring to figure 12.1, the trustees' policy has been far less successful this period than it has in the past (on average). In contrast, the manager's strategy this period was far more appropriate than it has usually been. His Security Selection has, on the other hand, been more or less in line with past performance. Individual figures are provided for each sector. Overseas investments, for example, have performed worse this period than in the past on average. Finally, the fund as

a whole has earned an excess return over that of the average pension fund which far exceeds that obtained in the past on average (1.15%).

This table therefore indicates that relative performance this period was, on the whole, a distinct improvement on past performance.[1] The danger of making hasty conclusions from just one quarter's results can be seen by the realisation that this quarter was in fact unrepresentative in the light of the averages over four years, as shown in Table 12.3. Nevertheless regular feedback of this nature to a manager may help him to modify his actions to suit changing conditions if he sees a regularly declining trend.

Average figures on income components and overseas sector components are not provided by the software in view of the fact that they would not be applicable to all funds.

V.4 TABLE 17 - "RISK MEASURES"

The ratios appearing in columns 15 to 21 of Table 12.3 were taken from the last column of table 17 in a report as at 31/3/78. But even at this stage in the history of Fund C, the ratios can be seen to be roughly in line with those in Table 12.3.

As explained in VII, Ch. 8, three risk measures are presented to allow the subjective judgement of whether the fund's relative level of risk is in any way a fair trade-off for its record of excess return. Any attempt to give a measure of risk-adjusted performance in this table would be fraught with difficulty. As Chapter 8 indicated, the use of Security Selection would entail lengthy explanation, and in any case, the more sophisticated user can find this elsewhere. Even a statement relating positive excess return to less-than-market risk would have its pitfalls. Fund C's results in figure 12.1 illustrates the problem very well. Superficially, Fund C has done very well this quarter, earning a return greater than that of the market while having a risk level less than that of the market.

1: Although risk-adjusted performance, as reflected by Security Selection, was well in line with past performance. See V. 4 to follow.

(b)

```
SOCIETY OF INVESTMENT ANALYSTS' EXAMPLE.
                                                        NO UPDATE
          2          1          6          3          4          5
NIL.
                   0.25       0.75        0.0        0.0        0.0        0.0
AS QUOTED IN SOCIETY'S EXAMPLE.
     600000    3000000     400000
     582653    3826836     100000
      50000     250000
          0     250000
     -50000    -100000
INCOME EARNED
       5625       9356       2250
       5651      10052       1375
       5620      10254        792
10 11977        300000       99.8      101.0
   21977             0
20 31978        -200000       98.4      103.0
REPAID INCOME          ALL
     1.1846     1.7085

     1.2308     1.7171
OPTIONS                1          1    1    1
FINISH
END
```

(a)

```
1 11977    1 31977    3
   100.0      100.0      100.0      100.0      100.0
       1      101.5       99.7      100.0      100.0      100.0
       2      104.5       99.1      100.0      100.0      100.0
       3      107.5       98.5      100.0      100.0      100.0
   109.0       98.2      100.0      100.0      100.0
    5.28       0.75                                       6.72
    5.16       0.75                                      11.88
    5.04       0.75                                       9.48
  1.1672     1.7020       0.25
  1.2343     1.7130
  1.2804     1.7104
  1.2412     1.7175
  1.1672     1.7020       0.25
```

FIGURE 12.10

Market (a) and Fund (b) data files associated with Figure 12.12

(a)

```
1 11974   31 31974    3
   100.0      100.0      100.0      100.0      100.0
       1      105.0       99.0      100.0      100.0      100.0
       2      108.0       96.0      100.0      100.0      100.0
       3      110.0       95.0      100.0      100.0      100.0
   115.0       96.0      100.0      100.0      100.0
   5.496       1.01                                       12.0
   5.496       1.04                                       12.0
   4.909       1.05                                       12.0
  1.8383     2.2470       0.25
  1.8136     2.2261
  1.8339     2.2743
  1.8361     2.3415
  1.8383     2.2470       0.25
```

(b)

```
EXAMPLE TAKEN FROM KINGSTON'S ARTICLE (  )                 10
                                                        NO UPDATE
          1          2          6          3          4          5
NIL.
                   0.75       0.25
AS SPECIFIED IN ARTICLE.
     200000     500000     100000
    1620000     370000     200000
      11500          0
      12500     200000
     433700    -310000
INCOME EARNED
       4500       5000       1000
       4500       6000       2000
       5700       5500       2500
      11974          0
      21974     400000
      71974      70000
REPAID INCOME          NONE

OPTIONS                1          1    1    1          1
FINISH
END
```

FIGURE 12.11

Market (a) and Fund (b) data files associated with Figure 12.13

3. ANALYSIS OF RETURN RELATIVE TO MODEL FUND

RELATIVE RETURN FROM LONG-RUN INVESTMENT POLICY	+	RELATIVE RETURN FROM CURRENT STRATEGY	=	TOTAL RELATIVE RETURN FROM SECTOR SELECTION	+	TOTAL RELATIVE RETURN FROM SECURITY SELECTION	=	TOTAL RELATIVE RETURN ON MAIN FUND
0/	+	.16/	=	.16/	+	2.98/	=	3.14/
				0.20%		3.02%		3.25%

PERFORMANCE REPORT FOR SOCIETY OF INVESTMENT ANALYSTS' EXAMPLE. OVER PERIOD 1 1 1977 TO 1 3 1977 PAGE. 2

4. ACHIEVED RATE OF RETURN (R.O.R.) FOR EACH SECTOR OVER THIS REVIEW PERIOD (/)

SECTOR	HISTORICAL MARKET R.O.R.	ACHIEVED MONEY-WEIGHTED R.O.R. (SEE NOTE 1 BELOW)	ACHIEVED TIME-WEIGHTED R.O.R. (SEE NOTE 2 BELOW)	DIFFERENCE (MONEY- LESS TIME-WEIGHTED, SEE NOTE 3)	GROSS GAIN (£000'S) (NET OF NEW MONEY)*	GROSS INCOME YIELD (/P.A.)	PERCENTAGE OF GAIN WHICH WAS INCOME*
TOTAL MAIN FUND	7.88 7.90 (MODEL FUND)	10.93	11.03 11.10	-.10	460.66	5.01	11.11
GILTS	.44	-.04	-.06	.02	-.25	11.57	NOT APPLICABLE
EQUITIES	10.37	13.82	14.32	-.50	456.50	3.69	6.50
CASH	2.29	1.67	1.78	-.11	4.42	6.96	100.00

NOTE 1: MONEY-WEIGHTED RATE OF RETURN IS AFFECTED BY THE TIMING OF NEW MONEY AND SECTOR SWITCHES DURING THE PERIOD. IT IS THE ORDINARY RATE OF RETURN, MEASURING INCREASE IN WEALTH.

NOTE 2: TIME-WEIGHTED RATE OF RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR. IT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BETWEEN DIFFERENT PORTFOLIOS.

NOTE 3: IN THE CASE OF AN INDIVIDUAL SECTOR, A LARGE POSITIVE DIFFERENCE (E.G. 1/ OR GREATER) INDICATES THAT SWITCHES INTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN THIS SECTOR WERE TIMED WELL. A LARGE POSITIVE DIFFERENCE FOR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOURABLE TO PERFORMANCE.

* ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP INCOME. SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET OF TAX.

FIGURE 12.12

Extract from the Fund Performance Report for the example quoted by the S.I.A.. Larger numbers are the S.I.A.'s results

ANALYSIS OF PERFORMANCE RELATIVE TO MODEL FUND

AS SPECIFIED BY THE SIA EXAMPLE

5. COMPOSITION OF FUNDS USED IN ANALYSIS

SECTOR	% OF MAIN FUND HYPOTHETICALLY INVESTED IN SECTORS IN THE CASE OF- MODEL FUND*	POLICY FUND**	INITIAL STRATEGY (AS AT 1 1 1977)	COMPOSITION OF FINAL FUND (AS AT 1 3 1977)
GILTS	25.00	25.00	15.00	12.92
EQUITIES	75.00	75.00	75.00	84.85
CASH	0	0	10.00	2.22
OTH FIXD INT	0	0	0	0
OVERSEAS	0	0	0	0
PROPTY TST	0	0	0	0

* BASIS FOR MODEL FUND PROFILE: IDENTICAL TO TRUSTEE POLICY IN EXAMPLE.

** BASIS FOR POLICY FUND PROFILE: AS QUOTED IN SOCIETY'S EXAMPLE.

FIGURE 12.12 CONTINUED

6. ANALYSIS OF RETURN RELATIVE TO MODEL FUND (PERCENTAGES*)

SOURCE OF RELATIVE RETURN	SECTORS OF MAIN FUND: GILTS	EQUITIES	CASH	OTH FIXD INT	OVERSEAS	PROPTY TST	TOTAL MAIN FUND
POLICY RETURN (FROM LONG-RUN INVESTMENT POLICY)	0	0	0	0	0	0	0
INITIAL STRATEGIC RETURN (FROM COMPOSITION OF INITIAL FUND)	-9.74	.08	9.85	0	0	0	.19
SUBSEQUENT STRATEGIC RETURN (FROM ACTION THIS PERIOD)	-.36	7.76	-7.44	0	0	0	-.02
TOTAL STRATEGIC RETURN (FROM CURRENT DEVIATION FROM POLICY)	-10.10	7.85	2.40	0	0	0	.16
TOTAL RELATIVE RETURN FROM SELECTION OF SECTORS (POLICY + STRATEGIC)	-10.10	7.85	2.40	0	0	0	0.20%.16
TOTAL RELATIVE RETURN FROM SELECTION OF SECURITIES	-.07 -.07	3.09 3.12	-.03	0	0	0	3.02%2.98
TOTAL RELATIVE RETURN (SECTOR SELECTION + SECURITY SELECTION)	-10.17	10.94	2.37	0	0	0	3.14

* AS A PERCENTAGE OF AN AVERAGE MAIN FUND

3. ANALYSIS OF RETURN RELATIVE TO MODEL FUND

RELATIVE RETURN FROM LONG-RUN INVESTMENT POLICY	+	RELATIVE RETURN FROM CURRENT STRATEGY	=	TOTAL RELATIVE RETURN FROM SECTOR SELECTION	: +	TOTAL RELATIVE RETURN FROM SECURITY SELECTION	=	TOTAL RELATIVE RETURN ON MAIN FUND
0/	+	-2.86/	=	-2.86/	: +	3.80/	=	.94/
				-2.70%		2.76%		.05%

FIGURE 12.13

Extract from the Fund Performance Report for the example quoted by Kingston. Larger numbers are Kingston's results after adjustment for error

PERFORMANCE REPORT FOR EXAMPLE TAKEN FROM KINGSTON'S ARTICLE (OVER PERIOD 1 1 1974 TO 31 3 1974 PAGE 2

4. ACHIEVED RATE OF RETURN (R.O.R.) FOR EACH SECTOR OVER THIS REVIEW PERIOD (/)

SECTOR	HISTORICAL MARKET R.O.R.	ACHIEVED MONEY-WEIGHTED R.O.R. (SEE NOTE 1 BELOW)	ACHIEVED TIME-WEIGHTED R.O.R. (SEE NOTE 2 BELOW)	DIFFERENCE (MONEY- LESS TIME-WEIGHTED. SEE NOTE 3)	GROSS GAIN (£.00'S) (NET OF NEW MONEY)*	GROSS INCOME YIELD (/P.A.)*	PERCENTAGE OF GAIN WHICH WAS INCOME*
TOTAL MAIN FUND	12.13 12.22 (MODEL FUND)	12.88	12.96 12.35	-.10	220.00	9.00	16.68
EQUITIES	10.46	23.00	23.87	-.91	228.00	6.17	6.45
GILTS	-.89	-2.49	-2.32	-.17	-13.50	12.93	NOT APPLICABLE
CASH	3.03	3.04	3.05	-.01	5.50	12.90	100.00

NOTE 1: MONEY-WEIGHTED RATE OF RETURN IS AFFECTED BY THE TIMING OF NEW MONEY AND SECTOR SWITCHES DURING THE PERIOD. IT IS THE ORDINARY RATE OF RETURN, MEASURING INCREASE IN WEALTH.

NOTE 2: TIME-WEIGHTED RATE OF RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR. IT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BETWEEN DIFFERENT PORTFOLIOS.

NOTE 3: IN THE CASE OF AN INDIVIDUAL SECTOR, A LARGE POSITIVE DIFFERENCE (E.G. 1/ OR GREATER) INDICATES THAT SWITCHES INTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN THIS SECTOR WERE TIMED WELL. A LARGE POSITIVE DIFFERENCE FOR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOURABLE TO PERFORMANCE.

* ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP INCOME, SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET OF TAX.

ANALYSIS OF PERFORMANCE RELATIVE TO MODEL FUND

5. COMPOSITION OF FUNDS USED IN ANALYSIS

AS SPECIFIED BY KINGSTON

SECTOR	% OF MAIN FUND HYPOTHETICALLY INVESTED IN SECTORS IN THE CASE OF- MODEL FUND *	POLICY FUND **	INITIAL STRATEGY (AS AT 1 1 1974)	COMPOSITION OF FINAL FUND (AS AT 31 3 1974)
EQUITIES	75.00	75.00	60.00	73.97
GILTS	25.00	25.00	33.33	16.89
CASH	0	0	6.67	9.13
OTH FIXD INT	0	0	0	0
OVERSEAS	0	0	0	0
PROPTY TST	0	0	0	0

* BASIS FOR MODEL FUND PROFILE: SAME PROFILE AS TRUSTEE'S POLICY

** BASIS FOR POLICY FUND PROFILE: AS SPECIFIED IN ARTICLE.

FIGURE 12.13 CONTINUED

6. ANALYSIS OF RETURN RELATIVE TO MODEL FUND (PERCENTAGES*)

SOURCE OF RELATIVE RETURN	SECTORS OF MAIN FUND: EQUITIES	GILTS	CASH	OTH FIXD INT	OVERSEAS	PROPTY TST	TOTAL MAIN FUND
POLICY RETURN (FROM LONG-RUN INVESTMENT POLICY)	0	0	0	0	0	0	0
INITIAL STRATEGIC RETURN (FROM COMPOSITION OF INITIAL FUND)	-19.71	9.58	7.69	0	0	0	-2.24
SUBSEQUENT STRATEGIC RETURN (FROM ACTION THIS PERIOD)	11.76	-16.20	3.42	0	0	0	-.62
TOTAL STRATEGIC RETURN (FROM CURRENT DEVIATION FROM POLICY)	-7.95	-6.62	11.71	0	0	0	-2.86
TOTAL RELATIVE RETURN FROM SELECTION OF SECTORS (POLICY + STRATEGY)	-7.95	-6.62	11.71	0	0	0	-2.70 -2.86
TOTAL RELATIVE RETURN FROM SELECTION OF SECURITIES	4.83 3.12	-.39 -.39	.00 .00	0	0	0	2.76 3.80
TOTAL RELATIVE RETURN (SECTOR SELECTION + SECURITY SELECTION)	-3.70	-7.01	11.71	0	0	0	.05 .94

But as figure 12.2 showed, this is entirely illusionary in the light of the knowledge that the market declined over this review period.

Fund managers can probably be made to realise however that because Fund C is a low risk fund, one would expect its return to decline by a less amount than the market when the market as a whole declines. That is, one would expect good performance relative to the model fund during this quarter from Fund C. The more sophisticated manager should look to the negative Security Selection component for a more accurate idea than this.

VI. VALIDATION OF THE SOFTWARE

As with any piece of programming, validation can never be complete as a result of its inductive nature. There are two sorts of validation involved with the present software. The first concerns confirmation that the TWR and other estimates produce espected results. The second relates to the accuracy of the estimates compared to known true values. The following sub-sections cover these points respectively.

VI.1 APPLICATION TO STANDARD EXAMPLES

To the author's knowledge, there are only two well-known standard worked examples of performance testing in the literature. These are those of the SIA(76,App.I) and Kingston(45,App). The Market and Fund Data files for these two examples are shown in figures 12.10 and 12.11 respectively. Tables 3 to 6 of the corresponding Fund Performance Reports are shown in figures 12.12 and 12.13. The comparable figures in the published examples are written in italics in these reports. In both cases the model fund was made equal to the trustee policy fund.

The agreement of the SIA figures is very close, to the nearest first decimal place in all but one case. What difference there exists is of course due to the refinements made to the SIA's procedure. The full effects of these refinements

are not evident in this particular example however as the data is tailor-made to minimise the inaccuracies of their method (e.g., by all income buy repaid to trustees for example).

The agreement concerning Kingston's example is not as good however and stems primarily from both inaccuracies in Kingston's working and his different simulation method for notional funds. The inaccuracy concerns Kingston's treatment of income earned as if it was repaid to trustees, when in fact he assumes it stays within the fund (being reinvested in equities). This led to small error in Kingston's components (since (11.41) includes a non-zero GRT when it should not) and also his TWR estimate. The italicised results in Figure 12.13 are corrected for these errors. Kingston's procedure for the simulation of notional funds $V(\pi_a)$ and $V(\pi_p)$ differs from that employed here in the following ways:-

1. Kingston rounds off his notional income estimates to the nearest £100, producing small inaccuracies which compound.

2. In simulating $V(\pi_a)$, Kingston does not reinvest excess notional income in the same sector in which it was generated. Instead, he invests it in equities in parallel with what was done with actual income. A fair comparison demands that only actual (retained) income be invested there.

3. In simulating $V(\pi_p)$ (corresponding to the model fund in figure 12.13), Kingston reinvests all notional income according to the strategy represented by π_p. This study's method is to reinvest any excess notional income over that repaid to trustees in the same sector as that in which it was generated. This was viewed as a more realistic and fairer procedure, since a manager does not, and could not be expected to, <u>continually</u> reallocate income amongst sectors according to a certain policy. In reality he would

review his position periodically and reallocate accumulated income in bulk. The method of this study does this in the form of realignment of notional portfolios between successive review periods. In truth of course, the most realistic assumption is between these two extremes. Of the two however, the latter was viewed as the more appropriate, for short review periods at least.

4. Kingston does not allow for transaction costs.

The importance of attending to what may seem as minor details, like those above, can be observed in the form of the sometimes significant differences in results in Figure 12.13 (i.e., nearly a 1% difference in excess return over the model fund over only three months).

VI.2 CHECKS ON ACCURACY

Accuracy is unfortunately a difficult aspect of the software to check, since it is primarily a function of the validity of the methodology used within it. It has already been observed III, Ch.4., that the index simulation method has been tested thoroughly only once, the results of which are given in Table 12.4

No further details than these (including details of how the results were derived[1]) are mentioned by the SIA, but Table 12.4 at least suggests that the likely error of the TWR estimate (11.29) is from 0.1% ot 0.5% depending on the conditions (the size of the new money flow probably being the most critical factor, as revealed by the BAI study (1)).

Firm conclusions about the likely errors in estimates of the TWR for individual sectors cannot be drawn from Table 12.4 because of the greater chance of new money flows being up to 50% of the initial value. The error in such an extreme case

---

1: It is not clear if the results in Table 12.4 are based on assumptions regarding the distribution of the relevant parameters, or whether they relate to fixed-point assumptions.

TABLE 12.4

Estimated error in estimation of TWR (source: SIA (76))

ASSUMPTIONS OVER ONE QUARTER			OBSERVED ERROR IN QUARTERLY ROR	
NEW MONEY AS % OF MV_0	MARKET ROR	DIFFERENCE MKT VS. FUND ROR	AVERAGE	MEAN ABSOLUTE ERROR
25%	15%	9%	0.00%	0.42%
10%	6%	3%	0.00%	0.06%

could be as much as 1 full percent. To quantify the error margin would require a detailed simulation study.

The lack of bias in the TWR estimate indicated by Table 12.4 was confirmed for the software by the use of an artificial example. Figure 12.14 shows the associated Fund Data Files and table 4 of the report produced from it. Ther is a complete absence of new money flows and transactions and no sector earns income, excepting Cash with last month of the quarter. Thus there were no inflows into, or outflows from, either the total fund or from individual sectors, implying that the TWR should be equal to the MWR in each case. This is what was produced by the package, as figure 12.14 shows.

(a)

```
1 71976  30 91976   3
    0.56      6.22      .09       0.07      0.02      0.04
AVERAGE PROFILE OF NON-L.A. PUBLIC FUNDS.
  155.41    123.27      5.6      134.78     89.08
       7    167.70   103.129     91.60    104.20    89.125
       8    152.85   102.430     76.120   107.79    87.775
       9    142.07   100.896     47.62    105.45    80.240
  135.30     98.53     46.7     105.24     90.42
    5.87      6.43     14.61      3.64      6.39     11.3
    6.25      1.30     14.72      3.74      6.46    10.625
    6.71      5.63     15.48      3.71      6.56    10.625
  1.2264    1.7647      0.25
  1.2555    1.7865
  1.2629    1.7834
  1.2173    1.7302
  1.1255    1.6680      0.25MO CHANGE
```

(b)

```
TIME-WEIGHTED RATE OF RETURN TEST                                  1                    6
        2         3         4         5
NIL. (PROPERTY IN SEPERATE FUND)
        0.30      0.0       0.6919    0.0       0.0481    0.0
15% TO PROPERTY FUND, + LIMIT HOLDING.
 12645175   401376  21271924  4335294   356391   4088365
 14700363   359536  20627705  5992225   360346   4497201
        0         0         0         0         0
        0         0         0         0         0
        0         0         0         0         0
INCOME EARNED                NET
        0         0         0         0         0         0
        0         0         0         0         0         0
        0         0         0         0         0    438876
16 71976          0    103.36     50.25    160.09    114.68    69.215
 6 81976          0    102.59     51.36    153.04    102.49    69.705
12 91976          0    100.09     47.34    143.12    104.23    91.240
REPAID INCOME          NONE
  1.2374    1.7754
  1.3190    1.7869
  1.2051    1.7537
FINISH
END
```

(c)

PERFORMANCE REPORT FOR TIME-WEIGHTED RATE OF RETURN TEST OVER PERIOD 1 7 1976 TO 30 9 1976 PAGE 2

4. ACHIEVED RATE OF RETURN (P.O.R.) FOR EACH SECTOR OVER THIS REVIEW PERIOD (%)

SECTOR	HISTORICAL MARKET R.O.R.	ACHIEVED MONEY-WEIGHTED R.O.R. (SEE NOTE 1 BELOW)	ACHIEVED TIME-WEIGHTED R.O.R. (SEE NOTE 2 BELOW)	DIFFERENCE (MONEY- LESS TIME-WEIGHTED, SEE NOTE 3)	GROSS GAIN (£000'S) (NET OF NEW MONEY)*	GROSS INCOME YIELD (%P.A.)	PERCENTAGE OF GAIN WHICH WAS INCOME*
TOTAL MAIN FUND	-6.73 (MODEL FUND)	7.99	7.99	-.00	3444.84	3.82	11.87
GILTS	-2.37	16.25	16.25	0	2055.13	0	0
OTH FIXD INT	-4.23	-10.41	-10.41	.00	-41.79	0	0
EQUITIES	-11.81	-3.03	-3.03	.00	-644.22	0	0
OVERSEAS	10.43	38.22	38.22	.00	1656.93	0	0
PROPTY TST	3.10	2.84	2.84	.00	9.95	0	0
CASH	2.71	10.00	10.00	.00	408.84	45.96	100.00

NOTE 1: MONEY-WEIGHTED RATE OF RETURN IS AFFECTED BY THE TIMING OF NEW MONEY AND SECTOR SWITCHES DURING THE PERIOD. IT IS THE ORDINARY RATE OF RETURN, MEASURING INCREASE IN WEALTH.

NOTE 2: TIME-WEIGHTED RATE OF RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR. IT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BETWEEN DIFFERENT PORTFOLIOS.

NOTE 3: IN THE CASE OF AN INDIVIDUAL SECTOR, A LARGE POSITIVE DIFFERENCE (E.G. 3% OR GREATER) INDICATES THAT SWITCHES INTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN THAT SECTOR WERE TIMED WELL. A LARGE POSITIVE DIFFERENCE FOR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOURABLE TO PERFORMANCE.

* ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP INCOME, SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET OF TAX

FIGURE 12.14

Market (a) and Fund (b) data files for artificial test for bias in RoR estimates

CHAPTER 13

FUND COMPARISON REPORT

This "once-off" report may be produced at any time and directly compares the performance of each fund against that of all the others included in the comparison. This chapter gives the technical details of how it is generated by the software, and how it can be interpreted.

I. INPUT REQUIREMENTS

Four types of input files are involved in the production of a Fund Comparison Report. They are shown schematically in Figure 13.1. They are the Parameters file, a Reference file, the Model History files and the various Fund History files. The latter two are generated automatically by the system. The former two files are explained below.

I.1 PARAMETERS FILE

This is a one-line file (refer Figure 13.2) giving the following data items:-

P1. Beginning data of the current review period.

P2. Ending data for the current review period.

The report distinguishes between current and past results of the funds. The dates P1 and P2 should refer to the most recent review period for which the funds have been assessed. If a fund has not in fact been updated to within two weeks of the date P2, a messages is printed to identify the fund, which is subsequently excluded from the comparisons and the report altogether.

P3. Number of reviews into the past over which past results are to be accumulated.

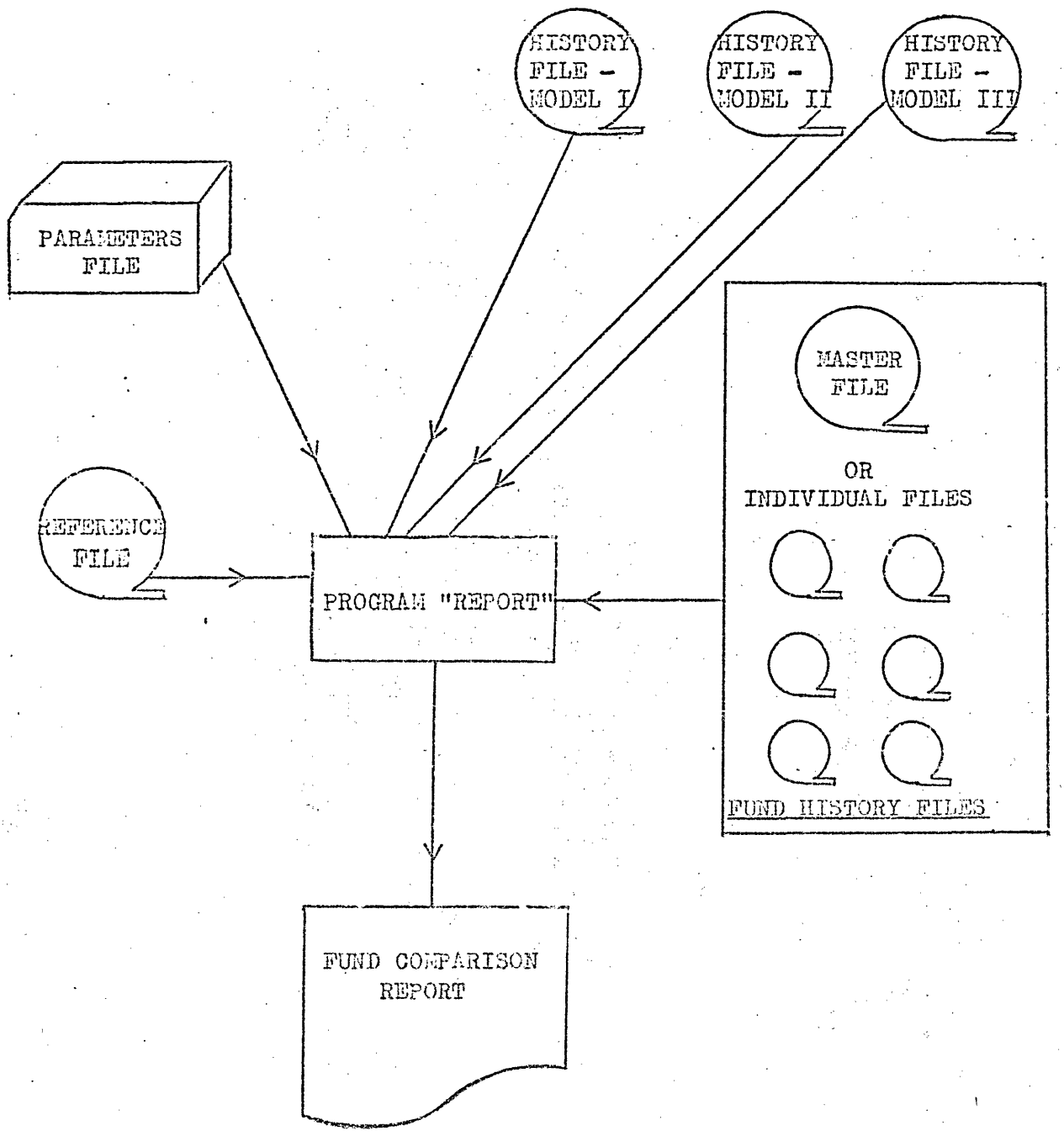


FIGURE 13.1

Over-view of design of program REPORT which produces the Fund Comparison Report

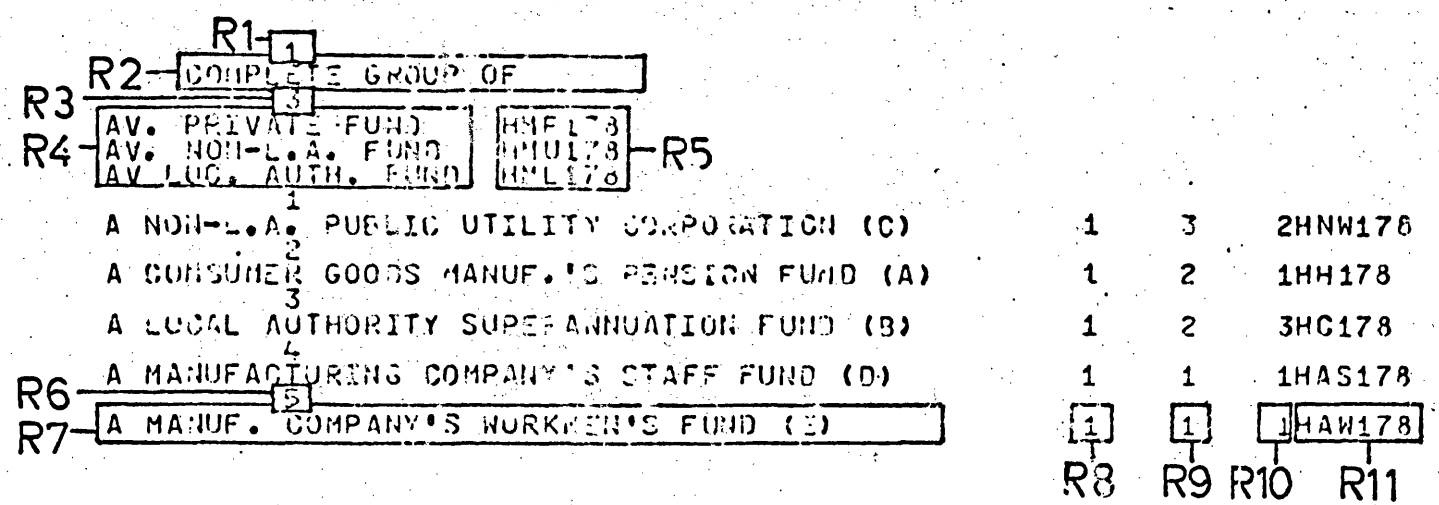
P1 [1 11978] [31 31978] P2 P3 [8] [3] P4

FIGURE 13.2

Format of the Parameters file

FIGURE 13.3

Format of the Reference file



Comparisons may be wished to be limited to a specific number of past reviews for a number of reasons. The most common will be to ensure that all funds are compared over an equal time interval. In the event of a particular fund having less than the specified number of review periods on its history file, averages are taken over this lesser number. To the extent that market conditions over the lesser number of reviews differed from those over the whold period, the statistics for such a fund will not be strictly comparable to those of the other funds.

The maximum number of periods is 12 (the capacity of the history files).

P4. Number of managers who, between them, manage all of the funds to be reviewed. For the comparison of the 5 funds of this study for example, this number would be three.

I.2 REFERENCE FILE

This file is a means by which the funds to be included in the comparison can be controlled. Only those funds which are listed on this file, and only those model types which are listed on this file, will be included in the Comparison Report. An example of this file appears in Figure 13.3. Its contents are as follows:

R1. Number of classes of fund to be processed.

Because of the basic incomparability of some funds (as discussed in I, Chapter 2), there is a facility for funds to be separated into two classes and separate comparisons done within each class. These classes may be formed, for example, on the basis of funds which are known to be free of any major trustee restrictions and funds which are not so free. Figure 13.2 specifies only one class of fund.

R2. Title of each class of fund.
This title will appear as it appears here in the Fund Comparison Report in table headings. If Figure 13.1 specified 2 classes, there would be two lines

associated with R2.

R3. Number of model funds to be included in the report.

When funds are ranked in the report according to performance, model funds are inserted within the ranking to give some absolute scale of performance to the rankings. Depending on what types of funds are being reviewed, from none to three model funds may be wished to be included in the comparisons.

R4. Title of each model fund.
These will appear in the report exactly as they are here.

R5. Name of each model fund's history file.
This history file should be updated to within two weeks of the end of the review period date P2.

If no model funds are to be included in the report (so that R3 is zero), the lines represented by R4 and R5 should not appear at all.

The rest of the file consists of the following items, each of which is repeated once for each fund which is to be processed.

R6. Numerical identifying code of the fund.
This must agree with the code used in the fund's history file (item FH1).

R7. The title of the fund.
It will appear exactly as it is here in the report.

R8 Class of fund (1 or 2)

R9. Manager code.
This is a numerical code to identify the manager of the fund.

R10 Model type of the fund.
The code 1 refers to the first model type read as items R4 and R5 at the beginning of this file. Code 2 refers to the second such model fund and so on.

R11 Name of the fund's history file.
This file should be updated to within two weeks of the date P2.

II. INTERPRETATION

Figure 13.4 shows the Fund Comparison Report for the five funds reviewed in the previous chapter. The report was generated from the files in Figures 13.1 and 13.2. It was run as at the end of the review for the first quarter of 1978, and compares past performance on the basis of the previous two years' results (so as to ensure all funds are compared over the same time period).

It must be emphasised that Figure 13.4 is based on an unrealistically small number of funds. Appendix 13-I displays extracts from a report based on a larger number of funds to give some idea of what it would look like in a realistic application. The following sub-sectors give details of the contents of each table in the report and its purpose.

II.1 TABLE 1 - "AVERAGES OF TWRs, EXCESS RETURNS AND RISK MEASURES".

Designed to summarised the performance of all funds under management (or as many as were included in the reference file at least). Averages are quoted separately for each class of fund as well as all funds taken together. Comparable averages for each model fund follow to act as benchmarks of performance. Figure 13.4 is based on only one class of fund, so only one set of averages appears. Both weighted and unweighted averages are quoted. The unweighted average is of interest because it allows the performance of the smaller funds to show through. A weighted average on the other hand provides a more accurate idea of the return earned on the "average pound" in the office. The fund sizes from which the weights are derived are items FH8 on the various fund history files.

Referring to Figure 13.4, it appears that the five

FUND COMPARISON REPORT FOR PERIOD 1 1 1978 TO 31 3 1978 PAGE 1

1. AVERAGES OF TIME WEIGHTED RETURNS (T.W.R.), EXCESS RETURNS AND RISK MEASURES OF ALL FUNDS

TYPE OF FUND	FUNDS REVIEWED THIS PERIOD		SIMPLE AVERAGES				WEIGHTED AVERAGES (WEIGHTED BY FUND SIZES)			
			RETURN THIS PERIOD (1 1 1978 TO 31 3 1978)		OVER PAST 8 REVIEWS	AVERAGE RISK MEASURE (FROM ALL PAST REVIEWS)	RETURN THIS PERIOD (1 1 1978 TO 31 3 1978)		OVER PAST 8 REVIEWS	AVERAGE RISK MEASURE (FROM ALL PAST REVIEWS)
	NO.	AMOUNT $ MILL	AVERAGE TWR (/)	AV. EXCESS RETURN OVER MODEL (/)	AVERAGE ANNUAL TWR (/PA)	(/P.A.)	AVERAGE TWR (/)	AV. EXCESS RETURN OVER MODEL (/)	AVERAGE ANNUAL TWR (/PA)	(/P.A.)
COMPLETE GROUP OF	5	150.93	-1.02	.62	17.00	31.25	-1.37	.26	15.28	28 37

MODEL FUND	1	AV. PRIVATE FUND	-1.59	16.76	25.48
MODEL FUND	2	AV. NON-L.A. FUND	-1.59	17.23	47.96
MODEL FUND	3	AV LOC. AUTH. FUND	-1.75	17.09	24.72

FIGURE 13.4

Example of a Fund Comparison Report, based on the five funds reviewed in this study and on results over the past 2 years

2. COMPLETE GROUP OF FUNDS - TIME WEIGHTED RATE OF RETURN THIS PERIOD AND EXCESS RETURN OVER MODEL FUND THIS PERIOD

FUND NAME	TIME WEIGHTED RATE OF RETURN THIS PERIOD			EXCESS MONEY WEIGHTED RETURN OVER MODEL FUND THIS PERIOD				MANAGER
	VALUE %	RANK	EXCESS OVER OFFICE AV. (%)*	WHICH MODEL	VALUE %	RANK	EXCESS OVER OFFICE AV. (%)**	
A MANUFACTURING COMPANY'S STAFF FUND (D)	-.47	1	.55	1	1.11	1	.50	1
A MANUF. COMPANY'S WORKMEN'S FUND (E)	-.54	2	.47	1	1.04	3	.43	1
A CONSUMER GOODS MANUF.'S PENSION FUND (A)	-.57	3	.44	1	1.11	2	.51	2
A NON-L.A. PUBLIC UTILITY CORPORATION (C)	-1.53	4	-.51	2	.06	4	-.55	3
MODEL FUND 1 AV. PRIVATE FUND	-1.59		-.57					
MODEL FUND 2 AV. NON-L.A. FUND	-1.55		-.58					
MODEL FUND 3 AV LOC. AUTH. FUND	-1.75		-.73					
A LOCAL AUTHORITY SUPERANNUATION FUND (B)	-1.97	5	-.95	3	-.25	5	-.87	2

FIGURE 13.4 CONTINUED

NOTES :

* AVERAGE AMONGST COMPLETE GROUP OF FUNDS WAS -1.02%.

** AVERAGE AMONGST COMPLETE GROUP OF FUNDS WAS .67%.

3. COMPLETE GROUP OF FUNDS - RISK / RETURN PERFORMANCE OVER PAST 8 REVIEWS

FUND NAME	AVERAGE ANNUAL TIME WEIGHTED RETURN OVER PAST 8 REVIEWS: DATE FROM WHICH RETURN AVERAGED	VALUE (%P.A.)	RANK	EXCESS OVER OFFICE AV. (%)*	RISK MEASURE (AVERAGE FLUCTUATION OF RETURN)+: VALUE (%P.A.)	RANK	EXCESS OVER OFFICE AV. (%)**	NO. OF PAST RETURNS	MANAGE
A CONSUMER GOODS MANUF.'S PENSION FUND (A)	1 4 1976	20.15	1	3.85	35.85	5	4.60	8	2
A MANUFACTURING COMPANY'S STAFF FUND (D)	1 4 1976	17.97	2	.98	32.79	3	1.54	11	1
MODEL FUND 2 AV. NON-L.A. FUND	1 4 1976	17.23		.23	47.96		16 71	15	
MODEL FUND 3 AV LOC. AUTH. FUND	1 4 1976	17.19		.19	24.72		-6.53	12	
MODEL FUND 1 AV. PRIVATE FUND	1 4 1976	16.76		-.24	25.48		-5.77	11	
A LOCAL AUTHORITY SUPERANNUATION FUND (B)	1 4 1976	16.58	3	-.42	28.74	2	-2.51	12	2
A MANUF. COMPANY'S WORKMEN'S FUND (E)	1 4 1976	16.31	4	-.68	33.15	4	1.90	11	1
A NON-L.A. PUBLIC UTILITY CORPORATION (C)	1 4 1976	13.27	5	-3.73	25.73	1	-5.52	16	3

FIGURE 13.4 CONTINUED

NOTES :

* AVERAGE AMONGST COMPLETE GROUP OF FUNDS WAS 17.00%.

** AVERAGE AMONGST COMPLETE GROUP OF FUNDS WAS 31.25%.

\+ THIS RISK MEASURE, TECHNICALLY KNOWN AS MEAN ABSOLUTE DEVIATION, MEASURES THE AVERAGE EXTENT TO WHICH THE FUND'S PER ANNUM TIME-WEIGHTED RATE OF RETURN HAS VARIED FROM ITS AVERAGE OVER THE PAST. THE HIGHER THE MEASURE, THE MORE 'RISKY' IS THE FUND, IN THE SENSE THAT ITS RETURN IS LESS RELIABLE. (N.B.: LITTLE EMPHASIS SHOULD BE PLACED ON A RISK MEASURE BASED ON LESS THAN SAY 8 PAST RETURNS.)

4. COMPLETE GROUP OF FUNDS - AVERAGE PERFORMANCE FIGURES FOR PERSONNEL

(FIGURES ARE AVERAGES OF RESULTS FOR ALL FUNDS UNDER THE MANAGER'S CONTROL.
THE RESULTS ARE WEIGHTED BY THE SIZE OF THE FUND IN EACH CASE.)

MANAGER AND FUNDS MANAGED	CURRENT RESULTS						*	OVER PAST 8 REVIEWS						*	RISK MEASUR	
	AVERAGE TIME-WEIGHTED RATE OF RETURN			AVERAGE EXCESS RETURNS OVER MODEL FUND			*	AVERAGE OF AV. ANNUAL TIME-WEIGHTED RETURNS			AVERAGE OF AV. PAST EXCESS RETURNS OVER MODEL			*		
(NO. , £MIL)	VALUE (%)	RANK	EXCESS OVER OFFICE AV. (%)*	VALUE (%)	RANK	EXCESS OVER OFFICE AV. (%)**	*	VALUE (%P.A.)	RANK	EXCESS OVER OFFICE AV (%PA)+	VALUE (%P.A.)	RANK	EXCESS OVER OFFICE AV (%PA)++	*	VALUE (%P.A.)	RANK
1 (2, 19.53)	-.50	1	.87	1.09	1	.83	*	17.38	2	2.10	.31	2	.69	*	32.92	3
2 (2, 45.09)	-1.43	2	-.06	.27	2	.01	*	18.22	1	2.94	.37	1	.75	*	31 47	2
3 (1, 86.30)	-1.53	3	-.16	.06	3	-.19	*	13.27	3	-2.01	-.92	3	-.55	*	25.73	1

NOTES :

* AVERAGE AMONGST COMPLETE GROUP OF FUNDS WAS -1.37%.
** AVERAGE AMONGST COMPLETE GROUP OF FUNDS WAS .26%.
\+ AVERAGE AMONGST COMPLETE GROUP OF FUNDS WAS 15.28%.
++ AVERAGE AMONGST COMPLETE GROUP OF FUNDS WAS -.34%.

FIGURE 13.4 CONTINUED

funds have on average earned a higher return (-1.20%) than the market, whichever model fund is taken to be representative of the market. Indeed, the funds beat their respective models this quarter by an average of 0.62%. The fact that the comparable weighted averages are lower indicates that the larger funds tended to do less well than the smaller funds. Average performance of the group over the past eight reviews (i.e. two years) appears to have been only at par with the market. The simple average of average annual TWRs (17.0% pa) only just beats one of the model funds. Further, this is done with an average level of risk which is higher than that of two of these average U.K pension funds, indicating that risk-adjusted performance may be below that of the market on average. This becomes even more likely if weighted averages of return and risk are used. Risk/return performance relative to the "average non-local authority" pension fund (i.e. other public sector) is indeterminate since there is no clear dominance pattern.

II.2 TABLE 2 - RANKING OF INDIVIDUAL FUNDS

Funds are listed in this table according to their order of decreasing TWR for the current review period. That is, the first column of ranks will always be consecutive numbers. The office averages used in this table are unweighted averages, as reported in table 1. As Figure 13.4 shows, it is possible for the ranking of funds to differ on their excess return over their respective model fund reflecting the influence of new money. These ranks are quoted in the sixth column of table 2. The model funds are inserted amongst the ranked funds according to their rank of current TWR, although they are not counted by the ranks quoted in the table. In this way, by reference to the "WHICH MODEL" column of table 2, some absolute scale to the ranks may be inferred. For example, it is immediately apparent from Figure 13.4 that Fund B not only did worse than its own type of model but did worse than all types.

Notice also that some idea may be gleaned of which

managers are associated with the best and worst performing funds by referring to the last column. With the rather small number of funds in Figure 13.4, it is immediately apparent that Manager 1 comes out on top.

II.3 TABLE 3 - RANKING OF FUNDS ON RISK/RETURN PERFORMANCE

Funds are ranked here according to both their average annual TWR and their risk measure. The funds are listed in decreasing order of their average annual TWR over the last n reviews, where n is a specified in the Parameters File (P3). The risk measure are based on the fund's whole history however, in view of the necessity to make them as accurate and stable as possible. The number of returns which they are based is indicated in the second last column.

The first column acts as a reminder that some funds may have been averged over different periods due to their relative youth or due to differently arranged review periods. Risk measures are ranked in an unusual way. The smallest risk measure is give a rank of 1, because it is connected with the best fund in the sense that it is the least risky fund. Thus, as to be expected from CAPM theory, the risk and return ranks are roughly negatively correlated. The first fund (Fund A) has both highest average return but worst risk level. The last fund (Fund C) has the lowest average return but the best risk level.

Model funds are inserted into this ranked list of funds according to their average annual return over their last n reviews. Their appearance can help indicate risk adjusted performance, in the sense that if a fund appears in the list <u>above</u> its relevant model type with a risk measure which is <u>less</u> than its model fund's risk measure, it has truly beat the market on a risk-adjusted basis. Conversely, if it appears below its model fund in the list, with a risk measure exceeding that of the model, it has truly under-performed the market on a risk-adjusted basis. For example, in Figure 13.4, Funds B and E can be said to have under-performed the market on a risk-adjusted basis, whereas risk-adjusted performance of the other funds is

indeterminate.

Once again, the managers connected with the highest and lowest average rates of return can be gleaned from the last column of this table. The office averages used in this table are simple averages.

II.4 TABLE 4 - "AVERAGE PERFORMANCE FIGURES FOR PERSONEL"

This table presents several average performance statistics for each of the managers connected with the funds. An average for a particular manager is obtained by taking a weighted average of the statistics for each fund under the manager's control (as indicated by the reference file, item R8). Weighted averages are taken on the basis that a manager is likely to devote more of his time to his larger funds. Thus the office averages used in this table are the weighted averages shown in table 1.

Although managers are listed in the table on the basis of the average current performance of their funds, it would of course be unfair to draw conclusions unless the manager's ranks on "performance over n reviews" were the same (or nearly so). For example, judgements on Manager 3 (forgetting for the moment that his performance is, in this small example, represented by only one fund) could be less reserved than that on the other two managers. One must also allow for the average risk measure of a manager's funds. For example, Manager 3 has the lowest average of all and so his bottom rank could be excused if the risk/return trade-off is thought to be a fair one. Reference to the entries in table 3 corresponding to his funds may clarify this fairness. It does not in this example however, as was observed in II.3 above.

If there had been two classes to this Fund Comparison Report, tables 2 to 4 would be repeated for the second class of fund.

III. USE OF THE REPORT

Although the software can handle the situation where

different funds have been reviewed using review periods of different lengths (eg quarterly versus monthly). the comparability of the statistics suffers if the resulting difference in the total time period covered by the last n reviews is large. Similar comments apply to differences in the dates up to which funds have been reviewed.

Several points need to be emphasised concerning the use of this report. They refer to the validity of the statistics in the report and to the consequential need to exercise care in using the report.

The statistics in the report are very blunt measures of performance. The direct comparison of funds' performance statistics is in itself not strictly valid, as Chapter 2 pointed out.' Yet notice that, at least for the small example of five funds, the ranking given by the report broadly agrees with the ranking given in Table 12.3 as a result of a a more careful analysis.

A Fund Comparison Report must be used by management on the basis of two philosophies:

1. It must be used as an exception report.

   Only the funds indicated as the very best or the various worst should be noted. The measures are too blunt to yield valid conclusions about funds which are clustered about a central rank.

2. It must be taken as an <u>indication</u> of trends only, and not proof of them.

   It should be used to highlight those funds and managers which should perhaps be further investigated to see if their rankings really do imply very good or very bad performance. This could be done by reference to their appropriate Fund Management Reports

III. 1 COMPARISON OF RISK-ADJUSTED PERFORMANCE

Although the Security Selection component was promoted

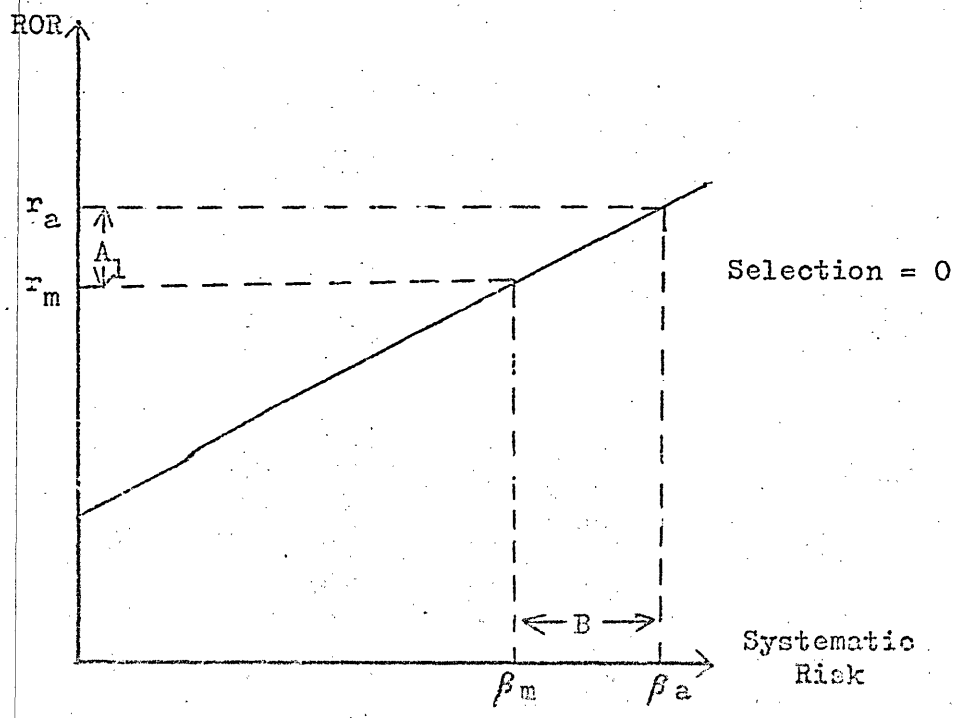
in previous chapters as the best available measure of risk-adjusted performance, it is conspicuously absent from the Comparison Report. This was done for the one simple reason that risk-adjusted performance is not the final answer to the assessment of a manager over the long term. A fund manager is paid to vary the risk of a portfolio to suit current market conditions, as well as to select superior securities within sectors. A concentration on risk-adjusted performance is only justified in the short term, as the manager can do little to vary the riskiness of his portfolio in the short run. In the long run however, the final test of his performance should be on the basis of return relative to the model fund, since by varying the risk of the portfolio, a manager can in the long term earn superior return to the market (as represented by the model fund). The Selection component and any risk-adjusted measure based on CAPM theory cannot adequately reflect the benefits of changes in the level of risk in a portfolio. They all assume that the β of the portfolio is a constant parameter over time. To illustrate this shortcoming, consider the highly artificial, but nevertheless meaningful, example in Figure 13.5. A fund manager is assumed to have adjusted the risk, β_a, of his portfolio in two successive periods of time to suit perfectly the prevailing market trend. In the first period, he managed to make the portfolio a risky one in order to take maximum advantage of the current boom. In the second period, he dramatically switched the emphasis of the portfolio between sectors so as to make it a low-risk portfolio and so minimise the impact of a general market downturn.[1] By varying the portfolio's risk in this manner, the manager has clearly done an excellent job.

Assuming the two periods are of equal length, and that the fund in each period earned a market return on a risk-adjusted basis (so that Selection in each case was zero),

---

1: For example, he could invest most of the fund in equities just before a boom in that sector and then switch most of the fund into gilts just before a monetary squeeze and stock market downturn.

(a) First time period



(b) Second time period

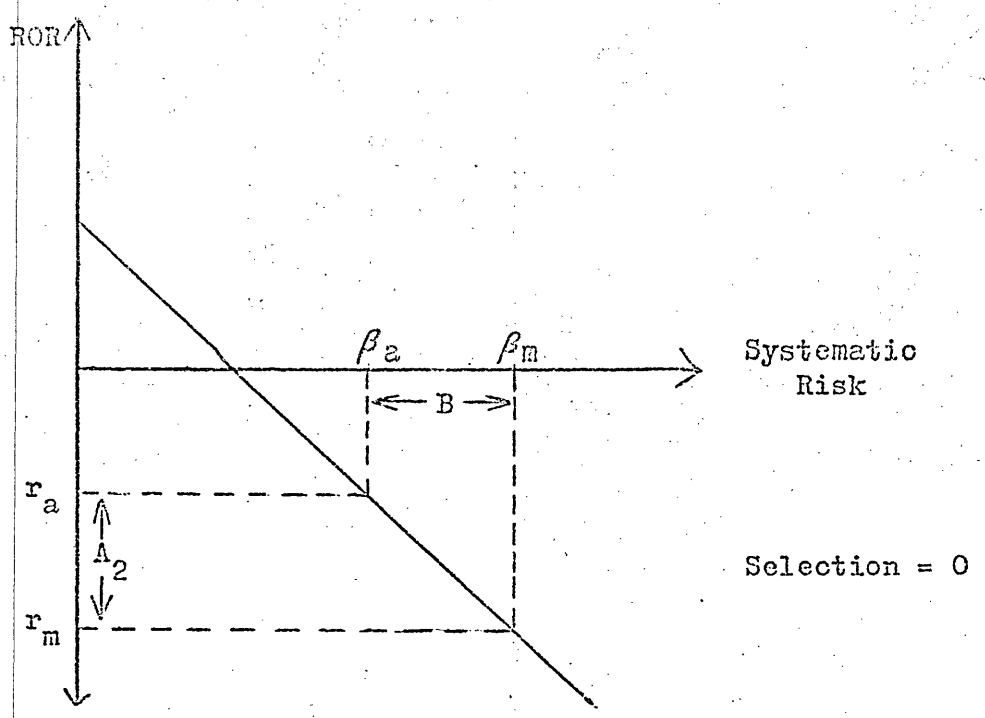


FIGURE 13.5

Risk-adjusted performance over two successive periods of a fund which adjusts its risk to suit the market.

an average Selection figure would be zero, indicating only average managerial performance. Yet managerial performance has been quite good, since average excess return has been positive (at $(A_1 + A_2)/2$) and average risk over the two periods has been the same as the market.

Average Selection is a poor measure on a dynamic basis because it completely ignores a manager's option of varying the risk of a portfolio. For this reason, it was not highlighted in the Fund Comparison Report, in favour of average excess return over the model fund, which at least reflects these dynamic effects. Risk-adjusted measures based on the CAPM have not been completely senseless in the face of this drawback because most funds either do not choose to, or cannot, vary their risk levels greatly, possibly due to large transaction costs or marketability problems. Hence on a practical basis, this dynamic element of risk-adjustment may not present a problem for large funds at least.

CHAPTER 14

CONCLUSIONS

The preceeding chapters constitute with few exceptions a virtually self-contained guide to the practical measurement of pension fund and fund manager performance. Three major areas of concern were covered, being rate of return estimation, the analysis of performance and the adjustment of performance for portfolio risk. The conclusions reached in each of these areas are listed below.

I. RATE OF RETURN ESTIMATION

It was concluded that:

1. Although the TWR is conceptually superior to the MWR for the purposes of inter-fund comparison and the measurement of fund manager performance, the MWR is nevertheless a useful additional measure for its complementary qualities relative to the TWR. These relate primarily to its ability to indicate timing effects and its relevance to the comparison of performance with a notional standard, such as a model fund.

2. Of the four methods which have been suggested in the literature to estimate the TWR, the technique which is both probably the most accurate and also the most practical is the index simulation method suggested by the Society of Investment Analysts. Because it has a similar approach to the BAI's regression estimation technique, index simulation is probably superior to the linked internal ROR method in accuracy. It is certainly more practical than the regression method, requiring the use of current data only and having much in common with calculations necessary for the analysis of performance.

II. ANALYSIS OF PERFORMANCE

The major conclusions regarding how to indicate the merit of achieved performance and its causes are as follows:

1. The many alternative methods which have been proposed in the literature can be categorised according to their positions on a set of 8 different decision levels which completely specify and account for the variations between systems.

2. Using this taxonomy, analysis systems can be categorised into four major classes, according to whether they are either:

   (i) Additive or multiplicative, and
   (ii) Dynamic or constant decompositions.

3. Since any additive system can always be re-expressed as a mutliplicative system (and vice-versa), the major issue involved in the choice of an analysis system is between dynamic and constant portfolio decompositions.

4. On the basis of what this author regards as the ideal characteristics of an analysis system, constant portfolio systems are inferior to dynamic systems, mainly because they give poor feedback on the wisdom of actions taken during the current review period.

5. Several new variations of components systems were suggested in Table 6.4, three of which were specified as being the most desirable alternatives of all analysis systems reviewed in this thesis. These are the dynamic systems labelled I, II and VII in Table 6.4. It is argued that a choice between these cannot be made in the absence of a

specific application or without resort to subjective preferences.

6. On the grounds that additive systems are simpler for the layman to comprehend, and that additive systems have more in common with the adjustment of portfolio performance for risk, system I of Table 6.4 was chosen in this study as the most desirable system for the analysis of fund performance. It is a hybrid of the systems currently offered by two consultancies.

7. The effect on overseas sector performance of exchange rate changes and the existence of, and changes in, the premium surrender rule can be quantified by the use of an additive system of components developed in this thesis.

8. Since the accurate measurement of a manager's timing skill is not practical due to the detailed data requirements, it is best done by the comparison of TWRs and MWRs. This yields approximate timing measures without the need for detailed (or any extra) data.

9. The income yield of a fund can be decomposed into components to indicate the merit of performance on a basis which excludes less reliable capital gains. The limitations of income indices prevents any emphasis of this analysis above other aspects of performance however.

10. Lastly, several minor refinements to the index simulation method as indicated by the SIA were made here in order to make it both a more accurate and a more general procedure.

III. ADJUSTMENT OF PERFORMANCE FOR RISK

In common with some previous studies, the mean absolute deviation is recommended as a better measure of risk than the standard deviation.

In the review of the theory surrounding the adjustment of performance for risk, two parallels were encountered between the analysis of return and the analysis of risk. These are shown in Table 14.1. Just as the TWR is best estimated using current data alone and relative ROR performance is best assessed using a notional standard, the overall superiority of the Selection component of performance as a risk-adjusted measure of performance corresponds to the use of current data and a notional model fund, rather than the use of historical data to estimate a fund's β value according to conventional CAPM theory. The recommended method of risk adjustment is to interpret the Selection component of performance in the same way as Jensen's statistic is interpreted according to conventional CAPM theory. This recommendation is the result of the following conclusions:-

1. The use of existing risk-adjusted measures of performance is impractical in the case of pension funds for three major reasons, all of which relate to their critical dependence on the CAPM theory from which they are derived.

   (i) Existing applications of these measures are restricted to the equity market, whereas pension funds are highly diversified into other sectors

   (ii) The linearity of risk and return, on which the risk-adjusted measures depend so critically, rapidly breaks down as the assumptions of the CAPM theory are relaxed to less unrealistic levels.

   (iii) All the measures depend on the stationarity of a fund's risk level (or β value), which is an

TABLE 14.1

Parallels in ROR analysis and risk analysis

Nature of parallel	ROR analysis	Risk analysis
Current data	SIA's index simulation method	Selection component of performance
vs.		
Past data	BAI's regression method	Jensen's statistic
Inter-fund standard	Av. ROR from sample of funds	Av. risk/return relationship
vs.		
Notional standard	Av. ROR from model fund based on av. profile	Notional risk/return relationship

unrealistic assumption in the long term for portfolios which are as widely diversified as pension funds.

2. By applying CAPM concepts to the wider context of a model fund composed of many sectors in addition to equities, Selection can be regarded as a risk-adjusted measure of performance. This is on the understanding that the index return in each sector constitutes what is a fair return for the risk represented by that sector[1], so that the systematic risk of a notional portfolio is entirely specified by its profile, and the amount by which actual return exceeds the return on the simulated actual portfolio $V(\pi_a)$ is therefore the extra return earned in excess of what was the expected return over the review period given the systematic risk of the fund (as represented by $\beta(\pi_a)$).

1: That is, what was the Markowitz-efficient market portfolio in CAPM theory is regarded as the model fund, and various combinations of sectors in the model portfolio are substitutes for the combinations of market portfolio and riskless asset in the theory.

3. The disadvantage of Selection as a risk-adjusted measure of performance is that it ignores any systematic risk (i.e., correlation of return with model fund return) which may exist within sectors. In addition, it ignores the effect of any lack of diversification (but so do Jensen's and Treynor's CAPM measures).

4. The great advantages of Selection as a risk-adjusted measure are that it is a generally more robust measure than anything based on the CAPM. It is not dependent in any way on assumptions about the linearity of the relationship between risk and return (indeed, it does not assume any functional form) and it makes no assumptions about the stationarity of parameters over successive review periods (it uses only the relationship between risk and return which existed over the current period). It is also a more practical measure, since it can be estimated on the basis of current data only.

IV. SUGGESTIONS FOR FURTHER WORK

IV.1 TIME-WEIGHTED ROR ESTIMATION

Chapter 4 indicated that a choice between different methods cannot be made with 100% certainty until information on the relative accuracy of the alternative techniques under controlled conditions was available. This would involve the generation of the distribution of errors of each technique as various factors (new money, review period length etc.) were varied systematically in a simulation procedure. To the author's knowledge, this has never been done. It would be beneficial to the extent that the deductions made in Chapter 4 regarding the probable superiority of index simulation in common with the regression technique over the linked internal ROR method could be confirmed, and to the extent that it could be used to set limits to the conditions under which the TWR can be estimated with a given level of accuracy.

IV.2 ANALYSIS OF PERFORMANCE

Further work needs to be done to confirm the adequacy of a model fund based on government statistics as a representation of the average performance of pension funds. This could in theory be verified in two ways:

1. By showing that the ROR on the model fund corresponds with observed average returns on pension fund portfolios at any one time.

2. By showing that pension funds do earn a return on average in each sector which equals the ROR on the index which best represents that sector.

The achievement of either of the above in practice will be difficult however in view of the lack of published statistics on the returns of individual portfolios.

Of more immediate practical benefit would be the improvement in the availability of indices to represent the overseas, cash and, above all, property sectors. U.K. government statistics do split cash holdings into certain types, possibly providing the basis for a composite index. The provision of a similar split for overseas holdings according to country would be equally useful. An accurate index to represent the property sector is the most urgently required addition to this field however.

IV.3 RISK ADJUSTMENT

Virtually every study of portfolio performance concludes that more work needs to be done on the question of risk. Sadly, this study is no exception, but does offer the following suggestions for the direction of further work on risk in the context of performance measurement:

1. On risk measures

   (i) No-one has made a detailed study on what is

the best differencing interval on which to base a risk measure, or on what factors should determine it.

(ii) Because performance measurement is not primarly interested in the mathematical tractability of a risk measure, there seems no reason why the semi-standard deviation could not be used.

(iii) Is non-marketability a risk, and if so, how can it be measured? Can it be linked in a systematic way to return and so be used to adjust performance? The measurement of property performance may increase the need for some allowance for non-marketability.

2. On the risk adjustment of performance

(i) Using Selection as a risk-adjusted measure of performance, there may be a heirarchy of risk-adjustment, where total performance can be first adjusted for systematic risk due to sector choice, then the Selection component of each sector can be adjusted for the systematic risk due to the choice of sub-sectors within that sector, and so on.

(ii) If such a heirarchy exists, does the first level (sector choice) contain most of the systematic risk of a portfolio? Or would the analysis of performance on the basis of sub-sectors as well as sectors considerably improve the accuracy of a Selection component as a risk-adjusted measure of performance? The risk-adjusted measure proposed in Chapter 8 is on the basis of the sector level only. It is unknown what proportion of total systematic risk would be typically accounted for by choice of sector.

3. On the assessment of performance over the long run.

Chapter 13 implied that the adjustment of performance for risk is, in the long term, not relevant, since one would expect the risk of a portfolio to be varied to suit prevailing conditions. A relatively static model fund based on the average pension fund profile may not be an adequate standard for the assessment of a manager's ability to adjust risk appropriately. It may be the case that this is not being done in the industry as a whole as much as it could be done. It may be that a model fund based on an approach similar to (5.10) may yield a standard of performance which would more fully indicate opportunity losses in this area.

REFERENCES

The following constitutes an almost complete list of publications concerning pension fund performance measurement up to the end of 1977.

1. BANK ADMINISTRATION INSTITUTE (B.A.I) (1968), Measuring the investment performance of pension funds for the purpose of inter-fund comparisons. Park Ridge, Illinois. Bank Administration Institute.

2. BANK OF ENGLAND QUARTERLY BULLETIN, December quarter

3. BANK OF ENGLAND QUARTERLY BULLETIN (1976), "The investment currency market" 60 (3) (Sept) pp 314-322

4. BEEBOWER G.L. and BERGSTROM G.L. (1977), A performance analysis of pension and profit-sharing portfolios: 1966-1975. Financial Analysts Jnl, May-June pp 31-42

5. BERIN B. (1974), BAI: One for two. Pension and Welfare News, October, pp 61-62, 102

6. BLACK F, JENSEN M.C. and SCHOLES M. (1972), "The capital asset pricing model: Some emperical tests" in Studies in the Theory of Capital Markets by M.C. Jensen (ed) Praeger (1972)

7. BREW J., "The measurement of portfolio performance - Internal assessment" in Investment Analysis and Portfolio Management by B. Taylor (ed.), Elek (1970)

8. BUSINESS MONITOR QUARTERLY STATISTICS, M5 Government Statistical Service, HMSO

9. CALLAN E.C. (1976), Performance measurement: Getting the most out of your money managers. Pension World, April, pp 41-43

10. CHIENE J. (1975), New techniques in measuring pension fund investment performance. Pensions World, July, pp 12-14

11. CHRISTIANSEN B.M. (1975), Pension fund management: A view from the inside, Financial Executive, July, pp 24-27

12. COCKS G. (1972), An objective approach to the analysis of portfolio performance. The Investment Analyst, December, pp 3-7

13. COCKS G. (1973), A set of indices for portfolio performance analysis. The Investment Analyst, September, pp 3-13.

14. COCKS G. (1974), On the measurement of the rate of return and the choice of a standard of comparson for portfolio performance analysis. The Investment Analyst, September, pp 7-13.

15. DENNIS G.J.J. (1977), Pension fund investment strategy and the market factors affecting performance measurement, Pensions World, July, pp 244-252

16. DIETZ P.O. (1966), Pension funds: Measuring investment performance. The Free Press, N.Y.

17. DIETZ P.O. (1968), Components of a measurement model: Rates of return, risk and timing. Jnl of Finance, 23, pp 267-275

18. DIETZ P.O. (1972), Objectives of measuring investment performance and their implications for developing a performance model. The Investment Analyst, May, pp 4-8

19. DOBBIE G.M. and WILKIE A.D. (1977), The F.T. - Actuaries fixed interest indices. Jnl of the Inst. of Actuaries, 105, pp 15-

20. DRAPER P.R. (1973), Some aspects of portfolio management in a financial institution. PhD Thesis,

Univ. of Sterling

21. EADIE D.M.(1973), A practical approach to the measurement and analysis of investment performance. The Investment Analyst, December, pp 12-18

22. EHRBAR A.F. (1976), Index funds - An idea whose time is coming. Fortune, June, pp 145-155

23. ELLIS C.D (1971), Danger ahead for pension funds. Harvard Business Review, May-June, pp 50-56

24. EVANS J.L. (1968), The random walk hypothesis, portfolio analysis and the buy and hold criterion. Jnl of Financial and Quantitative Analysis, September.

25. FAMA E. (1965), The behaviour of stock-market prices, Jnl of Business, 38, pp 34-105

26. FAMA E. (1968), Risk, return and equlibrium: Some clarifying comments. Jnl of Finance, 23, pp 29-40

27. FAMA E. (1968), Risk and the evaluation of pension fund portfolio performance. Supplement to the BAI report (reference 1 above).

28. FAMA E. (1972), Components of investment performance. Jnl of Finance, June, pp 551-567

29. FINANCIAL EXECUTIVE (1973), Digest Feature "Past no guide to pension fund manager's performance". May, p8

30. FINANCIAL TIMES (1972), Guide to the FT Statistics Financial Times Ltd.

66 39 (1),

31. FISHER L. (1966), An algorithm for finding exact rates of return. Jnl of Business, 39(1), pp 111-118

32. FISHER L. and LORIE J. (1964), Rates of return on investments in common stocks. Jnl of Business, July, pp 1-21

33. FOX E. A. (1968), Comparing performance of equity pension trusts, Financial Analysts Jnl, Sept-Oct, pp 121-129

34. FRANCIS J.C. and ARCHER S.H. (1971), Portfolio analysis. Prentice-Hall

35. FRIEND I. and BLUME M. (1970), Measurement of portfolio performance under uncertainty. American Economic Review, 60, pp 561-575

36. FRIEND I., BLUME M and CROCKETT J. (1970), Mutual funds and other institutional investors: A new perspective. McGraw Hill

37. GARDNER E. B. (ed.) (1968), Pension fund investment management. Chartered Financial Analysts Assoc., Irwin

38. GOODING A.E. (1975), Quantification of investors' perceptions of common stocks: risk and return dimensions. Jnl of Finance, 30 (5), pp 1301-1316

39. GUARDIAN (1977), Financial Extra: Still room for the small investor. Sept 26th, p15

40. HASTY J.M. and FIELITZ B.D. (1975), Systematic risk for heterogeneous time horizons. Jnl of Finance, 30 (2), pp659-673

41. HOLBROOK J.P. (1977), Investment performance of pension funds. Jnl of the Inst. of Actuaries, June, pp1-91

42. JENSEN M.C. (1968), The performance of mutual funds in the period 1945-1964. Jnl of Finance, 23, pp389-419

43. JENSEN M.C. (1972), "The foundations and current state of capital market theory" in Studies in the theory of capital markets by M.C. Jensen (ed.), Praeger

44. KASS D.R. (1971), Valuation of pension assets in the 1970s. Pension and Welfare News, June, pp25-28

45. KINGSTON T.D. (1975), Measuring investment performance, Transactions of the Faculty of Actuaries, 34 (3) pp241-

46. KLITZGERG R. and BOWES J.J. (1977), How you can solve the mystery behind market timing. Pension World, February, pp23-26

47. LATANÉ H.A. and TUTTLE D.L. (1970), Security analysis and portfolio management. Ronald Press, N.Y.

48. LEE C.F. (1977), Functional form, skewness effect, and the risk-return relationship. Jnl of Financial and Quantitative Analysis, March, pp55-72

49. LINDEY G.M. (1975), Pension fund investment performance - The wood and the trees. The Investment Analyst, May, pp13-15

50. LINTNER J. (1965), Security prices, risk and maximal gains from diversification. Jnl of Finance, 20, pp587-615

51. McDONALD J.G. (1974), Objectives and performance of mutual finds 1960-1969. Jnl of Financial and Quantitative Analysis, June, pp311-333

52. MAINS N.E. (1977), Risk, the pricing of capital assets, and the evaluation of investment portfolios: Comment. Jnl of Business, 50, (3), pp371-384

53. MARKOWITZ H.M. (1959), Portfolio selection: Efficient diversification of investments. Wiley and Sons, N.Y.

54. MILLER M.H. and SCHOLES M. (1972), "Rates of return in relation to risk: A re-examination of some recent findings" in Studies in the theory of capital

markets, by M.C. Jensen (ed.), Praeger

55. MILLS H.D. (1970), On the measurement of fund performance. Jnl of Finance, 25, pp1125-1131

56. MINTO G.S. (1970), Some suggestions relating to the assessment of investment performance in multi-asset funds subject to decentralised control. The Investment Analyst, December, pp7-11

57. MOLES P. and TAYLOR B. (1977), Unit trust risk-return performance. The Investment Analyst, May, pp34-41

58. MULLIGAN J.A. (1975), Investment manager control by lay trustees. Pensions World, Jan-Feb, pp17-20

59. NURSAW W.G. (1966), Principles of pension fund investment. Hutchinson.

60. OBSERVER (1978), Business Review, "The unstoppable money machine", February 5th

61. PALMER J.K. (1973), Measurement of pension fund performance, M.Sc Thesis, Imperial College

62. PENSION WORLD (1975), The winners and the also-rans. December, pp13-18

63. PHILLIPS and DREW (1978), P and D pension fund indicators. Phillips and Drew, July

64. PILCH M. and WOOD V. (1974), Managing pension schemes. Gower Press

65. ROSE D. (1928), A scientific approach to investment management. Harper and Bros.

66. ROSE H. (1971), Share price indices and the measurement of investment performance. The Investment Analyst, December, pp3-9

67. ROSS-JACKSON J.T. (1976), Performance measurement. Pensions World, March, pp77-78

68. RUTTER R.C. (1970), Measurement of investment performance in a pension fund, M.Sc. Thesis, Imperial College

69. SHARPE W.F. (1964), Capital asset prices: A theory of market equilibrium under conditions of risk. Jnl of Finance, 29, pp425-442

70. SHARPE W.F. (1966), Mutual fund performance. Jnl of Business, 39 (2), pp119-138

71. SHARPE W.F. (1978), Investments. Prentice-Hall, New Jersey

72. SHORT E. and BRUNWELL J.C. (1974), Composition of the F.T. - Actuaries share indices. Jnl of the Institute of Actuaries Students' Society, 21 (1), pp1-

73. SINQUEFIELD R.A. (1977), Index funds: What they can do for plan sponsors. Pension World, March, pp21-23

74. SKELTON D.J. (1973), Investment strategies for pension funds (in an age of inflation). Long Range Planning, December, pp47-51

75. SMITH K.V. (1971), Portfolio management, Holt, Reinhart and Winston

76. SOCIETY OF INVESTMENT ANALYSTS (SIA) (1972), The measurement of portfolio performance for pension funds. Society of Investment Analysts, London

77. SPIRO A.J. (1970), Measuring the performance of the equity investments of a pension fund. M.Sc. Thesis, Imperial College

78. TAYLOR G. (1976), Developing an investment strategy. Pensions World , April, pp108-111

79. TEPPER I. (1977), Risk vs. return in pension fund investment. Harvard Business Review, March-April, pp100-107

80. THACKRAY J. (1977), America's mutual mayhem. Management Today, May, pp74-77

81. TREYNOR J. (1965), How to rate management of investment funds. Harvard Business Review, February, pp63-75

82. TUTT S. and TUTT L. (1971), Private pension scheme finance. Stone and Cox Ltd

83. W. GREENWELL and CO., (1978), Property indices, W. Greenwell and Co., April

84. WEAVER D. (1971), Investment analysis, Longmans

85. WEST R.R. (1968), Mutual fund performance and the theory of capital asset pricing: Some comments. Jnl of Business, 41, pp230-236

86. WILSON P.N. (1977), Do pension fund portfolio managers earn their keep?. Pension World, February, pp13-18

87. WOOD R.N. (undated), Measuring the investment yield of pension funds. Alexander and Alexander Inc., USA

88. WRIGHT R. (1974), The development of a computer model as a measure of pension fund performance. M.Sc. Thesis, Imperial College

APPENDIX 3-I

THE BAI FORMULA FOR THE TIME-WEIGHTED ROR

The definition of the TWR given by the BAI(1), based on a continuous compounding assumption is as follows, in the notation of this study.

$$TWR = \frac{1}{\sum l(i)} \ln\left(\frac{MV_{n+1}}{MV_o}\right) - \sum_{i=1}^{n} \ln \frac{MV_{t(i)} + C_{t(i)}}{MV_{t(i)}} \quad - (3\text{-I}.1)$$

The definition given in this study using discrete compounding is as given by (3.9), which may be re-written as

$$1 + TWR = \frac{MV_1}{MV_o} \cdot \frac{MV_2}{MV_1 + C_1} \; \frac{MV_3}{MV_2 + C_2} \cdots\cdots \frac{MV_n}{MV_{n-1} + C_{n-1}} \; \frac{MV_{n+1}}{MV_n}$$

where t(i) is written as i as a simplification. This may be re-written as

$$TWR = \frac{MV_{n+1}}{MV_o} \div \frac{1}{MV_1} \cdot \frac{MV_1+C_1}{MV_2} \; \frac{MV_2+C_2}{MV_3} \cdots\cdots \frac{MV_{n-1}+C_{n-1}}{MV_n} \; MV_n - 1$$

$$= \frac{MV_{n+1}}{MV_o} \div \frac{MV_1+C_1}{MV_1} \; \frac{MV_2+C_2}{MV_2} \cdots\cdots \frac{MV_{n-1}+C_{n-1}}{MV_{n-1}} - 1$$

$$- (3\text{-I}.2)$$

(3-I.2) may be recognised as the discrete compounding equivalent of (3-I.2) after annualisation.

APPENDIX 4-I

EFFECT ON MONEY-WEIGHTED ROR OF IGNORING INTEREST-ON-INTEREST

If (4.3) is taken to second order terms in the derivation of an approximation for the MWR, the term

$C_{t(i)}\ (1 + r)^{1-t(i)}$ in (4.2) may be approximated by

$$C_{t(i)}\quad 1 + (1 - t(i)\ r - \frac{t(i)}{2}\ (1 - t(i))\ r^2 \qquad \text{- (4-I.1) corresponding to (4.4)}$$

so that (4.2) becomes

$$MV_n = MV_o\ (1+r) + \sum_{i=1}^{m} C_{t(i)}$$

$$+ r \sum_{i=1}^{m} C_{t(i)}\ 1 - \frac{t(i)}{2} r - t(i) + r\ \frac{t(i)^2}{2}$$

which simplifies to the following quadratic equation in r:

$$\tfrac{1}{2} \sum (\ t(i)\ C_{t(i)} - \sum t^2_{(i)}\ C_{t(i)})\ r^2 - (MV_o + \sum C_{t(i)} - \sum t(i)\ C_{t(i)})$$

$$+ (MV_n - MV_o - \sum C_{t(i)}) = 0 \qquad \text{- (4-I.2) corresponding to (4.5)}$$

Solving (4-I.2) for r yields

$$\frac{(MV_o + \bar{C}) \pm \sqrt{(MV_o + C)^2 - 4\ (\tfrac{1}{2}\sum t(i)w(i)C_{t(i)})\ (MV_n - MV_o - C)}}{2\ \tfrac{1}{2}\sum t(i)w(i)C_{t(i)}}$$

where $w(i) = 1-t(i)$, $\bar{C} = \sum w(i)C_{t(i)}$ — (4-I.3) corresponding to (4.6)

and $C = \sum C_{t(i)}$

This is equivalent to the equation shown in Table 4.1.

The degree of error incurred in a quarterly ROR by ignoring interest-on-interest and solving (4.6) instead of (4-I.3) would probably not exceed 0.1% at the very most. For example, the MWR obtained using (4-I.3) for the fund whose report is shown in Figure 12.1 is -5.976% compared with a value given by (4.6) of -5.990%, an error of only 0.014%. This is under the relatively gentle condition of new money being less than 10% of the initial fund. Cases where new money exceeds 10%, or where the review period is longer or where the average ROR is greater may more closely approach the 0.1% mark.

APPENDIX 5-I

USE OF U.K. GOVERNMENT STATISTICS TO DERIVE A PROXY FOR THE AVERAGE U.K. PENSION FUND

U.K. Government statistics are published in (8) on the following basis:-

1. Annual figures on the estimated total market value of U.K. pension fund's assets

2. Quarterly figures on the estimated net purchases (at cost) of U.K. pension funds.

All figures are split by type of security and by type of fund (private sector/local authority/other public sector). In each case they are aggregated, so that the proportion of the average pension fund constituted by the sth sector is estimated as

$$\bar{p}_s = \frac{MV^s}{\sum_s MV^s} \qquad - (5\text{-I}.1)$$

Letting MV_i^s = value of the sth sector in the ith pension fund

MV_i = total market value of the ith fund

and MV = total market value of all funds,

the correct average proportion with which the sth sector is held by pension funds on average is the weighted average

$$\sum_i w_i \frac{MV_i^s}{MV_i} \qquad - (5\text{-I}.2)$$

where $w_i = \dfrac{MV_i}{MV}$ reflects the importance of the ith fund as a function of its size.

But (5-I.2) is equivalent to

$$\sum_i \frac{MV_i}{MV} \frac{MV_i^s}{MV} = \frac{\sum_i MV_i^s}{MV}$$

$$= \frac{MV^s}{MV}, \text{ or } (4\text{-I.1})$$

Thus use of the government statistics is equivalent to taking the weighted average of the profiles of individual pension funds, where the weight for a fund is its relative importance according to size.

ACCURACY OF THE DATA

The data is generated from a sample of pension funds, so the data can be inaccurate due to a number of causes, ranging from sampling error to the fact that not all the data on market values is as at the same date.

Given that the figures are taken as being accurate reflections of the weighted average split of U.K. pension funds between sectors, a notional fund based on this average profile may be regarded as constituting a representation of the performance of the average U.K. pension fund, as explained in XI.2.4, Ch 5. An individual security is represented in the model fund according to a two-teir structure of weights.

1. A sector weight according to the importance of that sector to pension funds as a whole, <u>ignoring</u> any other investors.

2. A weight within the sector based on the market capitalisation of that security as a proportion of total market value of the whole sector, <u>including</u> other types of investors.

The weights will therefore be an inaccurate representation of the market commanded by pension fund money to the extent that other types of investors are invested in individual

sectors in a different pattern of holdings within sectors than are pension funds. The exact extent of any such differences is unknown, but since pension funds are amongst the largest institutional investors in the economy, one could safely assume that any difference is small. This argument is probably entirely valid in the equity sector and less valid for the other sectors such as other fixed interest, overseas, property trust and cash. The relatively small size of these sectors implies however that any inaccuracy has marginal impact on the total return on the model fund. As Chapter 9 discussed, the above argument is probably only valid for gilts if the index used is oriented towards the long end of the market. The use in this study of a market-wide index for gilts, combined with the fact that index return may not be average sector returns (as outlined in Chapter 5) makes the performance of the model fund possibly a little removed from true average performance but not so far removed as to be a goal which is unattainable in the long run.

APPENDIX 6-I

EADIE'S ADDITIVE CONSTANT PORTFOLIO DECOMPOSITION

The system illustrated in Eadie(21) has a general algebraic structure as shown in Table 6-I.1. This is an additive system expressed in terms of premium returns, as the following lines show.

The line in Table 6-I.1 is equivalent to

$$\sum_s W_s\left(\frac{R_s - R_m}{1 + R_m}\right) + \sum_s (w_s - W_s)\frac{R_s - R_m}{1 + R_m} + \sum_s w_s \frac{r'_s - R_s}{1 + R_m}$$

$$+ \frac{r - r'}{1 + R_m} = \frac{1 + r}{1 + R_m} - 1 \qquad - (6\text{-I}.1)$$

Adding 1 to both sides and multiplying by $(1 + R_m)$ leads to

$$\sum_s (w_s - W_s) R_s + \sum_s w_s (r'_s - R_s) - r' + 1 + R_m = 1 \qquad - (6\text{-I}.2)$$

Approximating the returns using (4.6) (recalling that the portfolio is constant), (6-I.2) is equivalent to

$$\sum_s (w_s - W_s)\frac{V(\pi_m^o) - MV_o}{MV_o} + \sum w_s \frac{MV_n'^s - MV_o}{MV_o} - \frac{V(\pi_m^o)^s - MV_o}{MV_o}$$

$$- \frac{MV_n' - MV_o}{MV_o} + \frac{V(\pi_m)}{MV_o} = 1 \qquad - (6\text{-I}.3)$$

Multiplying by MV_o and simplifying, this reduces to

$$\sum_s (w_s - W_s)\, V(\pi_m^o)^s + \sum_s w_s\, MV_n'^s - \sum_s w_s\, V(\pi_m^o)^s$$

$$- (MV_n' - MV_o) + V(\pi_m^o) = MV_o \qquad - (6\text{-I}.4)$$

TABLE 6-I.1

SPECIFICATION OF EADIE'S ADDITIVE CONSTANT PORTFOLIO PERFORMANCE ANALYSIS SYSTEM

Total performance premium, p

$$= \frac{1 + r}{1 + R_m} - 1 = \underbrace{\underbrace{\sum_s \left(\frac{1 + R_s}{1 + R_m} - 1\right) W_s}_{\text{Index}} + \underbrace{\sum_s (w_s - W_s)\left(\frac{R_s - R_m}{1 + R_m}\right)}_{\text{Loading}}}_{\sum_s w_s \left(\frac{R_s - R_m}{1 + R_m}\right)} + \underbrace{\sum_s w_s \left(\frac{1 + r'_s}{1 + R_m} - \frac{1 + R_s}{1 + R_m}\right)}_{\text{Selection}}$$

Policy

$$+ \underbrace{\frac{r - r'}{1 + R_m}}_{\text{Dealing}}$$

where the notation is the same as that in Table 6.3, and r'_s = ROR on s^{th} sector of constant portfolio, r' = ROR on constant total portfolio; r = ROR on whole portfolio, with changes.

which in turn is equivalent to

$$\sum_s (w_s - W_s)\, V(\pi_m^o)^s + MV_n' - V(\pi_b^o) + (MV_o - MV_n') + V(\pi_m^o) = MV_o \qquad - (6\text{-I}.5)$$

Adding MV_n to both sides and subtracting new money, C, and $2MV_o$ from both sides gives the decomposition shown in Table 6-I.1.

APPENDIX 9-I

MARKET-WIDE COMPOSITE GILT INDEX

Table 9-I.1 shows the statistics on which the weights for combining the three seperate Phillips and Drew indices were based. They refer to the nominal value of holdings by the public (excluding official holdings) and are available on an annual basis from (2). As III.2.3, Ch.9 indicated, the weights should be based on market values but these are unavailable. The composite index is derived for prices as:

$$X_t = \sum_{i=1}^{3} w_i X_t^i \qquad - (9\text{-I}.1)$$

and for income as

$$IX_t = \frac{1}{12} \sum_{i=1}^{3} w_i \left[\frac{y_t^i \; X_t^i + y_t^{'i} \; X_{t+1}^i}{2} \right] \qquad - (9\text{-I}.2)$$

where w_i = Weight applicable to index of ith maturity class. The weights in Table 9-I.1 were used for the previous and following 6 months

X_t^i = Price index of ith maturity class

y_t^i = Redemption yield of ith maturity class at the beginning of the tth month.

The composite index values produced are shown in Table 9-I.2. The near-zero correlation of the income index with that of the FTA government securities index (Figure 9.2) is primarily due to the fact the (9-I.2) smooths annual income over months, whereas the FTA income index reflects income as received.

TABLE 9-I.1

Distribution of government stock by maturity (nominal value in the hands of the public).

As at Match		Less than 5 years	5 - 15 years	Greater than 15 yrs.	Total
1974	£m	5699	4969	9692	20360
	Weight	0.28	0.24	0.48	
1975	£m	8354	4605	9987	22946
	Weight	0.36	0.20	0.44	
1976	£m	10205	4910	13125	28240
	Weight	0.36	0.17	0.47	
1977	£m	12544	5080	18381	36005
	Weight	0.35	0.14	0.51	

TABLE 9-I.2

Composite P & D gilt index values (monthly averages)

	1974		1975		1976		1977	
	Price	Income	Price	Income	Price	Income	Price	Income
J	63.765	0.645	59.398	0.661	64.573	0.649	63.733	0.690
F	61.855	0.648	63.268	0.646	66.276	0.637	64.756	0.636
M	60.972	0.652	66.291	0.640	65.349	0.626	68.146	0.639
A	59.369	0.647	65.336	0.640	64.879	0.633	68.444	0.633
M	61.591	0.636	63.791	0.643	65.010	0.644	68.807	0.636
J	60.844	0.637	63.793	0.644	64.049	0.647	67.299	0.645
J	59.325	0.638	65.025	0.652	64.241	0.646	66.450	0.644
A	58.417	0.631	64.827	0.653	63.848	0.648	67.895	0.634
S	59.134	0.636	65.491	0.655	62.640	0.658	71.187	0.608
O	61.277	0.649	63.531	0.656	58.652	0.677	74.767	0.601
N	59.00	0.659	63.319	0.662	58.072	0.689	73.070	0.618
D	57.555	0.670	62.999	0.657	58.670	0.682		

APPENDIX 9-II

NOTIONAL INCOME INDICES

The income from an index over a certain sub-period t (e.g., one month) is theoretically a sum of the income to be earned on the index on each day according to the index level for that day. If there are n_t days in the sub-period, income from the index should be

$$IX_t = \sum_{d=1}^{n_t} \frac{y_{td} \quad X_{td}}{n_t} \qquad - (9\text{-II}.1)$$

where y_{td} = income yield for the tth sub-period on d^{th} day during the tth sub-period.

X_{td} = Index level on d^{th} day.

Since y_{td} and X_{td} are either not available or (9-II.1) is too tedious to calculate, some approximation must be made. Weaver(84) assumes that income increases linearly (or at least varies symmetrically) over the sub-period, so that income for the whole period may be taken as the simple average of the rate of income per annum at the beginning and end of the sub-period:

$$IX_t = \frac{y_{t-1} \; X_{t-1} + y_t \quad X_t}{2} \qquad - (9\text{-II}.2)$$

This method requires the use of data other than that of the current sub-period, which in turn requires some extra input. An alternative approximation to (9-II.1) which used only data relevant to the current sub-period is obtained by assuming that the income yield y_{td} is equal each day to its average, $\bar{y}_t$, over the sub-period. That is if

$$\bar{y}_t = \frac{1}{n_t} \sum_{d=1}^{n_t} y_{td}, \quad (9\text{-II}.1) \text{ becomes}$$

$$IX_t = \bar{y}_t \frac{1}{n_t} \sum_d X_{td}$$

$$= \bar{y}_t \bar{X}_t \qquad - (9\text{-II}.3)$$

This is the method used in this study to generate notional income. It assumes that income <u>yield</u> varies symmetrically over the sub-period so that average yield during the sub-period is on balance a fair reflection of each daily yield.

To see that the two approaches are equivalent, assume that both the index and the income yield increase linearly at rates a and b respectively over the review period, so that

$$y_{td} = y_{t-1} + ad \qquad - (9\text{-II}.4)$$

$$X_{td} = X_{t-1} + bd \qquad - (9\text{-II}.5)$$

Then (9-II.1) becomes

$$IX_t = \frac{1}{n_t} \sum_d (y_{t-1} + ad)(X_{t-1} + bd) \qquad - (9\text{-II}.6)$$

Weaver's method assumes that income grows linearly which in turn involves assuming the index is constant over the sub-period (which is unrealistic) or that the yield is constant at value Y.

Under the latter assumption,

$$IX_t = \frac{Y}{n_t} \left(b \sum_d d + n_t X_{t-1} \right)$$

$$= Y \left(X_{t-1} + \frac{b}{2} n_t \right) \qquad - (9\text{-II}.7)$$

using the sum of an arithmetic series in d.

By substituting (9-II.5) plus Y for y_t and y_{t-1} in (9-II.2), it can be shown that (9-II.7) is derived.

The method used in this study is equivalent to the above with Y equal to the average yield $\bar{y}_t$ for the sub-period.

```
      DATA PENCH,NN,JJ,KK,PDDAYS,RM,R,W,RI,WO,DATNUM,MESIZE(1),
     3  AVWGHT,ZWGHT,LIMIT,INDEX(1,6),
     4  INDEX(2,6),INDEX(3,6),INDEX(4,6),INDEX(5,6),INDEX(6,6),INDEX(7,
     5  6),INDEX(8,6),INDEX(9,6),INDEX(10,6),INDEX(11,6),INDEX(12,6),
     6  INDEX(13,6),INDEX(14,6),WH,PLACE,NN,FVALU(5,7),
     7  TOTVAL,SECTR,OSEAS,II,M,CUMINC,MODFLG,SCRTEX,CONSIN,
     8 REPAID,PROPNS(3,1),PROPNS(3,2),PROPNS(3,3),PROPNS(3,4),
     9 PROPNS(3,5),PROPNS(3,6),MODMAD

     4  /21*0,2,0,0,0,5,6,3,7,8,31,29,31,31,30,31,30,31,31,30,31,30,31,
     9 0.0,12*0.5,12*0.0,6,14*100.0,2,6,1,0.0,600000.0 ,
     9  1,2,3,4,5,6,4,5,3,7*0.0,0 ,1,12,1,12,1,12,1,12,1,12,1,12,
     9 117*0,117*0,6*0.166667,7*0.0 /
      DATA POLDES,BLANK,FNISH,HIST(1),HIST(2),VALPAD(1),VALPAD(2),
     3  VALPAD(3),MODEX,INCDEX,TCTEXT,INCOPT,PASTFL,MDHSTX
     4 7*6H      ,6H      ,6HFINISH,6HNO FIL,6HNEW FI,6HALL    ,
     5 6HNONE  ,6HSOME  ,
     6  6HMODEL ,6H      ,6HMONTHL,6HGRAND ,6HSECTOR,
     7 6HPARTIA,6H      ,6H      ,6H      /
      DATA CHARG /1.0342,1.0142,1.0025,1.0025,1.0030,1.0030,1.01314,
     1 1.01314,1.034,1.014,1.0,1.0 /
      DATA YIELDS /1,3,4,5,6,0/
C
C INPUT DETAILS OF MODEL FUND TO BE USED FOR ANALYSIS.
C
C INPUT MODEL FUND PROPORTIONS
      READ(RI,1300) MODEL
      READ(RI,2000) TEXT
 2000 FORMAT(7A6)
      WRITE(4,3010) MODEL,TEXT
 3010 FORMAT(1X,13HMODEL PROPNS=,6F10.3,/,1X,7A6)
      DO 169 J=1,6
      PROPNS(1,J) = MODEL(J)
  169 CONTINUE
C  INPUT FILE NAMES OF OLD AND NEW MODEL HISTORY FILE, SPECIFICATION
C      FOR PATTERN OF ACCUMULATION AND MODEL HISTORY UPDATE OPTION.
      READ(RI,1670) OLMDFL,NUMDFL,PATTN2,MODUPD
 1670 FORMAT(A6,4X,A6,4X,5I5,5X,A6)
      PASTFL = NUMDFL
C  IF NO PATTERN OF ACCUMULATION SPECIFIED, SET TO DEFAULT SERIES.
      IF( PATTN2(1).NE.0 ) GOTO 166
      DO 1 I=1,5
      PATTN2(I) = I
    1 CONTINUE
  166 WRITE(4,3075)
 3075 FORMAT(37HFILE NAMES (OLD,NEW),PATTN2 +  MODUPD)
      WRITE(4,1670) OLMDFL,NUMDFL,PATTN2,MODUPD
C  IF NO OLD HISTORY FILE SPECIFIED, SET INDICATOR TO NO OR NEW FILE.
      IF( OLMDFL.NE.BLANK ) GOTO 168
      MDHSTX = HIST(1)
      IF( NUMDFL.NE.BLANK ) MDHSTX = HIST(2)
C
C READ INFORMATION FROM CENTRAL FILE OF MARKET CONDITIONS AGAINST WHICH A
C      FUNDS ARE TO BE ASSESSED OVER THE SAME REVIEW PERIOD.
C
  168 READ(RM,1000)(RPDATE(1,J),J=1,3),(RPDATE(2,J),J=1,3),N
 1000 FORMAT( 2(2I2,I4,2X), I2 )
      WRITE(4,3000) (( RPDATE(I,J),J=1,3 ),I=1,2 ),N
 3000 FORMAT(1X,13HREVIEW DATES=,6I5,/,1X,2HN=,I5)
C TEST FOR INVALID REVIEW PERIOD LENGHT
      IF(N.LT.0) GOTO 9999
      IF(N.GT.12) GOTO 9999

C INPUT SECTOR INDICES
      READ(RM,1100)(INDEX(1,J),J=1,5 )
 1100 FORMAT(5F10.0)
      DO 10 K = 1,N
      READ(RM,1200) MTHNUM(K),( INDEX(K+1,J),J=1,5 )
 1200 FORMAT(I10,5F10.0)
   10 CONTINUE
      READ(RM,1100)(INDEX(N+2,J),J=1,5 )
      WRITE(4,3020) (I, ( INDEX(I,J),J=1,6 ),I=1,N+2 )
 3020 FORMAT(1X,7HINDICES,/,12(1X,I3,5X,6F10.3,/))
C INPUT SECTOR NOTIONAL INCOME INDICES
      DO 2 K=1,N
      READ(RM,1300)(NINCDX(K,J),J=1,6)
 1300 FORMAT(6F10.0)
    2 CONTINUE
      WRITE(4,3030) ( MTHNUM(I), (NINCDX(I,J),J=1,6 ),I=1,N)
 3030 FORMAT(1X,14HINCOME INDICES,/,12(5X,I3,5X,6F10.3,/))
C INPUT OVERSEAS EXCHANGE RATES
      READ(RM,1400) (RATE(1,J),J=1,2), PRMPEN(1)
 1400 FORMAT(3F10.0)
      DO 3 K=1,N
      READ(RM,1500) (RATE(K+1,J),J=1,2)
 1500 FORMAT(2F10.0)
    3 CONTINUE
      READ(RM,1550) (RATE(N+2,J),J=1,2),PRMPEN(N+2),PENEX
 1550 FORMAT(3F10.0,A6)
      WRITE(4,3050)(RATE(1,J),J=1,2),( RATE(N+2,J),J=1,2)
 3050 FORMAT(1X,12HOPENING AND END RATES,/,2(5X,2F10.3,/))
      WRITE(4,3040) (I, ( RATE(I,J),J=1,2 ),I=2,N+1 )
 3040 FORMAT(1X,14HEXCHANGE RATES,/,12(5X,I3,5X,2F10.3,/))
      WRITE(4,3060) PRMPEN(1),PRMPEN(N+2)
 3060 FORMAT(1X,7HPENALTY,/,1X,2F10.3)
      IF(PENEX.NE.BLANK) GOTO 9992

      IF( PRMPEN(1).EQ.PRMPEN(N+2) ) GOTO 101
CINPUT DETAILS OF PREMIUM PENALTY CHANGES, IF ANY AS INDICATED ABO
      PENEX = FNISH
      READ(RM,1650)(( ( PENCH(I,J),J=1,3),PENVAL(I) ),I=2,6 )
 1650 FORMAT( 5(2I2,I4,F7.0) )
      WRITE(4,3070) ((I, ( PENCH(I,J),J=1,3 ),PENVAL(I) ),I=2,6 )
 3070 FORMAT(1X,7HCHANGES,/,5(1X,I3,2I3,I5,5X,F10.3,/))
C DO INPUT VALIDITY CHECKS
  101 TEMP1 = RPDATE(2,3) - RPDATE(1,3)
      WRITE(4,5010) TEMP1
 5010 FORMAT(1X,6HTEMP1,/,5X,I10)
      IF(TEMP1.GT.1) GOTO 9998
      DO 4 K=1,N+2
      DO 5 J=1,5
      IF( INDEX(K,J).LT.0.05 ) GOTO 9997
    5 CONTINUE
      DO 6 J=1,2
      IF( RATE(K,J).LT.0.05 ) GOTO 9997
    6 CONTINUE
    4 CONTINUE
```

APPENDIX 10-I (see text on last page)

```
C
C INPUT INFORMATION FOR NEXT FUND.
C
 1559 PRINT1 = 0
      PRINT2 = 0
      PRINT3 = 0
      PRINT4 = 0
      PRINT5 = 0
      PRINT6 = 0
      PRINT7 = 0
      PRINT8 = BLANK
      HIST_X = BLANK
      PARTIN = BLANK
      HSTMSG = 0
      HFLAG = 0
      MODFLG = 0
      MODPR = 0
      PAGE = 0
      SUMINC(1) = 0.0
      SUMINC(2) = 0.0


      SUMINC(3) = 0.0
      SUMINC(4) = 0.0
      DO 176 J=1,6
      PARTAL(J) = 0
      SECTEX(1,J) = 0
      SECTEX(2,J) = N
      LIFE(J) = FLOAT(N)
  176 CONTINUE
      TMCST3 = 0.0
      TMCST4 = 0.0
      DO 177 K=1,13
      SAGAMM(K) = 0
      DO 178 J=1,9
      APURCH(K,J) = 0
      AINCOM(K,J) = 0
      GROSIN(K,J) = 0
      PAIDI(K,J) = 0
      SINING(K,J) = 0
  178 CONTINUE
  177 CONTINUE
      READ(R,1600) PFNAME,PFNUM,S
 1600 FORMAT(7A6,8X,I10,19X,I1)
      WRITE(4,4000) PFNAME,PFNUM
 4000 FORMAT(1X,7A6,I10)
C IF REACHED END OF INPUT FILE....
      IF( PFNUM.EQ.0 ) GOTO 10000
C INPUT DATA VALIDITY CHECK
      IF( S.EQ.0 ) GOTO 9996
      READ(R,1670) OLDHST,NEWHST,PATTN,PRINT8
      WRITE(4,1670) OLDHST,NEWHST,PATTN,PRINT8
C IF NO PATTN INFO SUPPLIED, SET TO DEFAULT VALUES
      IF( PATTN(1).NE.0 ) GOTO 206
      DO 347 I=1,5
      PATTN(I) = PATTN2(I)
  347 CONTINUE
  206 DO 346 I=1,5
      IF( PATTN(I).GT.12 ) GOTO 9993
  346 CONTINUE
C  IF NO OLD HISTORY FILE SPECIFIED, SET INDICATOR FOR NO OR NEW FILE.
      IF( OLDHST.NE.BLANK ) GOTO 207
      HISTEX = HIST(1)
      IF( NEWHST.NE.BLANK ) HISTEX = HIST(2)
C  IF NEW HISTORY FILE  DIFFERENT FROM PREVIOUS FUND'S, WRITE EOF MARKER
C    ON PREVIOUS HISTORY FILE AND SAVE IT (SYSTEM DEPENDENT*******.)
  207 IF( NEWHST.NE.PASTFL ) CALL HSTEOF(PASTFL,NEWHST)
      READ(R,1700) SECTR,TEMP1
 1700 FORMAT(7I10)
C TEST FOR CORRECT NUMBER OF SECTORS.
      IF( SECTR(1).EQ.0 ) GOTO 9995
      IF( TEMP1.NE.0 ) GOTO 9995
      READ(R,1800) EXCLNA,EXLAMT
 1800 FORMAT(7A6,8X,I10)
      WRITE(4,4010) SECTR,EXCLNA,EXLAMT
 4010 FORMAT(1X,7HSECTORS,/,1X,15,5X,6I5,/,5X,7A6,I10)
      DO 174 J=1,5
      JJ = SECTR(J)
      IF( JJ.GT.6 ) GOTO 9985
      IF( JJ.LT.1 ) GOTO 9985
      PROPNS(1,J) = MODEL(JJ)
      MODDES(J) = TEXT(J)
  174 CONTINUE
      MODDES(7) = TEXT(7)
C READ SECTOR PROPORTIONS
  551 READ(R,1900) POLEX,( PROPNS(2,J),J=1,6 )
 1900 FORMAT(A6,4X,6F10.0)
      WRITE(4,4015) POLEX,( PROPNS(2,J),J=1,6 )
 4015 FORMAT(6HPOLEX=,A6,/,12HPROPNS(2,J)=,6F8.3)
      IF( POLEX.EQ.MODDES ) GOTO 651
      IF( POLEX.NE.BLANK ) GOTO 751
      READ(R,2000) POLDES
      GOTO 861
C INPUT THIS FUND'S SPECIAL MODEL FUND PROPORTIONS + DESCRIPTION
C   'MODFLG' INDICATES IF THIS FUND HAS OWN MODEL PROFILE (=1).
  651 DO 172 J=1,6
      PROPNS(1,J) = PROPNS(2,J)
  172 CONTINUE
      MODFLG = 1
      READ(R,2000) MODDES
      GOTO 551
C NO POLICY FUND EXISTS,SO SET POLICY PROPNS TO MODEL
  751 DO 172 J=1,6
      PROPNS(2,J) = PROPNS(1,J)
  172 CONTINUE
C INPUT FUND DATA
  861 READ(R,1700) ( AVALU(1,J),J=1,S )
      WRITE(4,4020) ( PROPNS(1,J),J=1,6 ),MODDES


      WRITE(4,4030) ( PROPNS(2,J),J=1,6 ),POLDES
 4030 FORMAT(1X,6HPOLICY,/,1X,6F10.3,/,5X,7A6)
 4020 FORMAT(1X,5HMODEL,/,1X,6F10.3,/,5X,7A6)
      READ(R,1700) ( AVALU(2,J),J=1,S )
      WRITE(4,4040) ( ( AVALU(I,J),J=1,S ),I=1,2 )
 4040 FORMAT(1X,10HVALUATIONS,/,2(5X,3I10,/))
      DO 13 K=1,N
      READ(R,1700) ( APURCH(K,J),J=1,S-1 ),APURCH(K,8)
   13 CONTINUE
      WRITE(4,4050)
 4050 FORMAT(1X,9HPURCHASES)
      DO 141 I=1,N
      WRITE(4,4060) ( APURCH(I,J),J=1,S-1 ), APURCH(I,8)
 4060 FORMAT(5X,6I10)
  141 CONTINUE
 4070 FORMAT(1X,12HAFTER SUMMAT,/,1X,I5,5X,3I10)
      READ(R,2100) INCMEX,TAX,INCOPT,TOTLIN
 2100 FORMAT(20X,A6,14X,A6,4X,A6,4X,A6)
      WRITE(4,4080) INCMEX,TAX,INCOPT,TOTLIN
 4080 FORMAT(1X,6HAINCOP,A6,/,7HINCMEX=,A6,2X,4HTAX=,A6,
     1 3HMOTIONAL INCOME OPTIONS:INCOPT,TOTLIN=,A6,2X,A6)
      IF( INCMEX.EQ.BLANK .AND. INCOPT.NE.BLANK ) GOTO 9983
C  IF INCOME EARNED FIGURES ARE GIVEN, INPUT THEM.     OTHERWISE READ FIGURE
C  ACCORDING TO OPTION 'TOTLIN'.
      IF( INCMEX.EQ.BLANK ) GOTO 901
      IF( TOTLIN.NE.BLANK ) GOTO 805
C  NO INCOME FIGURES KNOWN AT ALL, SO SET INCOME EARNED TO ZERO.
      DO 14 K=1,N+1
      DO 15 J=1,S
      AINCOM(K,J) = 0
   15 CONTINUE
      AINCOM(K,8) = 0
   14 CONTINUE
      GOTO 851
  805 AINCOM(N+1,7) = 0
      IF( TOTLIN.EQ.TOTEXT(1) ) GOTO 811
      IF( TOTLIN.EQ.TOTEXT(2) ) GOTO 821
      IF( TOTLIN.EQ.TOTEXT(3) ) GOTO 831
      IF( TOTLIN.EQ.TOTEXT(4) ) GOTO 841
      GOTO 9993
C  'PARTIAL' OPTIONS.  READ SECTOR NUMBERS THEN INCOMES.
  861 READ(R,1700) TEMP1,( IDUMMY(J),J=1,6 ),PARTIN
 1700 FORMAT(I1,I9,5I10,A6)
      IF( TEMP1.EQ.0 ) GOTO 9996
      DO 143 K=1,N
      READ(R,1700) ( AINCOM(K,IDUMMY(J)),J=1,TEMP1 ),AINCOM(K,8)
  143 CONTINUE
      DO 144 J=1,TEMP1
      JJ = IDUMMY(J)
      IF( JJ.LT.1 ) GOTO 9994
      IF( JJ.GT.S ) GOTO 9995
C SET 'PARTAL(JJ)' =1 IF J TH  SECTOR HAS INCOME EARNED FIGURES AVAILABLE.
      PARTAL(JJ) = 1
      AINCOM(N+1,JJ) = 0
      DO 145 I= 1,N
      AINCOM(N+1,JJ) = AINCOM(N+1,JJ) + AINCOM(I,JJ)
  145 CONTINUE
  144 CONTINUE
C  ALSO READ INCOME TOTALS IF PRESENT (AS INDIC BY 'PARTIN')
      IF( PARTIN.EQ.TOTEXT(1) ) GOTO 811
      IF( PARTIN.EQ.TOTEXT(2) ) GOTO 821
      IF( PARTIN.EQ.TOTEXT(3) ) GOTO 831
```

```
      GOTO 891
C 'MONTHLY TOTALS' OPTION. READ 'N' TOTAL INCOME FIGURES. THEN EXCLUDED SECTOR
  811 READ(R,1710) ( AINCOM(K,7),K=1,N )
      READ(R,1710) ( AINCOM(K,8),K=1,N )
 1710 FORMAT(8I10)
      DO 146 K=1,N
      DO 142 J=7,8
      AINCOM(N+1,J) = AINCOM(N+1,J) + AINCOM(K,J)
  142 CONTINUE
  146 CONTINUE
      GOTO 891
C 'GRAND TOTAL' OPTION. READ TOTAL INCOME FOR ALL SECTORS OVER WHOLE PERIOD
C    AS WELL AS TOTAL INCOME OF EXCLUDED SECTOR (IF AVAILABLE)
  821 READ(R,1700) AINCOM(N+1,7),AINCOM(N+1,8)
C DIVIDE TOTLA EXCLUDED SECTOR INCOME UP INTO S UNLESS ALREADY DOT IT
C    MONTHLY UNDER OPTION 'PARTIAL'.
  149 IF( TOTLIN.EQ.TOTEXT(4) ) GOTO 891
      DO 148 K=1,N
      AINCOM(K,8) = FLOAT( AINCOM(N+1,8) ) / FLOAT(N)
  148 CONTINUE
      GOTO 891
C 'SECTOR TOTALS' OPTION. READ TOTAL INCOME FOR EACH SECTOR + EXCL. SECTOR INC
  831 READ(R,1700) ( AINCOM(N+1,J),J=1,6 ),AINCOM(N+1,8)
      DO 147 J=1,6


      AINCOM(N+1,7) = AINCOM(N+1,7) + AINCOM(N+1,J)
  147 CONTINUE
      GOTO 149
C ADD EXCLUDED SECTOR INCOME TO GET INCOME FOR WHOLE PORTFOLIO AND EQUATE
C    REPAID INCOME (NET) TO PARTIAL INCOME EARNED DATA.
  891 DO 152 I=1,N+1
      AINCOM(I,8) = AINCOM(I,7) + AINCOM(I,8)
      PAIDI(I,7) = AINCOM(I,7)
      PAIDI(I,8) = AINCOM(I,8)
      PAIDI(I,9) = AINCOM(I,9)
  152 CONTINUE
      DO 153 J=1,6
      PAIDI(N+1,J) = AINCOM(N+1,J)
  153 CONTINUE
C  GROSS UP THIS INCOMPLETE INCOME EARNED MATRIX IF REQUIRED (TAX NOT= BLANK)
      IF( TAX.EQ.BLANK ) GOTO 1001
      CALL GROSS(AINCOM,GROSIN,N+1,7)
C IF GOT INCOME TOTALS BY SECTOR, DERIVE TOTAL GROSS INCOME AS TRUE TOTAL.
      IF( TOTLIN.EQ.TOTEXT(3) .OR. PARTIN.EQ.TOTEXT(3) ) GOTO 882
      GOTO 883
  882 GROSIN(N+1,7) = 0
      DO 155 J=1,6
      GROSIN(N+1,7) = GROSIN(N+1,7) + GROSIN(N+1,J)
  158 CONTINUE
  883 DO 157 I=1,N+1
      GROSIN(I,9) = GROSIN(I,7) + GROSIN(I,8)
  157 CONTINUE
      GOTO 881
  901 DO 16 K=1,N
      READ(R,1700) ( AINCOM(K,J),J=1,S ),AINCOM(K,8)
   16 CONTINUE
C HERE INCOME FIGURES EITHER TOTALLY UNKNOWN OR TOTALLY KNOWN. SUM TOTALS
C    AND PLACE ZEROS IN UNUSED SECTORS.
  851 CALL SUMMAT(AINCOM)
C  GROSS UP INCOME EARNED FIGURES IF NECESSARY('TAX'.NE.BLANK).
      IF( TAX.EQ.BLANK ) GOTO 1001
      CALL GROSS(AINCOM,GROSIN,N,S)
      CALL SUMMAT(GROSIN)
      GOTO 841
 1001 DO 135 K=1,N+1
      DO 139 J=1,9
      GROSIN(K,J) = AINCOM(K,J)
  139 CONTINUE
  135 CONTINUE
  881 WRITE(4,4074)
 4074 FORMAT(12HGROSS INCOME)
      DO 136 I=1,N+1
      WRITE(4,4070) I,(GROSIN(I,J),J=1,9 )
  136 CONTINUE
      DO 137 I=1,N+1
      WRITE(4,4070) I, ( AINCOM(I,J),J=1,9 )
  137 CONTINUE
C
      DO 17 K=1,N
      IF( S.GT.5 ) GOTO 1005
      READ(R,2200) ( NMDATE(K,J),J=1,S ),NMAMT(K,1),(DUMMY(J),J=1,S-1 ),
     1  ( DUMMY(J),J=S+6 )
      GOTO 1007
 1005 READ(R,2200) ( NMDATE(K,J),J=1,S),NMAMT(K,1),( DUMMY(J),J=1,S-1 )
 2200 FORMAT(2I2,I4,2X,I10,9F10.0)
 1007 DUMMY(S) = 100.0
C ALLOCATE INDICES INPUT IN FUND'S ORDER OF SECTORS TO THE PROPER (MASTER)CODE
      DO 18 J=1,6
      JJ=SECTR(J)
      NMINDX(K+1,JJ) = DUMMY(J)
C  IF NO DAY'S DATE SPECIFIED, SET INDICES TO AVERAGES FOR THE MONTH. DO
C    SAME EVEN IF NO NEW MONEY IN K TH  MONTH, IN
C    CASE NEW MONEY INTO MAIN FUND, 'NMAMT(K,1)', IS NON-ZERO.   ALSO SET
C    NEW MONEY DATE TO WHOLE OF MONTH FOR SAME REASON.
      IF( NMDATE(K,1).EQ.0 ) NMINDX(K+1,JJ) = INDEX(K+1,JJ)
   18 CONTINUE
      IF( NMDATE(K,1).NE.0 ) GOTO 17
      NMDATE(K,1) = 15
      NMDATE(K,2) = MTHNUM(K)
      NMDATE(K,3) = RFDATE(1,3)
      IF( NMDATE(K,2).LE.RFDATE(1,2) ) NMDATE(K,3) = RFDATE(2,3)
   17 CONTINUE
      WRITE(4,4090) (( NMDATE(I,J),J=1,3 ),NMAMT(I,1),( NMINDX
     1 (I+1,J),J=1,6 ) ),I=1,N )
 4090 FORMAT(1X,9HNEW MONEY,/,12(5X,2I3,I5,5X,I10,6F10.3,/))
      READ(R,2300)  PAIDEX,TEMP1
 2300 FORMAT(2X,A6,8X,A6)
C TEST FOR INPUT VALIDITY
      IF( TEMP1.NE.BLANK ) GOTO 9992
      IF( PAIDEX.EQ.VALPAD(1) ) GOTO 1101
      IF( PAIDEX.EQ.VALPAD(2) ) GOTO 1201


      IF( PAIDEX.EQ.VALPAD(3) ) GOTO 1301
      GOTO 9994
 1101 DO  19 K=1,N
      DO 20 J=1,S
      PAIDI(K,J) = AINCOM(K,J)
   20 CONTINUE
      PAIDI(K,8) = AINCOM(K,8)
   19 CONTINUE
      GOTO 1401
 1201 DO 21 K=1,N
      DO 22 J=1,S
      PAIDI(K,J) = 0
   22 CONTINUE
      PAIDI(K,8) = 0
   21 CONTINUE
      GOTO 1401
 1301 DO 23 K=1,N
      READ(R,1700) ( PAIDI(K,J),J=1,S ),PAIDI(K,8)
   23 CONTINUE
C INSERT NIL VALUES AND SUM MARGINAL TOTALS UNLESS REPAID INCOME ALREADY SET
C    EQUAL TO PARTIAL INCOME EARNED DATA.
 1401 IF( INCHEX.NE.BLANK .AND. TOTLIN.NE.BLANK ) GOTO 1402
      CALL SUMMAT(PAIDI)
 1402 WRITE(4,4100) (I, ( PAIDI(I,J),J=1,9 ),I=1,N+1 )
 4100 FORMAT(1X,13HREPAID INCOME,/,12(1X,I5,5X,9I10,/))
C  IF NECESSARY, CALCULATE TRUE REPAID INCOME INCLUDING THAT TO TAXMAN
C    UNTIL TAX REFUND RECEIVED IN FUTURE AS NEW MONEY.
      IF( TAX.EQ.BLANK ) GOTO 1305
      DO 544 I = 1,N+1
      DO 545 J=1,9
      REPAID(I,J) = GROSIN(I,J) - AINCOM(I,J) + PAIDI(I,J)
  545 CONTINUE
  544 CONTINUE
      GOTO 1306
 1305 DO 541 K=1,N+1
      DO 542 J=1,9
      REPAID(K,J) = PAIDI(K,J)
  542 CONTINUE
  541 CONTINUE
 1306 WRITE(4,4105)
 4105 FORMAT(22HADJUSTED REPAID INCOME)
      DO 543 I=1,N+1
      WRITE(4,4070) I, ( REPAID(I,J),J=1,9 )
  543 CONTINUE
C IDENTIFY 'OSEAS' AS OVERSEAS SECTOR FOR THIS FUND.
      DO 24 J=1,6
      IF( SECTR(J).EQ.4 ) GOTO 1501
   24 CONTINUE
      GOTO 1505
 1501 OSEAS = J
 1505 DO 25 K=1,N
      READ(R,1400) ( NMRATE(K+1,J),J=1,2 ),RTEMP1
C TEST FOR CORRECT INPUT DATA
      IF( RTEMP1.NE.0.0 ) GOTO 9995
C  IF NO NEW MONEY RATES SPECIFIED (EITHER BECAUSE NO NEW MONEY OR NO
C    SPECIFIC DATE GIVEN) SET AVERAGE RATES FOR THIS MONTH IN CASE NEW
      IF( NMRATE(K+1,1).NE.0.0 ) GOTO 25
      NMRATE(K+1,1) = RATE(K+1,1)
      NMRATE(K+1,2) = RATE(K+1,2)
   25 CONTINUE
      WRITE(4,4110)(I, (NMRATE(I+1,J),J=1,2 ), I=1,N )
 4110 FORMAT(1X,33HEXCHANGE RATES AT NEW MONEY DATES,/,12(5X,I5,5X,2F
     1 10.4,/))
```

```
C READ PRINT OPTIONS (IF ANY) AND THEN TEST FOR CORRECT NUMBER OF INPUT CARDS.
      READ(8,2400)  TEMP1,PRINT1,PRINT2,PRINT3,PRINT4,PRINT5,PRINT6,
     1 PRINT7,PRINT8
 2400 FORMAT(A6,1X,I3,8I5)
      WRITE(4,4120) PAIDEX,TEMP1
 4120 FORMAT(1X,7HPAIDEX=,A6,10X,6HTEMP1=,A6)
      IF(  TEMP1.EQ.FNISH ) GOTO 1001
      READ(8,2440) TEMP1
 2440 FORMAT(A6)
      IF( TEMP1.NE.FNISH ) GOTO 9992
C
C HAVE FINISHED INPUT FOR CURRENT FUND. NOW START PROCESSING.
```

FORMATS OF INPUT DATA

The format of both Fund and Market data files may be deduced form the above input sections of the main part of PRFORM2. The exact formats of the history files may be seen in subroutines LOCATE, MDDHST and UPDATE in Appendix 11-VI.

```
C
C THISS ECTION HANDLES ERROR MESSAGES.
C
 9999 WRITE(WO,9050) N
 9050 FORMAT(1X,10(1H*),31HINVALID REVIEW PERIOD LENGTH OF,I10)
      GOTO 10900
 9998 WRITE(WO,9150) ( RPDATE(1,J),J=1,3 ), ( RPDATE(2,J),J=1,3 )
 9150 FORMAT(1X,10(1H*),19HINVALID PERIOD DATES,2I3,I5,3HAND,2I3,I5,1X,
     1  28HARE MORE THAN ONE YEAR APART)
      GOTO 10900
 9997 WRITE(WO,9250) INDEX(K,J),RATE(K,J),K,J
 9250 FORMAT(1X,10(1H*),16HINVALID INPUT OF,F10.3,A1,2HJR,F10.3,10H FOR
     1MONTH,I3,1X,10HAND SECTOR,I3)
      GOTO 10900
 9996 CALL HEAD
      WRITE(WO,9350)
 9350 FORMAT(1X,10(1H*),34HINPUT NUMBER OF SECTORS IS INVALID)
      CALL NXTFND
      GOTO 1559
 9995 CALL HEAD
      WRITE(WO,9450)  S
 9450 FORMAT(1X,10(1H*),55HINPUT INFORMATION DOES NOT AGREE WITH NUMBER
     1OF SECTORS, I3)
      CALL NXTFND
      GOTO 1559
 9994 CALL HEAD
      WRITE(WO,9550)
 9550 FORMAT(1X,10(1H*),66HREPAID INCOME NOT ADEQUATELY INDICATED AS 'AL
     1L', 'SOME', OR 'NONE')
      CALL NXTFND
      GOTO 1559
 9993 CALL HEAD
      WRITE(WO,9900) PATTN
 9900 FORMAT(//,1X,10(1H*),83HSPECIFIED PATTERN OF ACCUMULATION OF PAST
     1RESULTS EXCEEDS CAPACITY OF HISTORY FILE:,/,5X,5I5 )
      CALL NXTFND
      GOTO 1559
 9992 CALL HEAD
      WRITE(WO,9650)
 9650 FORMAT(1X,10(1H*),20HTOO MANY INPUT CARDS)
      CALL NXTFND
      GOTO 1559
 9991 CALL HEAD
      WRITE(WO,9250) NMRATE(K+1,J), NMINDX(K+1,JJ),K,J
      CALL NXTFND
      GOTO 1559
 9989 CALL HEAD
      WRITE(WO,9750) SECTR(S)
 9750 FORMAT(1X,10(1H*),39HLAST SECTOR IS NOT CASH BUT CODE NUMBER,I5)
      CALL NXTFND
      GOTO 1559
 9988 CALL HEAD
      J = APURCH(N+1,9) - APURCH(N+1,S)
      I = AINCOM(N+1,S) - PAIDI(N+1,9)
      WRITE(WO,9850) A,AVALU(1,S), NMANT(N+1,1),J,I,
     1  TEMP1, AVALU(2,S)
 9850 FORMAT(1X,10(1H*),43HFUND DATA APPEARS INCONSISTENT AS FOLLOWS -,/
     1  ,1X,14HINITIAL CASH =,I10,2X,   11HNEW MONEY =,I10, 2X,17HTOTAL P
     2URCHASES =,I10,2X,17HRETAINED INCOME =,I10,5X,/,5X,30H,SO TOTAL F
     3INAL CASH SHOULD B', I10, 2X,3HNOT, I10 )
      CALL ENDPR
      GOTO 1559
 9986 CALL HEAD
      WRITE(WO,10050) OLDHST, PFNUM
10050 FORMAT(1X,10(1H*),17HHISTORY FILE ,A6,16H FOR FUND NUMBER,I10,
     1 74H COULD NOT BE FOUND.  CHECK INPUT AND RESUBMIT SO THAT FILE MA
     2Y BE UPDATED)
      HFLAG = 1
C  PRODUCE REST OF THOSE RESULTS WHICH CAN WITHOUT HISTORY FILE.
      GOTO 2405
 9985 CALL HEAD
      WRITE(WO,11050) JJ,J
11050 FORMAT(1X,10(1H*),26HINVALID SECTOR CODE NUMBER,I10,5HOF SECTOR,
     1      I3)
      CALL NXTFND
      GOTO 1559
 9984 CALL HEAD
      WRITE(WO,12050) J
12050 FORMAT(1X,10(1H*),68HINCONSISTENT DATA CONCERNING COMPLETE PURCHAS
     1E OR SALE OF SECTOR NO.,I2)
      GOTO 1559
 9983 CALL HEAD
      WRITE(WO,13050) INCHDX,INCOPT,TOTLIN
13050 FORMAT(1X,10(1H*),66HCONFLICTING OR UNRECOGNISABLE INCOME OPTION I
     1NFORMATION AS FOLLOWS,/,5X,13HAVAILABILITY=,A6,1X,
     2 23HNOTIONAL INCOME OPTION=,A6,5X,20HPARTIAL DATA OPTION=,A6 )
      CALL NXTFND
      GOTO 1559
C PUT END OF FILE MARKER ON CURRENT HISTORY FILE.
10100 CALL HSTCOF(NEWHST,NEWHST,
C PUT END OF FILE MARKER ON OUTPUT FILE.
      WRITE(W,8114)
 8114 FORMAT(9X,1H0)
10900 STOP
      END
C
C
      SUBROUTINE HEAD
      INTEGER PAGE,WO,R,WH,PH,RPDATE(2,3),PFNAME(7)
      COMMON /G6/ WO,R
      COMMON /G7/ PAGE,PFNAME
      COMMON /G16/ RPDATE
C SUBROUTINE TO PRINT PAGE HEADING
      PAGE = PAGE + 1
      WRITE(WO,1000) ( PFNAME(J),J=1,7 ),((RPDATE(I,J),J=1,3),I=1,2 ),
     1     PAGE
 1000 FORMAT(1H1,//,7X,22HPERFORMANCE REPORT FOR,1X,7A6,1X,11HOVER PERIO
     1D:    1X,2I3,I5,2X,2HTO,1X,2I3,I5,7X,4HPAGE,I3,//)
      RETURN
      END
C
C
      SUBROUTINE NXTFND
      INTEGER R,THING,FNISH,WO,PH,WH,END
      COMMON /G6/ WO,R
      DATA FNISH,END/ 6HFINISH,6HEND   /
C
C SUBROUTINE TO READ REST OF CARDS IN A FUNDS INPUT DECK UNTIL REACH THE NEXT
C       'FINISH' CARD, WHEN AM READY TO START A NEW FUND.
C
      CALL ENDPR
  100 READ(R,1300) THING
 1300 FORMAT(A6)
      IF( THING.EQ.FNISH ) GOTO 200
      IF( THING.EQ.END ) GOTO 301
      GOTO 100
  200 RETURN
  301 STOP
      END
```

ERROR MESSAGES

```
C
C
      SUBROUTINE ENDPR
      INTEGER WO,R,PFNAME(7),PAGE
      COMMON /G6/ WO,R
      COMMON /G7/ PAGE,PFNAME
C
C PRINTS INDICATION OF END OF REPORT FOR CURRENT FUND
C
      WRITE(WO,8850) PFNAME
 8850 FORMAT(/////,1X,37(1H*),3X,16HEND OF REPORT FOR ,7A6,1X,36(1H*))
      RETURN
      END
```

Upon an error fatal to the continued analysis of a fund, HEAD prints a heading to identify the fund, after which the error message is printed. ENDPR then "rules off" the page and NXTFND moves the input file to the beginning of the data for the next fund (if any).

COMPUTER ROUTINES TO DO DATA MODIFICATION

Shown below is the calling routine in the main part of PRFORM to do the data modification for both market and fund. Following are the subroutines involved.

Market :

```
C
C SET UP DATA NEEDED BY ALL FUNDS ANALYSED.
C
      DO 7 J=1,7
      PENCH(1,J) = RPDATE(1,J)
      PENCH(7,J) = RPDATE(2,J)
    7 CONTINUE
      PENVAL(1) = PRMPEN(1)
      PENVAL(7) = PRMPEN(N+2)
      WRITE(4,5000) PENVAL(1),PENVAL(7)
 5000 FORMAT(1X,8HPENVALUES,/,5X,2F10.3)
C  FOR EACH MONTH ......
      DO 8 K = 1,N
      IF( MTHNUM(K).EQ.PENCH(NN,1) ) GOTO 401
C   NO CHANGE IN THIS MONTH, SO SET PENALTY TO LAST KNOWN NEW VALUE.
      PRMPEN(K+1) = PENVAL(NN-1)
      GOTO 8
C   SET PENALTY FOR THIS MONTH AS TIME-WEIGHTED AVERAGE OF OLD AND NEW VALUES.
  401 TEMP1 = DAYNUM(K) - PENCH(NN,1) + 1
      WAIT = FLOAT( TEMP1 ) / FLOAT( DAYNUM(K) )
C   *WAIT IS FRACTION OF MONTH IN WHICH NEW PENALTY WAS REIGNING.
      PRMPEN(K+1) = WAIT*PENVAL(NN) + (1.0 - WAIT)*PENVAL(NN-1)
C   INCREMENT POINTER TO NEXT CHANGE
      NN = NN + 1
    8 CONTINUE
C SET PARAMETERS FOR EACH MONTH. FIRST INDICES FOR BEGINNING AND ENDING DATES.
      WRITE(4,3080)(PRMPEN(J),J=1,N+2 )
 3080 FORMAT(1X,16HPENALTY BY MONTH,/,5X,12F10.3)
C CALCULATE PENALISED SELLING RATE FOR SALES OF OVERSEAS INVESTMENTS.
      CALL EXCHNG(RATE,PRMPEN)
      WRITE(4,3090) ( I, ( RATE(I,J),J=1,3 ), I=1,N+2 )
 3090 FORMAT(1X,22HPENALISED EXCH RATES,/,14(5X,I10,5X,3F10.3,/))
C FOR EACH MONTH IN REVIEW PERIOD......
      DO 11 K=1,N
C ACCUMULATE TOTAL NUMBER OF DAYS IN REVIEW PERIOD .
      MNTH = MTHNUM(K)
      PDDAYS = PDDAYS + DAYNUM(MNTH)
   11 CONTINUE
C  PRE-DIVIDE INITIAL OVERSEAS INDEX VALUE BY INITIAL PENALISED EXCHANGE RATE.
      INDEX(1,4) = INDEX(1,4) / RATE(1,3)
      WRITE(4,3100) PDDAYS
 3100 FORMAT(1X,23HTOTAL NO. OF DAYS IN PERIOD=,I10)
      WRITE(4,3020) ( I,( INDEX(I,J),J=1,6 ), I=1,N+2 )
C   FOR THOSE SECTORS WHOSE MONTHLY INCOME IS EXPRESSED AS YIELDS (GIVEN
C       BY VECTOR 'YIELD'), CONVERT TO INDICES.
      DO 165 J=1,6
      JJ = YIELD(J)
      IF( JJ.EQ.0   GOTO 167
      CALL INDVLD(NINDCX,INDEX,JJ)
  165 CONTINUE
  167 WRITE(4,3030) ( MTHNUM(I),( NINDCX(I,J),J=1,6 ),I=1,N )
C  SET UP BEGINNING AND ENDING DATE INFORMATION.
      DO170 J = 1,5
      NMINDX(1,J) = INDEX(1,J)
      NMINDX(N+2,J) = INDEX(N+2,J)
      PROPNS(1,J) = MODEL(J)
  170 CONTINUE
      DO 12 J = 1,3
      NMRATE(1,J) = RATE(1,J)
      NMRATE(N+2,J) = RATE(N+2,J)
   12 CONTINUE
```

Fund :

```
C
C DO INPUT VALIDITY CHECKS
 3001 IF( OSEAS.GT.5 ) GOTO 2001
      WRITE(4,7003) OSEAS
 7003 FORMAT(5X,6HOSEAS=,I10)
      DO 28 K=1,N+1
      DO 29 J=1,5
      IF( NMRATE(K+1,J).LT.0.005 ) GOTO 9991
   29 CONTINUE
   28 CONTINUE
 2001 DO 30 K=1,N+1

      DO 31 J=1,6
      JJ= SECTOR(J)
      IF( NMINDX(K+1,JJ).LT.0.005 ) GOTO 9991
   31 CONTINUE
   30 CONTINUE
      WRITE(4,7005)
 7005 FORMAT(5X,19HINPUT VALIDITY O.K.)
      IF( SECTOR(5).NE.0 ) GOTO 9989
C
C PRELIMINARY CALCULATIONS BEFORE ANALYSIS.
C
      MFSIZE(1) = 0.0
      AVALU(1,S+1) = 0
      AVALU(2,S+1) = 0
      MSTMSG=0
      NMAMT(N+1,1) = 0
      NMAMT(N+1,2) = 0
C FOR EACH MONTH DURING THE REVIEW PERIOD.....
      DO 32 K=1,N
C FIND MAIN FUND NEW MONEY
      NMAMT(K,2) = NMAMT(K,1) - APURCH(K,8)
C FIND WEIGHT FOR NEW MONEY FLOW THIS MONTH
      IF( NMAMT(K,2).EQ.0 ) GOTO 2201
      MNTH = MTHNUM(K,2)
      WRITE(4,7007) K,MNTH
 7007 FORMAT(5X,8HK, MNTH=,2I10)
      DO 33 I=1,2
      DATE(I,2) = MNTH
      DATE(I,1) = NMDATE(K,3)
   33 CONTINUE
      DATE(1,1) = 1
      DATE(2,1) = NMDATE(K,1)
      INTVAL = DAYNUM(MNTH)
      CALL DAYPT( DATE,INTVAL,WAIT)
      WEIGHT(K) = WAIT
      GOTO 2101
 2201 WEIGHT(K) = 0.0
C  CALCULATE INCREASE IN CASH BALANCE FOR THIS MONTH
 2101 TEMP1 = 0
      DO 34 J=1,S-1
      TEMP1 = TEMP1 + APURCH(K,J)
   34 CONTINUE
      APURCH(K,S) = NMAMT(K,2) - TEMP1
C SUM UP NEW MONEY
      NMAMT(N+1,1) = NMAMT(N+1,1) + NMAMT(K,1)
      NMAMT(N+1,2) = NMAMT(N+1,2) + NMAMT(K,2)
   32 CONTINUE
C  INSERT NEW VALUES IN UNUSED SECTORS AND SUM TOTALS OF PURCHASES.
      CALL SUMMAT(APURCH)
      WRITE(4,7071)
 4071 FORMAT(5X,9HPURCHASES)
      DO 131 K = 1,N+1
      WRITE(4,7070) K,( APURCH(K,J),J=1,9 )
  131 CONTINUE
C CALCULATE PENALISED SELLING RATE ON NEW MONEY DATES.
      CALL EXCHNG(NMRATE,PRMPEN)
      DO 154 J=1,S
C SUM TOTAL VALUES OF BEGINNING AND END PORTFOLIOS
      AVALU(1,S+1) = AVALU(1,S+1) + AVALU(1,J)
      AVALU(2,S+1) = AVALU(2,S+1) + AVALU(2,J)
C INITIALISE AVERAGE NEW MONEY STORE
      AVNM(J) = 0.0
      AVPAID(J) = 0.0
C  IDENTIFY THE SIZE OF EACH SECTOR AS 'LIVE' AND MONTHS OF PURCHASE
C    AND COMPLETE SALE AS 'SECTEX(1,J),SECTEX(2,J)'
      IF( AVALU(1,J).EQ.0.0 ) GOTO 2105
      IF( AVALU(2,J).EQ.0.0 ) GOTO 2110
C SECTOR EXISTED FOR WHOLE REVIEW PERIOD
      GOTO 154
C HERE A SECTOR WAS BOUGHT FOR 1ST TIME. SET 'SECTEX(1,J)' TO NO. OF
C    THE MONTH IN WHICH 1ST PURCHASE MADE.
 2105 DO 64 K=1,N
      IF( APURCH(K,J).NE.0 ) GOTO 2115
   64 CONTINUE
      GOTO 9984
```

```
 2115 SECTEX(1,J) = K
C  IF SECTOR ALSO SOLD DURING PERIOD, FIND WHEN SOLD
      IF( AVALU(2,J).EQ.0 ) GOTO 2110
      LIFE(J) = FLOAT( N - SECTEX(1,J) ) + 0.5
      GOTO 154
C HERE A SECTOR HAS SOLD.  SET 'SECTEX(2,J)' TO NO. OF MONTH IN WHICH
C  FINAL SALE MADE.
 2110 DO 65 K=1,N
      TEMP1 = N+1-K
      IF( APURCH(TEMP1,J).NE.0 ) GOTO 2120
   65 CONTINUE


      GOTO 9984
 2120 SECTEX(2,J) = TEMP1
      LIFE(J) = FLOAT( SECTEX(2,J) ) - 0.5
      IF( AVALU(1,J).EQ.0 ) LIFE(J) = FLOAT(SECTEX(2,J)-SECTEX(1,J))
  154 CONTINUE
      WRITE(4,1006) ( (SECTEX(I,J),J=1,6),I=1,2 )
 1006 FORMAT(1H0MONTHS OF PURCHASES,6I5./,15HMONTHS OF SALES,6I5)
      LIFE(7) = FLOAT(N)
      AVPM(S+1) = 0.0
      AVPAID(S+1) = 0.0
      TOTVAL = FLOAT( AVALU(1,S+1) )
C CALCULATE SECTOR PROPORTIONS OF INITIAL AND FINAL FUNDS.
      DO 36 I=3,4
      RTEMP1 = FLOAT( AVALU(I-2,S+1) )
      DO 37 J=1,S
      PROPNS(I,J) = FLOAT( AVALU(I-2,J) ) / RTEMP1
   37 CONTINUE
   36 CONTINUE
C SET REMAINING SECTORS' ACTUAL PROPORTIONS TO ZERO.
      IF( S.GT.5 ) GOTO 2301
      DO 155 J=S+1,6
      PROPNS(4,J) = 0.0
      PROPNS(3,J) = 0.0
  155 CONTINUE
C DO VALIDITY CHECK ON FUND DATA ON BASIS OF RECONCILIATION ON CASH ACCOUNT.
C RECONCILIATION IS NOT POSSIBLE IF REPAID INCOME FIGURES ARE AVAILABLE BUT
C     INCOME EARNED FIGURES ARE NOT.
 2301 IF( INCHEX.NE.BLANK .AND. PAIDEX.NE.VALPAD(1) ) GOTO 2404
      TEMP1= AVALU(1,S) + NHAMT(N+1,1) + AINCOM(N+1,9) -
     1 PAIDI(N+1,9) - ( APURCH(N+1,9) - APURCH(N+1,S) )
      TEMP2 = TEMP1 - AVALU(2,S)
      IF(IABS(TEMP2).GT.500 ) GOTO 9988
C
C
      SUBROUTINE EXCHNG(RATE,PRMPEN)
      COMMON N,S
      REAL RATE(14,3),PRMPEN(14)
      INTEGER N,K,S
C SUBROUTINE TO COMPUTE FOR EACH MONTH THE PENALISED SELLING EXCHANGE
C      RATE (3RD COL) GIVEN THE PREMIUM (1ST COL) AND ORDINARY (2ND COL)
C      RATES.
      DO 1 K = 1,N+2
      RATE(K,3) = 1.0 / ( PRMPEN(K) / RATE(K,2)  +  11.0 -
     1  PRMPEN(K)) / RATE(K,1)  )
    1 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE PERIOD(DATES,DAYS)
      INTEGER PRD(12),PATTN(9),DAYNUM(12),DATES(2,3),MNTH,K,MAXY1,MAXY2,
     1   DAYS,MTHNUM(12),DAYS1
      COMMON /G4/ PATTN,DAYNUM,MTHNUM
C SUBROUTINE TO CALCULATE THE EXACT NUMBER OF DAYS BETWEEN TWO DATES (INCLUS
      DAYS1= 0
      WRITE(4,1000) ( ( DATES(I,J),J=1,3 ),I=1,2 )
 1000 FORMAT(1H0PERIOD BETWEEN,2I3,I5,4H AND,2I3,I5,3H IS)
C CHECK IF BOTH DATES ARE WITHIN THE ONE YEAR.
      IF( DATES(2,3).GT.DATES(1,3) ) GOTO 101
C COMPUTE NUMBER OF MONTHS BETWEEN DATES (INCLUSIVE) AND COUNT UP THEIR DAYS.
      MAXY1 = DATES(2,2) - DATES(1,2) + 1
      WRITE(4,1010) MAXY1
 1010 FORMAT(7H(MAXY1=,I10,1H))
      IF( MAXY1.LT.1 ) GOTO 201
      DO 1 K=2,MAXY1+1
      MNTH = MTHNUM(K)
      DAYS1= DAYS1+ DAYNUM(MNTH)
    1 CONTINUE
      GOTO 201
C DO AS ABOVE BUT IN TWO STAGES TO BRIDGE THE YEARS . .
  101 MAXY1 = 12 - DATES(1,2)
      DO 2 K=2,MAXY1+1
      MNTH = MTHNUM(K)
      DAYS1= DAYS1+ DAYNUM(MNTH)
    2 CONTINUE
      MAXY2 = DATES(2,2) - 1
      IF( MAXY2.LT.1 ) GOTO 201
      DO 3 K=1,MAXY2
      MNTH = MTHNUM(MAXY1+K)
      DAYS1= DAYS1+ DAYNUM(MNTH)
    3 CONTINUE
C ADD DAYS IN ENDING MONTH, SUBTRACT THOSE OF BEGINNING MONTH AND ADD
C       ONE TO ALLOW FOR INCLUSIVENESSS.
  201 MNTH = DATES(1,2)
      DAYS1 = DAYS1 + DAYNUM(MNTH) - DATES(1,1) + DATES(2,1) + 1
      IF( DATES(1,2).EQ.DATES(2,2) ) DAYS1 = DAYS1 - DAYNUM(MNTH)
      WRITE(4,1020) DAYS1
      END
```

```
C
C
      SUBROUTINE SUMMAT(TABLE)
      INTEGER N,S,I,J,TABLE(13,9)
      COMMON N,S
C SUBROUTINE TO FIND MARGINAL TOTALS OF A MATRIX  AFTER PLACING ZEROS IN NON-
C     INVESTED SECTORS
      IF( S.GE.5 ) GOTO 100
      DO 5 I=1,N+1
      DO 6 J=S+1,6
      TABLE(I,J) = 0
    6 CONTINUE
    5 CONTINUE
C FOR EACH ROW, ADD FIRST 6 COLUMNS,PUT TOTAL IN 7TH
  100 DO 1 I=1,N
      TABLE(I,7) = 0
      DO 2 J=1,S
      TABLE(I,7) = TABLE(I,7) + TABLE(I,J)
    2 CONTINUE
C ADD IN (8)TH COLUMNAND PUT TOTAL IN (9)TH COLUMN.
      TABLE(I,9) = TABLE(I,7) + TABLE(I,8)
    1 CONTINUE
C FIND COLUMN TOTALS.
      DO 3 J=1,9
      TABLE(N+1,J) = 0
      DO 4 I=1,N
      TABLE(N+1,J) =-TABLE(N+1,J) + TABLE(I,J)
    4 CONTINUE
    3 CONTINUE
      RETURN
      END
C
C
C
      SUBROUTINE DAYWT(DATE,INTVAL,WAIT)
      REAL WAIT
      INTEGER DATE(2,3),DAYS,INTVAL
C SUBROUTINE TO COMPUTE THE WEIGHT RELATIVE TO A PERIOD OF 'INTVAL'
C       DAYS APPROPRIATE TO AN EVENT OCCURING ON DATE 'DATE(2,1-3)'
C
C       RELATIVE TO BASE DATE 'DATE(1,1-3)'.  CALCULATE TIME BETWEEN
C       EVENT AND BASE DATE AS 'DAYS'.
      CALL PERIOD(DATE,DAYS)
C CALCULATE WEIGHT
      WAIT = FLOAT(INTVAL-DAYS) / FLOAT(INTVAL)
      RETURN
      END
C
C
      SUBROUTINE INCYLD(NINCDX,INDEX,JJ)
      REAL NINCDX(12,6),INDEX(14,6)
      INTEGER K,N,JJ,S
      COMMON N,S
C
C  CALCULATES THE INCOME PER 100 INDEX UNITS OF JJ TH   SECTOR GIVEN
C       THE AVERAGE YIELDS INPUT INTO JJ TH    COLUMN OF 'NINCDX'.
C
      DO 1 K= 1,N
      NINCDX(K,JJ) = NINCDX(K,JJ)  * INDEX(K+1,JJ) / 1200.0
    1 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE GROSS( AINCOM,GROSIN ,ROW,COL )
      REAL INCTAX(8)
      INTEGER AINCOM(13,9),N,S,GROSIN(13,9),I,J,SECTR(6),
     1 ROW,COL,NCOL
      COMMON N,S
      COMMON /G12/ SECTR
      DATA INCTAX / 5*0.35,0.0,0.35,0.0 /
C
C  GROSSES UP AFTER-TAX EARNED INCOME ACCORDING TO TAX RATES IN 'INCTAX'.
C    CALLED IF NOT ALL INCOME IS GROSS IN EVERY SECTOR.
C
      NCOL = COL
      IF( COL.GT.6 ) NCOL = 6
      DO 1 I =1,ROW
      DO 2 J=1,NCOL
      GROSIN(I,J) = FLOAT( AINCOM(I,J) )/( 1.0 - INCTAX(SECTR(J)) )
    2 CONTINUE
      IF( COL.GT.6 ) GROSIN(I,7) = FLOAT( AINCOM(I,7) ) /(1.0-INCTAX(7))
      GROSIN(I,8) = FLOAT( AINCOM(I,8) )/( 1.0 - INCTAX(8) )
    1 CONTINUE
      RETURN
      END
```

(See text on last page)

```
C FOR EACH SIMULATED INVESTMENT POLICY...
 2406 DO 40 II=1,5
      WRITE(4,1009) II
 1009 FORMAT(//,14HSIMULATION NO.,I5,/,19(1H-) )
C  SET 'M' TO ACT AS POINTER TO APPROPRIATE SECTOR PROPORTIONS.
      M=II
      IF( II.GT.2) M=3
C  CHARGE NOTIONAL FUND WITH SIMULATED TRADING EXPENSES OF REALIGNMENT
C     FROM LAST PERIOD'S ENDING PROFILE TO CURRENTLY SPECIFIED PROFILE.
C     UNLESS NOTIONAL FUND IS WITHOUT NEW MONEY (II=5) OR HAVE NO INFORMATION
C     ON PAST PROFILE, DUE TO LACK OF A HISTORY FILE.
      IF( HIST_X.NE.BLANK ) GOTO 2407
      IF( HFLAG.EQ.1 ) GOTO 2407
      IF( II.EQ.5 ) GOTO 2407
      CALL CHARGE(II,M,TOTVAL,TRCST4)
      INITVL = TOTVAL - TRCST4
      IF( II.EQ.3 ) TRCST3 = TRCST4
      GOTO 2409
 2407 INITVL = TOTVAL
C IF THERE IS NO POLICY FUND, DO NOT SIMULATE.
 2409 IF( II.NE.2 ) GOTO 2501
      IF( POLEX.NE.BLANK ) GOTO  2902
 2501 FVALU(II,7) = 0.0
      NINCOM(II,7) = 0.0
      DO 33 J=1,7
      CUMINC(J) = 0.0
   33 CONTINUE
      WRITE(4,1060) M,INITVL,( ( PROPNS(I,J),J=1,6 ),I=1,4 )
 1060 FORMAT(9HM,INITVL=,I5,F12.2,5X,19HSECTOR PROPORTIONS,/,
     1 4(5X,6F10.2,/) )
C  DO INVESTMENT SIMULATION VIA S/R 'SIMUL'.  IF NOTIONAL INCOME OPTION
C     SPECIFIED, USE SIMULATED NOTIONAL INCOME 'SIMINC' AS INCOME EARNED
C     AND INCOME REPAID.
      IF( INCOPT.EQ.BLANK ) GOTO 2701


      CALL SIMUL(II,M,INITVL,SIMINC,SIMINC,0)
      GOTO 2901
 2701 CALL SIMUL(II,M,INITVL,GROSIN,REPAID,0)
      GOTO 2901
C NOW THAT HAVE DONE SIMULATION FOR ALL MONTHS, FIND FINAL VALUE OF PORTFOLI
 2902 DO 50 J=1,7
      FVALU(2,J) = FVALU(1,J)
      NINCOM(2,J) = NINCOM(1,J)
   50 CONTINUE
      GOTO 408
C FOR EACH SECTOR, NOTE NOTIONAL INCOME AND VALUE TOTAL INDEX UNITS
C     HELD AT FINAL INDEX PRICE.  FOR SIMULATION OF TYPE4, VALUE AT AVERAGE
C     INDEX AT MONTH OF SALE IF SALL SECTOR WAS SOLD DURING THAT PERIOD.
 2901 DO 49 J=1,6
      JJ = SECTR(J)
      NINCOM(II,J) = CUMINC(J)
      IF( II.NE.4 ) GOTO 2905
      IF( SECTEX(2,J).EQ.N ) GOTO 2905
      FVALU(II,J) = VALUNT(J) * INDEX( SECTEX(2,J)+JJ )
      IF( JJ.EQ.4 ) FVALU(II,J) = FVALU(II,J) /
     1  RATE( SECTEX(2,J)+1,3 )
      GOTO 2906
 2905 FVALU(II,J) = VALUNT(J) * INDEX(N+2,JJ)
      IF( JJ.EQ.4 ) FVALU(II,J) = FVALU(II,J) / RATE(N+2,3)
 2906 FVALU(II,7) = FVALU(II,7) + FVALU(II,J)
      NINCOM(II,7) = NINCOM(II,7) + CUMINC(J)
   49 CONTINUE
  408 WRITE(4,1040) ( FVALU(II,J),J=1,7)
 1040 FORMAT(22HRETURN_D - FINAL VALUE,/,6F13.2,/,6HTOTAL=,F15.2)
      WRITE(4,1050) ( NINCOM(II,J),J=1,7)
 1050 FORMAT(21HTOTAL NOTIONAL INCOME,/,5X,6F10.3,/,5X,F10.3)
C  NOTE FINAL PROFILE OF NOTIONAL FUND FOR HISTORY FILE.
      IF( II.EQ.5 ) GOTO 40
      DO 595 J=1,6
      FINALP(II,J) = FVALU(II,J) / FVALU(II,7)
  595 CONTINUE
   40 CONTINUE
C
C CALCULATE COMPONENTS OF PERFORMANCE, FOR BOTH TOTAL GAIN AND INCOME.
C
C FOR EACH SECTOR PLUS WHOLE MAIN FUND,COMPUTE COMPONENT.
      DO 51 J=1,7
      IF( J.GT.5 ) GOTO 2903
      RTEMP1 = FLOAT( AVALU(2,J) )
      GOTO 2904
 2903 RTEMP1 = 0.0
      IF( J.EQ.7 ) RTEMP1 = FLOAT( AVALU(2,S+1) )
 2904 PROFIT(1,J) = RTEMP1 - FVALU(1,J)
      SCYSEL(1,J) = RTEMP1 - FVALU(2,J)
      SUSTRT(1,J) = FVALU(2,J) - FVALU(3,J)
      INSTRT(1,J) = FVALU(3,J) - FVALU(2,J)
      POLICY(1,J) = FVALU(2,J) - FVALU(1,J)
   51 CONTINUE
C COMPUTE MEAN SIZE OF MAIN FUND
      DO 52 J=1,3
      DATE(1,J) = RPDATE(1,J)
   52 CONTINUE
      WRITE(4,2000) ( DATE(1,J),J=1,3 )
 2000 FORMAT(15HBEGINNING DATE=,2I3,I5)
C FOR EACH MONTH IN REVIEW PERIOD.....
      RTEMP1 = FLOAT(N)
      DO 53 K=1,N
      WRITE(4,2010) K
 2010 FORMAT(/,5HMONTH,I3,/,9(1H-))
      IF( NMANT(K,2).EQ.0 ) GOTO 3001
      DO 54 J=1,3
      DATE(2,J) = NMDATE(K,J)
   54 CONTINUE
      WRITE(4,2020) ( DATE(2,J),J=1,3)
 2020 FORMAT(/,35HWEIGHT CALCULATED ON BASIS OF DATE,2I3,I5)
      CALL DAYWT(DATE,PDDAYS,WAIT)
      NMWGHT(K) = WAIT
      WRITE(4,2030) NMWGHT(K)
      GOTO 3101
 3001 NMWGHT(K) = 0.0
      WRITE(4,2030) NMWGHT(K)
 2030 FORMAT(7HWEIGHT=,F10.4)
 3101 AVNM(S+1) = AVNM(S+1) + FLOAT( NMANT(K,2) )*NMWGHT(K)
      WRITE(4,2040) AVNM(S+1)
 2040 FORMAT(33HAV. NEW MONEY ACCUMULATED SO FAR=,F14.1)
   53 CONTINUE
C  IF INCOME EARNED FIGURES UNAVAILABLE, USE SIMULATED INCOME TO CALCULATE
C     AVERAGE REPAID INCOME.
      IF( INCMEX.EQ.BLANK ) CALL AVFLOW(REPAID,7,AVPAID(S+1) )
      IF( INCMEX.NE.BLANK ) CALL AVFLOW( SIMINC,7,AVPAID(S+1) )
      MFSIZE(1) = TOTVAL + AVNM(S+1) - AVPAID(S+1)

C CALCULATE COMPONENTS AS PERCENTAGES.
      MFSIZE(2) = MFSIZE(1) / 100.0
      WRITE(4,2050) MFSIZE(1),MFSIZE(2)
 2050 FORMAT(/,19HMEAN FUND SIZE=,F14.1,19H AND AS PERCENTAGE=,F10.3)
      DO 55 J=1,7
      PROFIT(2,J) = PROFIT(1,J) / MFSIZE(2)
      SCYSEL(2,J) = SCYSEL(1,J) / MFSIZE(2)
      SUSTRT(2,J) = SUSTRT(1,J) / MFSIZE(2)
      INSTRT(2,J) = INSTRT(1,J) / MFSIZE(2)
      POLICY(2,J) = POLICY(1,J) / MFSIZE(2)
C SUM COMPONENTS TO GET STRATEGY,SECTOR SELECTION COMPONENTS.
      DO 56 I=1,2
      STRAT(I,J) = SUSTRT(I,J) + INSTRT(I,J)
      SCTSEL(I,J) = STRAT(I,J) + POLICY(I,J)
   56 CONTINUE
   55 CONTINUE
C IF EARNED INCOME FIGURES ARE AVAILABLE AND WANTED, CALCULATE INCOME PERFORMANC
C        COMPONENTS USING GROSS INCOME FIGURES.
      IF( INCMEX.EQ.BLANK .AND. PRINTX.EQ.0 ) GOTO 3202
      IF( TOTLIN.EQ.TOTEXT(3). OR. PARTIN.EQ.TOTEXT(3) ) GOTO 3202
      GOTO 3201
C FIND TOTAL OF INCOME FROM SOURCES OTHER THAN EQUITIES OR GILTS.
 3202 TEMP1 = 0
      DO 57 J=1,6
      IF( SECTR(J).LT.3 ) GOTO 57
      DO 58 I=1,4
      SUMINC(I) = SUMINC(I) + NINCOM(I,J)
   58 CONTINUE
      TEMP1 = TEMP1 + GROSIN(N+1,J)
   57 CONTINUE
C *TEMP1* STORES TOTAL ACTUAL GROSS INCOME FROM ALLLSECTORS OTHER THAN EQUITIES
C        OR GILTS.        NOW COMPUTE COMPONENTS.
      JJ = 0
      DO 59 J = 1,6
      IF( SECTR(J).GT.2 )GOTO 59
      JJ = JJ+1
      RTEMP1 = FLOAT( GROSIN(N+1,J) )
      IPROFT(JJ) =(RTEMP1 - NINCOM(1,J) ) / MFSIZE(2)
      ISCYSL(JJ) =(RTEMP1 - NINCOM(4,J) ) / MFSIZE(2)
      ISTRGY(JJ) = ( NINCOM(4,J) - NINCOM(2,J) ) / MFSIZE(2)
      IPOLCY(JJ) = ( NINCOM(2,J) - NINCOM(1,J) ) / MFSIZE(2)
      ISCTSL(JJ) = ISTRGY(JJ) + IPOLCY(JJ)
   59 CONTINUE
      RTEMP1 = FLOAT(TEMP1)
      IPROFT(3) = ( RTEMP1 - SUMINC(1) ) / MFSIZE(2)
      ISCYSL(3) = (RTEMP1 - SUMINC(4) ) / MFSIZE(2)
      ISTRGY(3) = ( SUMINC(4) - SUMINC(2) ) / MFSIZE(2)
      IPOLCY(3) = ( SUMINC(2) - SUMINC(1) ) / MFSIZE(2)
      ISCTSL(3) = ISTRGY(3) + IPOLCY(3)
      RTEMP1 = FLOAT( GROSIN(N+1,7) )
      IPROFT(4) = ( RTEMP1 - NINCOM(1,7) ) / MFSIZE(2)
      ISCYSL(4) = (RTEMP1 - NINCOM(4,7) ) / MFSIZE(2)
      ISTRGY(4) = ( NINCOM(4,7) - NINCOM(2,7) ) / MFSIZE(2)
      IPOLCY(4) = ( NINCOM(2,7) - NINCOM(1,7) ) / MFSIZE(2)
      ISCTSL(4) = ISTRGY(4) + IPOLCY(4)
```

```
C
C
      SUBROUTINE SIMUL(II,N,INITVL,GROSIN,REPAID,FLAG)
      REAL VALU(6),PRMPEN(14),OSRATE(3),NINDOX(12,6),NM(6),VALUNT(6),
     1 CUMINC(7),NMRAT(14,3),NMINDX(14,6),RATE(14,3),INDEX(14,6),
     2 AVWGHT(12),WEIGHT(12),ZEWGHT(12),RPONM,INITVL,PROPNS(14,6)
      INTEGER N,S,REPAID(13,9),II,OSEAS,APURCH(13,9),POINT,K,
     1 NMAMT(13,2),SECTR(6),M,FLAG,SIMINC(13,9),BLANK,
     2 GROSIN(13,9)
      COMMON N,S
      COMMON /G1/ NINDOX,SIMINC,BLANK,K,
     1   NM,VALUNT,CUMINC
      COMMON /G2/ INDEX
      COMMON /G5/ PRMPEN,OSEAS,OSRATE
      COMMON /G12/ SECTR
      COMMON /G15/ APURCH
      COMMON /G23/ PROPNS
      COMMON /G36/ NMAMT,NMRATE,NMINDX,WEIGHT
      COMMON /G37/ RATE
      DATA AVWGHT,ZEWGHT / 12*0.5,12*0.0 /
C
C FOR EACH OF 'N' MONTHS, SETS UP PARAMETERS FOR SIMULATION OF INVESTMENT
C   POLICY TYPE 'II' VIA S/R 'INVEST'.  EXCHANGE RATES FOR INVESTMENT OF
C   NEW MONEY = 'OSRATE', NEW MONEY = 'NM' FOR A PARTICULAR MONTH.
C 'SIMUL' RETURNS TOTAL NO. OF INDEX UNITS 'VALUNT' ACCUMULATED OVER 'N'
C   MONTHS AND TOTAL NOTIONAL INCOME 'CUMINC'.
C INPUT PARAMETERS ARE BEGINNING TOTAL MARKET VALUE 'INITVL' NET OF ANY
C   TRADING EXPENSES OF PROFILE ADJUSTMENT / SIMULATION TYPE 'II' /
C   GROSS INCOME EARNED 'GROSIN' / GROSS INCOME REPAID 'REPAID' / 'M' =
C   WHICH SET OF PROPORTIONS APPLICABLE TO THIS SIMULATION / 'FLAG' TO STOP
C   SIMULATION BEFORE REINVESTMENT OF EXCESS INCOME IF ONLY WANT NOTIONAL
C   INCOME.
C
      DO 41 J=1,6
      VALU(J) = INITVL * PROPNS(M,J)
      JJ = SECTR(J)
(3)   VALUNT(J) = VALU(J) / INDEX(1,JJ)
   41 CONTINUE
      WRITE(4,1010) M,( PROPNS(M,J),J=1,6 ),VALUNT
 1010 FORMAT(23HPROPORTIONS CASED ON M=,I5,/,5X,6F10.4,/,
     1 23HINDEX UNITS PURCHASED,/,5X,6F10.3)
C FOR EACH MONTH IN REVIEW PERIOD.....
      DO 42 K=1,N
      WRITE(4,1030) K
 1030 FORMAT(/,5HMONTH,I5)
C DETERMINE PARAMETERS FOR THIS MONTH
C  DEPENDING ON PARTICULAR INVESTMENT STRATEGY, SET NEW MONEY FOR THIS MONTH
      IF( II.GT.3 ) GOTO 2701
C FOR MODEL,POLICY AND INITIAL STRATEGIES, ALLOCATE NEW MONEY AFTER
C   SUBTRACTING REPAID ACTUAL INCOME OF SECTORS UNREPRESENTED
C   BY CURRENT NOTIONAL POLICY/STRATEGY.  USE NEW MONEY DATES.
C   ACCUMULATE ALL REPAID INCOME OF UNREPRESENTED SECTORS IN 'RPONM'. (IF NO
C   INCOME OPTION SPECIFIED, REPAID INCOME WILL BE SIMULATED NOTIONAL INC)
      RPONM = 0.0
      DO 43 J=1,6
      IF( VALUNT(J).GT.0.001 ) GOTO 43
(4)   RPONM = RPONM + FLOAT( REPAID(K,J) )
   43 CONTINUE
      WRITE(4,1035) NMAMT(K,2),RPONM
 1035 FORMAT(10HNEW MONEY=,I10,
     1 /,5X,41HREPAID INCOME FROM UNREPRESENTED SECTORS=,F14.2)
(5)   RTEMP1 = FLOAT( NMAMT(K,2) ) - RPONM
      WRITE(4,1037) RTEMP1
 1037 FORMAT(20HTOTAL NEW MONEY DISTRIBUTED=,F14.2)
      DO 44 J=1,6
      NM(J) = RTEMP1 * PROPNS(M,J)
   44 CONTINUE
      DO 45 J=1,3
      OSRATE(J) = NMRATE(K+1,J)
   45 CONTINUE
      WRITE(4,1020) NM,OSRATE
 1020 FORMAT(22HPARAMETERS - NEW MONEY,/,5X,6F10.1,/,
     1 9H - OSRATE,5X,3F10.4)
      CALL INVEST(II,NMINDX,WEIGHT,GROSIN,REPAID,FLAG)
      GOTO 42
C SET EXCHANGE RATES AT AVERAGE RATES FOR MONTH.
 2701 DO 46 J=1,3
      OSRATE(J) = RATE(K+1,J)
   46 CONTINUE
      IF( II.EQ.5 ) GOTO 2801
C SET PARAMETERS FOR SIMULATION OF ACTUAL INVESTMENTS.
      DO 47 J=1,6
      NM(J) = FLOAT( APURCH(K,J) )
   47 CONTINUE
      IF( K.GT.6 ) GOTO 2304
      DO 156 J=6+1,6
      NM(J) = 0.0
  156 CONTINUE
 2304 WRITE(4,1020) NM,OSRATE
      CALL INVEST(II,INDEX,AVWGHT,GROSIN,REPAID,FLAG)
      GOTO 42
C SET PARAMETERS FOR SIMULATION WITH NO NEW MONEY
 2801 DO 48 J=1,6
      NM(J) = 0.0
   48 CONTINUE
      CALL INVEST(II,INDEX,ZEWGHT,GROSIN,REPAID,FLAG)
C DO NEXT MONTH.
   42 CONTINUE
      RETURN
      END
C
      SUBROUTINE INVEST(II,NMINDX,WEIGHT,GROSIN,REPAID,FLAG)
      REAL NMINDX(14,6),NM(6),NMUNIT,
     1  INCOM,NINC,CUMINC(7),OSMINC,NINC1,LIFE(7),  VALUNT(6),
     2   WEIGHT(12),NINDOX(12,6),CHARG(2,6),CASHIN,
     3 NINC2,OSINCU,RATE(14,3)
      INTEGER J,JJ,K,S,SECTR(6),PAIDEX,VALPAD(3),BLANK,INCMEX,
     1 REPAID(13,9),II,TRANS,CASH,GROSIN(13,9),SECTEX(2,6)
     2 ,FLAG,SIMINC(13,9), NCOPT,DBUG
      COMMON N,S
      COMMON /G1/ NINDOX,SIMINC,BLANK,K,
     1   NM,VALUNT,CUMINC
      COMMON /G4/ INCMEX,PAIDEX,VALPAD,INCOPT
      COMMON /G12/ SECTR
      COMMON /G22/ CHARG
      COMMON /G37/ LIFE,SECTEX
      COMMON /G37/ RATE
      DATA CASH /6/
      DATA DBUG /6/
      IF( K.LT.DBUG ) WRITE(4,2001) ( NMINDX(K+1,J),J=1,6 ),
     1 ( WEIGHT(J),J=1,N )
 2000 FORMAT(1H0SUBROUTINE,/,6HNMINDX,/,5X,6F10.3,/,6HWEIGHT,/,
     1 5X,6F10.4 )
      OSMINC = 0.0
C FOR EACH SECTOR DESIRED TO BE SIMULATED.....
      DO 1 J=1,6
(5)   IF SECTOR ALL SOLD ALREADY, DO NOT DO SIMULATION OF TYPE 4.
      IF( K.GT.SECTEX(2,J) .AND. II.EQ.4 ) GOTO 1
      JJ = SECTR(J)
C   IF CASH SECTOR, WAIT UNTIL HAVE SIMULATED ALL NON-CASH SECTORS.
      IF( JJ.EQ.6 ) GOTO 1
C IF OUT OVERSEAS SECTOR, DO ITS SIMULATION IN SEPERATE SUBROUTINE.
(7)   IF( JJ.NE.4 ) GOTO 101
      CALL OSINV(II,NMINDX,WEIGHT,GROSIN,REPAID,FLAG,RATE,OSMINC,OSINCU)
      IF( INCMEX.NE.BLANK .AND. INCOPT.EQ.BLANK ) GOTO 1
      CUMINC(J) = CUMINC(J) + OSMINC
      IF( K.LT.DBUG ) WRITE(4,2330) CUMINC(J)
      IF( FLAG.NE.0 ) SIMINC(K,J) = IFIX(OSMINC)
      IF( II.EQ.5 ) GOTO 1
      OSMINC = OSMINC + OSINCU
      GOTO 1
C INVEST NEW MONEY IN SECTOR INDEX.
  101 TRANS = 1
C TRANS INDICATES IF NEW MONEY IS 'BUY' OR 'SELL' (1 OR 2).
      IF( NM(J).LT.0.00001 ) TRANS = 2
(8)   NMUNIT = NM(J) / NMINDX(K+1,J)/ CHARG(TRANS,JJ)
      IF( K.LT.DBUG ) WRITE(4,2010) J,NMUNIT
 2010 FORMAT(/,6HSECTOR,I3,/,25HNEW MONEY AS INDEX UNITS=,F14.2)
C IF  INCOME FIGURES ARE NOT AVAILABLE AND NOTIONAL INCOME OPTION NOT SPECIFIED
C       DO NOT REINVEST NOTIONAL INCOME (ASSESS ON CAPITAL VALUE ONLY).
      IF( INCMEX.EQ.BLANK ) GOTO 201
      IF( INCOPT.NE.BLANK ) GOTO 201
      INCOM = 0.0
      GOTO 501
C COMPUTE NOTIONAL INCOME.
(10)  201 NINC = ( WEIGHT(K)*NMUNIT + VALUNT(J) )*NINDOX(K,JJ)
      IF( K.LT.DBUG ) WRITE(4,2020) NINC
 2020 FORMAT(16HNOTIONAL INCOME=,F14.2)
      CUMINC(J) = CUMINC(J) + NINC
      IF( K.LT.DBUG ) WRITE(4,2030) CUMINC(J)
 2030 FORMAT(27HCUMULATIVE NOTIONAL INCOME=,F14.2)
C  IF SIMULATING JUST TO COMPUTE NOTIONAL INCOME, RECORD IT IN 'SIMINC'
C     AND DO NOT REINVEST ANY EXCESS INCOME.
      IF( FLAG.EQ.0 ) GOTO 301
```

```
      SIMINC(K,J) = IFIX(NINC)
      INCUN = 0.0
      GOTO 501
C  DO NOT SUBTRACT REPAID INCOME IF EITHER SIMULATING MARKET OR SECTOR
C  IS UNREPRESENTED IN CURRENT NOTIONAL POLICY/STRATEGY.
  301 IF( II.EQ.5 ) GOTO 401
      IF( VALUNT(J).LT.0.001 ) GOTO 401
C SPLIT EXCESS OF NOTIONAL INCOME OVER THAT REPAID TO TRUSTEES AND TAX
C  INTO 2 PARTS: NINC1= EXCESS OF NOTIONAL OVER ACTUAL GROSS INCOME, AND
C  NINC2 = INCOME ACTUALLY EARNED AND RETAINED.  IF II=4 SIMULATION,
C  REINVEST 'NINC2' IN CASH SECTOR  AND REINVEST 'NINC1' IN SIMS SECTOR.
C  OTHERWISE, REINVEST BOTH (I.E. ALL OF EXCESS NOTIONAL) IN SAME SECTOR.
      NINC1 = NINC - FLOAT( GROSIN(K,J) )
      NINC2 = FLOAT( GROSIN(K,J) - REPAID(K,J) )
      IF( II.NE.4 ) GOTO 701
      IF( K.LT.DBUG ) WRITE(4,2040) NINC1
 2040 FORMAT(34HREINVESTED EXCESS NOTIONAL INCOME=,F14.2)
      IF( K.LT.DBUG ) WRITE(4,2050)NINC2
 2050 FORMAT(26HINCOME REINVESTED IN CASH=,F14.2)
      CALL REVEST(K,NINC2,CASH,INCUN)
      CSHINU = CSHINU + INCUN
      GOTO 405
  701 NINC1 = NINC1 + NINC2
      GOTO 407
  401 NINC1 = NINC
  407 IF( K.LT.DBUG ) WRITE(4,2040) NINC1
  405 CALL REVEST(K,NINC1,JJ,INCUN)
C TOTAL UP TOTAL NUMBER OF INDEX UNITS POSSESSED AT END OF MONTH.
  501 VALUNT(J) = VALUNT(J) +NMUNIT + INCUN
C DO NEXT SECTOR
      WRITE(4,2060) VALUNT(J)
 2060 FORMAT(30HCUMULATIVE NO. OF INDEX UNITS=,F14.2)
    1 CONTINUE
C  SIMULATE CASH SECTOR IN SEPERATE SUBROUTINE.
      CALL CSHINV(II,NMINDX,WEIGHT,REPAID,FLAG,CSHINU)
      RETURN
      END
C
C
      SUBROUTINE CSHINV(II,NMINDX,WEIGHT,REPAID,FLAG,CSHINU)
      REAL NMINDX(14,6),WEIGHT(12),NM(6),NINCDX(12,6),
     1 VALUNT(6),CUMINC(7),CHARG(2,6),INCUN,CSHINU,NMUNIT,NINC
      INTEGER TRANS,REPAID(13,9),BLANK,K,III,II,FLAG,S,NEINCOPT,
     1 INCNEX,PAIDEX,VALPAD(3),JJ,SECTEX(2,6),SIMINC(13,9),DBUG
      COMMON N,S
      COMMON /G1/ NINCDX,SIMINC,BLANK,K,
     1  NM,VALUNT,CUMINC
      COMMON /G8/ INCNEX,PAIDEX,VALPAD,INCOPT
      COMMON /G22/ CHARG
      DATA DBUG /4 /
C
C  SIMULATES INVESTMENT IN CASH SECTOR FOR  K TH  MONTH AFTER ALL NON-
C    CASH SECTORS' RETAINED INCOME IS KNOWN IN TERMS OF UNITS 'CSHINU'
C    INJECTED INTO CASH THIS MONTH.
C
      JJ = 6
      TRANS = 1
C 'TRANS' INDICATES IF NEW MONEY IS 'BUY' OR 'SELL' (1 OR 2).
      IF( NM(S).LT.0.00001 ) TRANS = 2
C INVEST  NEW MONEY IN SECTOR INDEX.
      NMUNIT = NM(S) / NMINDX(K+1,JJ)/ CHARG(TRANS,JJ)
      IF( K.LT.DBUG ) WRITE(4,2010) S,NMUNIT
 2010 FORMAT(/,6HSECTOR,I3,/,25HNEW MONEY AS INDEX UNITS=,F14.2)
C IF  INCOME FIGURES ARE NOT AVAILABLE, DO NOT REINVEST NOTIONAL
C          INCOME (ASSESS ON CAPITAL VALUE ONLY).
      IF( INCNEX.EQ.BLANK ) GOTO 201
      IF( INCOPT.NE.BLANK ) GOTO 201
      INCUN = 0.0
      GOTO 501
C COMPUTE NOTIONAL INCOME.
  201 NINC = ( WEIGHT(K)*NMUNIT + VALUNT(S) )*NINCDX(K,JJ)
      IF( K.LT.DBUG ) WRITE(4,2020) NINC
 2020 FORMAT(16HNOTIONAL INCOME=,F14.2)
      CUMINC(S) = CUMINC(S) + NINC
      IF( K.LT.DBUG ) WRITE(4,2030) CUMINC(S)
 2030 FORMAT(27HCUMULATIVE NOTIONAL INCOME=,F14.2)
C   ADD TO NEW MONEY THE INCOME FROM OTHER SECTORS
C   AND ALLOW FOR CASH INTEREST ON IT.
      NMUNIT = NMUNIT + CSHINU
      NINC = NINC + 0.5 * CSHINU * NINCDX(K,JJ)
      IF( K.LT.DBUG ) WRITE(4,2045)
 2045 FORMAT(42HWITH INCOME TRANSFERED FROM OTHER SECTORS-)
      IF( K.LT.DBUG ) WRITE(4,2020) NINC
C  IF SIMULATING TO JUST RECORD NOTIONAL INCOME IN 'SIMINC', DO NOT REINVEST
C    ANY EXCESS NOTIONAL INCOME.
      IF( FLAG.EQ.0 ) GOTO 301
      SIMINC(K,S) = IFIX(NINC)
      INCUN = 0.0
      GOTO 501
C  DO NOT SUBTRACT REPAID INCOME IF EITHER SIMULATING MARKET OR SECTOR
C  IS UNREPRESENTED IN CURRENT NOTIONAL POLICY/STRATEGY.
  301 IF( II.EQ.5 ) GOTO 401
      IF( VALUNT(S).LT.0.001 ) GOTO 401
 2040 FORMAT(34HREINVESTED EXCESS NOTIONAL INCOME=,F14.2)
C  REINVEST EXCESS NOTIONAL INCOME ABOVE THAT REPAID TO TRUSTEES AND TAX.
      NINC = NINC - FLOAT( REPAID(K,S) )
      IF( K.LT.DBUG ) WRITE(4,2040) NINC
  401 CALL REVEST(K,NINC,JJ,INCUN)
  501 VALUNT(S) = VALUNT(S) +NMUNIT + INCUN
      WRITE(4,2060) VALUNT(S)
 2060 FORMAT(30HCUMULATIVE NO. OF INDEX UNITS=,F14.2)
      RETURN
      END
C
C
      SUBROUTINE REVEST(K,INCOME,JJ,INCUN)
      REAL INCOME,INCUN,INDEX(14,6),CHARG(2,6)
      INTEGER JJ,TRANS,K,DBUG
      COMMON /G2/ INDEX
      COMMON /G22/ CHARG
      DATA DBUG /4 /
C
C  REINVEST 'INCOME' IN 'JJ'TH SECTOR.
C
      TRANS = 1
      IF( INCOME.LT.0.001 ) TRANS = 2
      INCUN = INCOME / INDEX(K+1,JJ) / CHARG(TRANS,JJ)
      IF( K.LT.DBUG ) WRITE(4,1000) JJ,INCUN
 1000 FORMAT(26HREINVESTED UNITS IN SECTOR,I3,2H =,F14.2)
      RETURN
      END
```

11 12a 12b 10a 13 9 14 8 10c 10b 10c 11 12 13 9,14

```
C
C
      SUBROUTINE OSINV(II,NMINDX,WEIGHT,GROSIN,REPAID,FLAG,RATE,OSMINC
     1 ,OSCOMU)
      REAL INDEX(14,6),NMINDX(14,6),NM(6),WEIGHT(12),NINCOX(14,6),
     1 RATE(14,3),CHARG(2,6),VALUNT(6),OSRATE(3),INCOME,OSTAX
     2 ,CUMINC(17),PRMPRN(14),NMUNIT,OSINCU,OSCOMU,NINC2,OSMINC
      INTEGER K,PAIDEX,VALPAD(3),BLANK,INCMEX,REPAID(13,9),II,OSEAS,
     1 TRANS,SECTR(5),APURCH(13,9),CASH,GROSIN(13,9),
     2 SECTEX(2,6),FLAG,SIMINC(13,9),INCOPT,DBUG
C
      COMMON /G1/NINDOX,SIMINC,BLANK,K,NM,VALUNT,
     1 CUMINC
      COMMON /G2/ INDEX
      COMMON /G5/ PRMPRN,OSEAS,OSRATE
      COMMON /G8/ INCMEX,PAIDEX,VALPAD,INCOPT
      COMMON /G12/ SECTR
      COMMON /G15/ APURCH
      COMMON /G22/ CHARG
      DATA OSTAX,CASH/0.15,6/
      DATA DBUG /4 /
C
C SUBROUTINE TO DO INVESTMENT SIMULATION FOR ONE MONTH FOR OVERSEAS SECTOR.
C
C INVEST NEW MONEY ACCORDING TO WHETHER IT IS BUY OR SELL
      OSCOMU = 0.0
      TRANS=1
      IF( K.LT.DBUG ) WRITE(4,1000) NM(OSEAS)
 1000 FORMAT(/,19HOVERSEAS SUBROUTINE,/,10HNEW MONEY=,F10.1)
      IF( NM(OSEAS).LT.-0.00001 ) GOTO 101
      NMUNIT = NM(OSEAS)*OSRATE(1) / NMINDX(K+1,4) /CHARG(1,4)
      GOTO 201
  101 NMUNIT = NM(OSEAS)*OSRATE(3) / NMINDX(K+1,4) / CHARG(2,4)
C IF REPAID INCOME FIGURES ARE UNAVAILABLE, DO NOT REINVEST EXCESS
C    NOTIONAL INCOME.

  201 IF( K.LT.DBUG ) WRITE(4,1010) NMUNIT
 1010 FORMAT(23HNEW MONEY AS INDEX UNITS=,F10.1)
      IF( INCMEX.EQ.BLANK ) GOTO 301
      IF( INCOPT.NE.BLANK ) GOTO 301
      OSINCU = 0.0
      GOTO 401
  301 INCOME = ( WEIGHT(K)*NMUNIT + VALUNT(OSEAS) ) * NINCOX(K,4) *
     1 ( 1.0 - OSTAX )
      OSMINC = INCOME / RATE(K+1,2)
      IF( K.LT.DBUG ) WRITE(4,1020) INCOME
 1020 FORMAT(16HNOTIONAL INCOME=,F10.1)
C IF JUST ESTIMATING INCOME, DO NOT REINVEST ANY EXCESS NOTIONAL INCOME.
      IF(FLAG.EQ.0 ) GOTO 901
      OSINCU = 0.0
      GOTO 501
C
C  DO NOT SUBTRACT REPAID INCOME IF SIMULATING MARKET RETURN OF OVERSEAS.
C    SECTOR IS UNREPRESENTED IN CURRENT NOTIONAL POLICY/STRATEGY.
  901 IF( II.EQ.5 ) GOTO 601
      IF( VALUNT(OSEAS).LT.0.001 ) GOTO 601
      IF( II.NE.4 ) GOTO 701
      INCOME = INCOME - FLOAT( GROSIN(K,OSEAS) )*RATE(K+1,2)
      IF( K.LT.DBUG ) WRITE(4,1070) INCOME
 1070 FORMAT(23HEXCESS NOTIONAL INCOME=,F10.1)
C  REINVEST RETAINED INCOME IN CASH SECTOR
      NINC2 = FLOAT( GROSIN(K,OSEAS) ) - REPAID(K,OSEAS) )
      IF( K.LT.DBUG ) WRITE(4,1080) NINC2
 1080 FORMAT(23HREINVESTED IN CASH=,F14.2)
      CALL REINVST(K,NINC2,CASH,OSCOMU)
      GOTO 801
  701 INCOME = INCOME - FLOAT( REPAID(K,OSEAS) )*RATE(K+1,2)
C DEPENDING ON WHETHER BUYING OR SELLING TO REINVEST EXCESS NOTIONAL INCOME,
C    REINVEST. IF SELL,CORRECT FOR EFFECT OF PENALTY.
  801 IF( INCOME.GT.0.0001 ) GOTO 601
      INCOME = INCOME * RATE(K+1,3)/RATE(K+1,2) )
      IF( K.LT.DBUG ) WRITE(4,1040) INCOME
 1040 FORMAT(25HAFTER PENALTY CORRECTION=,F10.1)
      TRANS = 2
  601 IF( K.LT.DBUG ) WRITE(4,1050) INCOME
 1050 FORMAT(14HREINVESTED OVSEAS=,F10.1)
      OSINCU = INCOME / INDEX(K+1,4) / CHARG(TRANS,4)
  401 IF( K.LT.DBUG ) WRITE(4,1060) OSINCU
 1060 FORMAT(22HREINVESTMENT AS UNITS=,F10.1)
C FIND TOTAL NO. OF INDEX UNITS ACCUMULATED SO FAR.
  501 VALUNT(OSEAS) = VALUNT(OSEAS) +NMUNIT + OSINCU
      WRITE(4,1060) VALUNT(OSEAS)
 1060 FORMAT(30HCUMULATIVE NO. OF INDEX UNITS=,F10.1,/,
     1 5X,8HQUIT S/R)
      RETURN
      END
```

```
C
C
      SUBROUTINE CHARGE(II,M,TOTVAL,TOTCHG)
      REAL CHARG(2,6),TOTCHG,PROPNS(4,6),PASTPR(4,6),RTEMP2,TOTVAL,DENOM
     1 ,CHRG
      INTEGER TRANS,II,SECTR(5),LASTDT(3),M
      COMMON /G12/ SECTR
      COMMON /G21/ LASTDT,PASTPR
      COMMON /G22/ CHARG
      COMMON /G23/ PROPNS
C
C  TO CALCULATE THE SIMULATED TRADING EXPENSES, 'TOTCHG', INVOLVED IN
C     ADJUSTING THE PROFILE OF A NOTIONAL FUND FROM 'PASTPR(II,*)' TO
C     'PROPNS(M,*)' WHERE 'II,M' INDICATES THE TYPE OF NOTIONAL FUND.
C
      DENOM = 0.0
      CHRG = 0.0
      DO 1 J=1,6
      TRANS = 1
      RTEMP2 = PROPNS(M,J) - PASTPR(II,SECTR(J))
      IF( RTEMP2.LT.0.0 ) GOTO 101
      GOTO 201
C  NEED TO SELL, SO CHANGE DIFFERENCE TO +VE QUANTITY AND SET TRANSACTION
C     TYPE INDICATOR, 'TRANS', TO SELL.
  101 RTEMP2 = -RTEMP2
      TRANS = 2
  201 CHRG = CHRG + ( CHARG(TRANS,SECTR(J)) - 1.0 ) * RTEMP2
      DENOM = DENOM + ( CHARG(TRANS,SECTR(J)) - 1.0 ) *
     1 PROPNS(M,J)
    1 CONTINUE
      CHRG = CHRG / ( 1.0 - DENOM )  * TOTVAL
      WRITE(4,1000) CHRG
 1000 FORMAT(25HTOTAL REALIGNMENT CHARGE=,F15.3)
      TOTCHG = CHRG
      RETURN
      END
```

COMPUTER ROUTINES CONCERNED WITH INVESTMENT SIMULATION

The circled numbers refer to the steps in the flow chart given by Figure 11.2 . The first page of this appendix shows the calling routine in the main part of PRFORM2 which uses the subroutines shown on the following pages. Also shown on the first page is the calculation of components.

APPENDIX 11-II

INCOME ESTIMATION

ACCURACY OF INCOME ESTIMATION

No general comments can be made on the accuracy of income estimates made from index yields except to say that, as a general principle, the larger the fund, the more accurate the estimates are likely to be.[1] Accuracy for any particular fund depends on how well it is diversified to the same degree as the index, and of course on the quality of the income index itself. It also leads to the paradoxical result that it is the largest sectors for which it is least critical to obtain known figures. (Refer equities in Table 12.5 mentioned below).

The ability to constrain estimation by what figures are known can overcome any inherent inaccuracy in the procedure however. This is demonstrated by Table 12.5, which shows income estimation errors for all six sectors under conditions of differing amounts of known income data. They are based on Fund C's data as in Figure 10.7.

The foundation for the advice of VI.6, Chapter 10 to only use monthly income totals if they are based on an accrual accounting system is immediately evident. The relatively wild gyrations of the actual monthly data for Fund C could only be handled when information on three sectors was available (f), or when the figures were known (c).

The results indicate that while additional information concerning grand total income may result in a better ROR estimate for the total fund, it may do little for individual sectors. The application of monthly cash accounting totals can actually increase estimation errors of sector incomes. Needless to say, the provision of actual data under the PARTIAL option has the greatest beneficial effect.

---

1. Weaver (84, p167) is so confident of the convergence of actual with index income that he regards income as a factor which can be ignored for large funds.

SAMPLE OUTPUTS

Figures 11-II.1 to 11-II.3 illustrate the fact that income estimation errors, unless exceptionally large (i.e of the order of 50%), do not have a great effect on rate of return estimates for large sectors, but that smaller sectors are badly affected. All the figures are based on the analysis of Fund C using the Market Data file in Figure 10.5 and modified Fund Data files based on Figure 10.7. The rate of return estimates may be compared with table 4 in Figure 12.1 to gain an idea of their relative accuracy.[1]

Figure 11-II.1 is based on capital values only. The rates of return in table 4 are very different for all sectors except equities, and are of course all lower. The tables shown are those whose appearance changes as a result of capital assessment. The message under table 8 is an example of the consequence of an option being inconsistent with the data of the fund (refer Chapter 10).

Figure 11-II.2 is based on the provision of Cash income data as well as the grand total of income (case (e) in Table 11-II.1). The message under table 1 is printed in every case of income estimation where some known income data is provided. The rates of return in table 4 are closer to their true values than assessment using capital values only, but are still wide of the mark for the smaller sectors of Other Fixed Interest and Property Trusts.

Figure 11-II.3 shows extracts from the report resulting from case (f) in Table 11-II.1. Errors concerning the two smaller sectors remain just as severe but errors in the sectors for which data is provided are entirely eliminated, since the timing of the income does not have to be estimated as it was

---

1. The estimates all differ to the order of 0.02% due to different taxation rates and transaction costs used for Figure 12.1

for Figure 11.II.2. The last two columns of table 4 illustrate the software's general principle of providing this information only when at least the relevant sector's total income is known.

CONCLUSIONS

1. Income estimates are probably only satisfactory for the larger sectors and the total fund.

2. Adding a small amount of known figures does not necessarily improve estimates for the incomes of sectors whose data is unknown.

3. Using estimated income figures may lead to more accurate HOR estimates than assessment on capital value only, since the latter involves a systematic negative bias.

4. Monthly totals should not be used if they are derived from a cash accounting system.

TABLE 11-II.1

Errors in estimation of income totals under various income options. Figures refer to error as a percentage of true value.

(a) No known income figures

BY MTH	BY SECTOR	
-62.9%	-27.5%	GILTS
225.3%	56.7%	OFI
17.3%	-4.6%	EQ
	-7.3%	OS
TOTAL	-62.4%	P.T.
-12.05%	5.11%	CASH

(b) Known grand total income

BY SECTOR	BY MTH
-17.6%	-57.8%
78.1%	269.9%
8.5%	37.54%
5.4%	
-57.3%	TOTAL
19.5%	0%

(c) Known monthly totals of income

BY MTH	BY SECTOR	
0%	-34.2%	GILTS
0%	101.1%	OFI
0%	18.3%	EQ
	12.2%	OS
TOTAL	-52.5%	P.T.
0%	30.9%	CASH

(d) Known sector totals of income

BY SECTOR	BY MTH
0%	-59.3%
0%	277.8%
0%	37.9%
0%	
0%	TOTAL
0%	0%

(e) Known cash income plus grand total

BY MTH	BY SECTOR	
-65.1%	-14.2%	GILTS
219.9%	-85.6%	OFI
81.4%	13.0%	EQ
	9.8%	OS
TOTAL	124.8%	P.T.
0%	0%	CASH

(f) Known income totals for 3 sectors (equities, gilts, cash) plus grand total

BY SECTOR	BY MTH
0%	0.5%
77.5%	11.9%
0%	-7.1%
5.0%	
-57.5%	TOTAL
0%	0%

PERFORMANCE REPORT FOR A NON-L.A. PUBLIC UTILITY CORPORATION (C) OVER PERIOD 1 7 1976 TO 30 9 1976 PAGE 1

SUMMARY OF PERFORMANCE THIS PERIOD

1. GROWTH OF MAIN FUND

SOURCE OF GROWTH	ACTUAL FUND AMOUNT (£000)	ACTUAL FUND % OF INITIAL FUND	MODEL FUND AMOUNT (£000)	MODEL FUND % OF INITIAL FUND
INITIAL MAIN FUND	43092.53	100.00	43092.53	100.00
NET NEW MONEY	4846.07	11.25	4846.07	11.25
(INCOME EARNED*)	NOT GIVEN		(0)	0
(INCOME WITHDRAWN)	NOT GIVEN		NOT GIVEN	
REINVESTED INCOME	NOT AVAILABLE		NOT AVAILABLE	
APPRECIATION	-3643.99	-8.45	-4124.28	-9.57
FINAL MAIN FUND	44295.66	101.75	43814.31	101.67

* BECAUSE NO INFORMATION ON INCOME EARNED IS AVAILABLE FOR THIS FUND, ASSESSMENT IS ON THE BASIS OF CAPITAL VALUE ONLY. (ALL MARKET RATES OF RETURN INCLUDE INCOME HOWEVER.)

- THIS REPORT DOES NOT ASSESS THE FOLLOWING INVESTMENTS: NIL. (PROPERTY IN SEPERATE FUND)

2. ANNUALISED RATE OF RETURN OVER THIS PERIOD (%P.A.)

TYPE OF RATE OF RETURN MEASURE	SECTORS OF MAIN FUND: GILTS	OTH FIXED INT	EQUITIES	OVERSEAS	PROPRTY TST	CASH	TOTAL MAIN FUND
ACHIEVED ORDINARY RATE OF RETURN (AFFECTED BY TIMING OF NEW MONEY)	-19.98	-5.68	-46.42	22.99	11.76	0	-27.88
ACHIEVED TIME WEIGHTED RETURN (NOT AFFECTED BY TIMING OF NEW MONEY)	-18.06	-6.03	-44.52	29.81	11.76	0	-26.39
HISTORICAL MARKET RATE OF RETURN ACCORDING TO INDEX	-9.09	-15.74	-39.36	48.25	12.88	11.20	(MODEL FUND) -23.93

3. ANALYSIS OF RETURN RELATIVE TO MODEL FUND

RELATIVE RETURN FROM LONG-RUN INVESTMENT POLICY	+	RELATIVE RETURN FROM CURRENT STRATEGY	=	TOTAL RELATIVE RETURN FROM SECTOR SELECTION	; +	TOTAL RELATIVE RETURN FROM SECURITY SELECTION	=	TOTAL RELATIVE RETURN ON MAIN FUND
-2.12%	+	3.78%	=	1.67%	; +	-.62%	=	1.04%

FIGURE 11-II.1 : Extract from a Fund Performance Report based on capital values only

4. ACHIEVED RATE OF RETURN (R.O.R.) FOR EACH SECTOR OVER THIS REVIEW PERIOD (/)

SECTOR	HISTORICAL MARKET R.O.R.	ACHIEVED MONEY-WEIGHTED R.O.R. (SEE NOTE 1 BELOW)	ACHIEVED TIME-WEIGHTED R.O.R. (SEE NOTE 2 BELOW)	DIFFERENCE (MONEY-LESS TIME-WEIGHTED, SEE NOTE 3)	GROSS GAIN (£000'S) (NET OF NEW MONEY)*	GROSS INCOME YIELD (/P.A.)*	PERCENTAGE OF GAIN WHICH WAS INCOME*
TOTAL MAIN FUND	-0.66	-7.91	-7.43	-.48	-3642.99	NOT AVAILABLE	
GILTS	-2.37	-5.46	-4.90	-.56	-620.87		
OTH FIXD INT	-4.23	-1.46	-1.56	.10	-5.70		
EQUITIES	-[illegible].81	-14.55	-13.80	-.75	-3295.22		
OVERSEAS	[illegible].43	5.35	6.80	-1.45	268.93		
PROPTY TST	[illegible].10	2.84	2.84	0	9.95		
CASH	2.71	0	0	0	0		

FIGURE 11-II.1

CONTINUED

NOTE 1: MONEY-WEIGHTED RATE OF RETURN IS AFFECTED BY THE TIMING OF NEW MONEY AND SECTOR SWITCHES DURING THE PERIOD. IT IS THE ORDINARY RATE OF RETURN MEASURING INCREASE IN WEALTH.

NOTE 2: TIME-WEIGHTED RATE OF RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR. IT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BETWEEN DIFFERENT PORTFOLIOS.

NOTE 3: IN THE CASE OF AN INDIVIDUAL SECTOR, A LARGE POSITIVE DIFFERENCE (E.G. 1/ OR GREATER) INDICATES THAT SWITCHES INTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN THIS SECTOR WERE TIMED WELL. A LARGE POSITIVE DIFFERENCE FOR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOURABLE TO PERFORMANCE.

* ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP INCOME, SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET OF TAX. INCOME INFORMATION IS SHOWN ONLY FOR THOSE SECTORS FOR WHICH INCOME FIGURES WERE GIVEN. 'GROSS GAIN' IS BASED ON CAPITAL VALUE ONLY IF NO INCOME FIGURE WAS PROVIDED FOR THAT SECTOR.

RECEIPTS AND ALLOCATIONS DURING REVIEW PERIOD

18. RECEIPTS AND ALLOCATIONS BY SECTOR

RECEIPTS

SOURCE	AMOUNT (£)	% OF INITIAL FUND
NET CONTRIBUTIONS	4846067	11.25
INVESTMENT INCOME-	COMPLETE FIGURES NOT PROVIDED	
GILTS	0	0
OTH FIXD INT	0	0
EQUITIES	0	0
OVERSEAS	0	0
PROPTY TST	0	0
CASH	0	0
TOTAL INCOME (MAIN FUND)	0	0
EXCLUDED SECTOR	0	0
TOTAL INCOME	0	0
TOTAL RECEIPTS	4846067	11.25

ALLOCATIONS

SOURCE	AMOUNT (£)		% OF INITIAL FUND
NET PURCHASES -			
GILTS	2676000		6.21
OTH FIXD INT	-3500		-.08
EQUITIES	2651000		6.15
OVERSEAS	1386000		3.22
PROPTY TST	0		0
TOTAL PURCHASES (MAIN FUND)	6679000		15.50
EXCLUDED SECTOR	0		0
TOTAL PURCHASES		6679000	15.50
INCREASE IN CASH		-1832933	-4.25
TOTAL ALLOCATIONS		4846067	

PERFORMANCE REPORT FOR A NON-L.A. PUBLIC UTILITY CORPORATION (C) OVER PERIOD 1 7 1976 TO 30 9 1976 PAGE 2

4. ACHIEVED RATE OF RETURN (R.O.R.) FOR EACH SECTOR OVER THIS REVIEW PERIOD (%)

SECTOR	HISTORICAL MARKET R.O.R.	ACHIEVED MONEY-WEIGHTED R.O.R. (SEE NOTE 1 BELOW)	ACHIEVED TIME-WEIGHTED R.O.R. (SEE NOTE 2 BELOW)	DIFFERENCE (MONEY- LESS TIME-WEIGHTED, SEE NOTE 3)	GROSS GAIN (EQUIVS) NET OF NEW MONEY!*	GROSS INCOME YIELD (%P.A.)*	PERCENTAGE OF GAIN WHICH WAS INCOME*
TOTAL MAIN FUND	-6.66 (MODEL FUND)	-5.96	-5.54	-.42	-2723.09	3.26	NOT APPLICABLE
GILTS	-2.37	-2.87	-2.28	-.59	-626.87		
OTH FIXD INT	-4.23	2.92	2.71	.21	-5.79		
EQUITIES	-11.81	-12.88	-12.23	-.65	-3295.22		
OVERSEAS	10.43	6.07	7.74	-1.67	264.93		
PROPTY TST	3.10	4.82	4.75	.07	9.95		
CASH	2.71	2.57	2.56	.01	156.71	10.50	100.00

NOTE 1: MONEY-WEIGHTED RATE OF RETURN IS AFFECTED BY THE TIMING OF NEW MONEY AND SECTOR SWITCHES DURING THE PERIOD. IT IS THE ORDINARY RATE OF RETURN, MEASURING INCREASE IN WEALTH.

NOTE 2: TIME-WEIGHTED RATE OF RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR. IT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BETWEEN DIFFERENT PORTFOLIOS.

NOTE 3: IN THE CASE OF AN INDIVIDUAL SECTOR, A LARGE POSITIVE DIFFERENCE (E.G. 1% OR GREATER) INDICATES THAT SWITCHES INTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN THAT SECTOR WERE TIMED WELL. A LARGE POSITIVE DIFFERENCE FOR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOURABLE TO PERFORMANCE.

* ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP INCOME, SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET OF TAX. INCOME INFORMATION IS SHOWN ONLY FOR THOSE SECTORS FOR WHICH INCOME FIGURES WERE GIVEN. 'GROSS GAIN' IS BASED ON CAPITAL VALUE ONLY IF NO INCOME FIGURE WAS PROVIDED FOR THAT SECTOR.

FIGURE 11-II.2

Extract from a Fund Performance Report based on the income data option "PARTIAL", providing Cash income and the grand total of income for the whole fund over the period

4. ACHIEVED RATE OF RETURN (M.O.R.) FOR EACH SECTOR OVER THIS REVIEW PERIOD (%)

SECTOR	HISTORICAL MARKET R.O.R.	ACHIEVED MONEY-WEIGHTED R.O.R. (SEE NOTE 1 BELOW)	ACHIEVED TIME-WEIGHTED R.O.R. (SEE NOTE 2 BELOW)	DIFFERENCE (MONEY-TIME-WEIGHTED) (SEE NOTE 3)	GROSS GAIN (GROSS) (NET OF NEW MONEY) *	GROSS INCOME YIELD (%P.A.) *	PERCENTAGE OF GAIN WHICH WAS INCOME*
TOTAL MAIN FUND	-6.06 (MODEL FUND)	-5.96	-5.54	-.42	-2723.09	0.24	NOT APPLICABLE
GILTS	-2.37	-2.87	-2.28	-.59	-620.87		
OTH FIXD INT	-4.23	2.92	2.71	.21	-5.72		
EQUITIES	-11.81	-12.88	-12.23	-.65	-3295.22		
OVERSEAS	10.73	6.07	7.74	-1.67	266.93		
PROPTY TST	3.10	4.82	4.75	.07	9.95		
CASH	2.71	2.57	2.56	.01	156.81	10.60	100.00

FIGURE 11-II.2

CONTINUED

NOTE 1: MONEY-WEIGHTED RATE OF RETURN IS AFFECTED BY THE TIMING OF NEW MONEY AND SECTOR SWITCHES DURING THE PERIOD. IT IS THE ORDINARY RATE OF RETURN, MEASURING INCREASE IN WEALTH.

NOTE 2: TIME WEIGHTED RATE OF RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR. IT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BETWEEN DIFFERENT PORTFOLIOS.

NOTE 3: IN THE CASE OF AN INDIVIDUAL SECTOR, A LARGE POSITIVE DIFFERENCE (E.G. 1% OR GREATER) INDICATES THAT SWITCHES INTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN THAT SECTOR WERE TIMED WELL. A LARGE POSITIVE DIFFERENCE FOR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOURABLE TO PERFORMANCE.

* ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP INCOME, SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET OF TAX. INCOME INFORMATION IS SHOWN ONLY FOR THOSE SECTORS FOR WHICH INCOME FIGURES WERE GIVEN. 'GROSS GAIN' IS BASED ON CAPITAL VALUE ONLY IF NO INCOME FIGURE WAS PROVIDED FOR THAT SECTOR.

RECEIPTS AND ALLOCATIONS DURING REVIEW PERIOD

18. RECEIPTS AND ALLOCATIONS BY SECTOR

RECEIPTS

SOURCE	AMOUNT (£)	% OF INITIAL FUND
NET CONTRIBUTIONS	4846067	11.25
INVESTMENT INCOME-	COMPLETE FIGURES NOT PROVIDED	
GILTS	0	0
OTH FIXD INT	0	0
EQUITIES	0	0
OVERSEAS	0	0
PROPTY TST	0	0
CASH	156809	.36
TOTAL INCOME (MAIN FUND)	597936	1.39
EXCLUDED SECTOR	-0	0
TOTAL INCOME	597936	1.39
TOTAL RECEIPTS	5444003	12.63

ALLOCATIONS

SOURCE	AMOUNT (£)	% OF INITIAL FUND
NET PURCHASES -		
GILTS	2676169	6.21
OTH FIXD INT	-36005	-.08
EQUITIES	2651150	6.15
OVERSEAS	1388680	3.22
PROPTY TST	0	0
TOTAL PURCHASES (MAIN FUND)	6679000	15.50
EXCLUDED SECTOR	0	0
TOTAL PURCHASES	6679000	15.50
INCREASE IN CASH	-1832933	-4.25
PAYMENTS TO TRUSTEES	597936	1.39
TOTAL ALLOCATIONS	5444003	12.63

S U M M A R Y O F P E R F O R M A N C E T H I S P E R I O D

1. GROWTH OF MAIN FUND

SOURCE OF GROWTH	ACTUAL FUND AMOUNT (£000)	ACTUAL FUND % OF INITIAL FUND	MODEL FUND AMOUNT (£000)	MODEL FUND % OF INITIAL FUND
INITIAL MAIN FUND	43692.53	100.00	43692.53	100.00
NET NEW MONEY	4846.07	11.25	4846.07	11.25
(INCOME EARNED **)	(919.9[illegible])	2.13	(852.76)	1.96
(INCOME WITHDRAWN)	(-919.9[illegible])	-2.13	(-919.9[illegible])	-2.13
REINVESTED INCOME	0	0	-67.13	-.16
APPRECIATION	-3642.99	-8.[illegible]	-4127.67	-9.57
FINAL MAIN FUND	44295.60	102.79	43748.79	101.52

** BECAUSE INCOME WAS REPORTED ON AN AFTER TAX BASIS, INCOME OF ACTUAL FUND HAS BEEN GROSSED UP TO A BEFORE-TAX FIGURE IN ADVANCE OF TAX REFUNDS. THIS MAKES IT DIRECTLY COMPARABLE TO THE GROSS INCOME OF THE MODEL FUND. 'INCOME WITHDRAWN' INCLUDES TAX PAID THIS PERIOD.

** THOSE INCOME FIGURES WHICH WERE NOT PROVIDED HAVE BEEN ESTIMATED USING INDEX YIELDS. THE ESTIMATES WERE FORCED TO BE CONSISTENT WITH THE FIGURES PROVIDED. ALL INCOME IS ASSUMED TO HAVE BEEN REPAID IN ITS ENTIRETY IN TRUSTEES.

- THIS REPORT DOES NOT ASSESS THE FOLLOWING INVESTMENTS: NIL. (PROPERTY IN SEPERATE FUND)

2. ANNUALISED RATE OF RETURN OVER THIS PERIOD (%P.A.)

TYPE OF RATE OF RETURN MEASURE	SECTORS OF MAIN FUND: GILTS	OTH FIXD INT	EQUITIES	OVERSEAS	PROPERTY TST	CASH	TOTAL MAIN FUND
ACHIEVED ORDINARY RATE OF RETURN (AFFECTED BY TIMING OF NEW MONEY)	-9.42	11.[illegible]4	[illegible]42.7[illegible]	2[illegible].18	2[illegible].1[illegible]	10.60	-21.73
ACHIEVED TIME WEIGHTED RETURN (NOT AFFECTED BY TIMING OF NEW MONEY)	-7.10	13.36	-[illegible].[illegible]8	3[illegible].24	1[illegible].83	1[illegible].55	-2[illegible].26
HISTORICAL MARKET RATE OF RETURN ACCORDING TO INDEX	-9.09	-15.74	-3[illegible].2[illegible]	[illegible]4[illegible].23	12.0[illegible]	1[illegible].2[illegible]	(MODEL FUND) -23.[illegible]8

3. ANALYSIS OF RETURN RELATIVE TO MODEL FUND

RELATIVE RETURN FROM LONG-RUN INVESTMENT POLICY	+	RELATIVE RETURN FROM CURRENT STRATEGY	=	TOTAL RELATIVE RETURN FROM SECTOR SELECTION	: +	TOTAL RELATIVE RETURN FROM SECURITY SELECTION	=	TOTAL RELATIVE RETURN ON MAIN FUND
-2.24%	+	7.85%	=	1.61%	: +	-.41%	=	1.20%

FIGURE 11-II.3 : Extract from Fund Perf. Report based on option "PARTIAL", providing income data for 3 sectors as well as grand total of income for the whole fund over the period

4. ACHIEVED RATE OF RETURN (R.O.R.) FOR EACH SECTOR OVER THIS REVIEW PERIOD (/)

SECTOR	HISTORICAL MARKET R.O.R.	ACHIEVED MONEY-WEIGHTED R.O.R. (SEE NOTE 1 BELOW)	ACHIEVED TIME-WEIGHTED R.O.R. (SEE NOTE 2 BELOW)	DIFFERENCE (MONEY- LESS TIME-WEIGHTED, SEE NOTE 3)	GROSS GAIN (£000'S) (NET OF NEW MONEY)*	GROSS INCOME YIELD (/P.A.)*	PERCENTAGE OF GAIN WHICH WAS INCOME*
TOTAL MAIN FUND	-6.30 (MODEL FUND)	-5.99	-5.55	-.44	-2723.09	8.27	NOT APPLICABLE
GILTS	-2.37	-2.46	-1.84	-.62	-272.71	13.06	NOT APPLICABLE
OTH FIXD INT	-4.23	2.72	2.52	.20	-5.79		
EQUITIES	-11.81	-13.11	-12.44	-.67	-2936.44	6.51	NOT APPLICABLE
OVERSEAS	10.43	6.04	7.71	-1.67	266.93		
PROPTY TST	3.10	4.73	4.67	.06	9.95		
CASH	2.71	2.57	2.56	.01	156.81	10.60	100.00

NOTE 1: MONEY-WEIGHTED RATE OF RETURN IS AFFECTED BY THE TIMING OF NEW MONEY AND SECTOR SWITCHES DURING THE PERIOD. IT IS THE ORDINARY RATE OF RETURN, MEASURING INCREASE IN WEALTH.

NOTE 2: TIME-WEIGHTED RATE OF RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR. IT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BETWEEN DIFFERENT PORTFOLIOS.

NOTE 3: IN THE CASE OF AN INDIVIDUAL SECTOR, A LARGE POSITIVE DIFFERENCE (E.G. 1/ OR GREATER) INDICATES THAT SWITCHES INTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN THIS SECTOR WERE TIMED WELL. A LARGE POSITIVE DIFFERENCE FOR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOURABLE TO PERFORMANCE.

* ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP INCOME. SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET OF TAX, INCOME INFORMATION IS SHOWN ONLY FOR THOSE SECTORS FOR WHICH INCOME FIGURES WERE GIVEN. 'GROSS GAIN' IS BASED ON CAPITAL VALUE ONLY IF NO INCOME FIGURE WAS PROVIDED FOR THAT SECTOR.

8. PERFORMANCE OF OVERSEAS SECTOR

SOURCE OF PERFORMANCE	AMOUNT OF GAIN (£000) (NET OF NEW MONEY)	MONEY-WEIGHTED RATE OF RETURN (%) *
STRATEGY (RETURN FROM INDEX - AT OLD EXCH RATE + PENALTY)	-103.9	-2.07
SELECTION OF SECURITIES (RETURN IN EXCESS OF INDEX -AT OLD EXCH RATES + PENALTY)	-134.5	-2.69
CHANGE IN PREMIUM (EXCHANGE RATE (FROM £1=1.23 TO £1= 1.13 - AT OLD PREMIUM PENALTY)	507.3	10.13
TOTAL PROFIT SINCE BEGINNING OF REVIEW PERIOD	268.9	5.37

* AS A PERCENTAGE OF AN AVERAGE INVESTMENT IN THIS SECTOR DURING THE REVIEW PEROID OF £5007462. THE ABOVE GAINS AND RETURNS DO NOT INCLUDE ANY UN-INVESTED INCOME.

****INPUT ERROR : ANALYSIS OF INCOME PERFORMANCE RELATIVE TO MODEL FUND WAS REQUESTED BUT INCOME EARNED FIGURES ON A SECTOR BASIS WERE NOT PROVIDED FOR THE FUND.

FIGURE 11-II.3 CONTINUED

Table 8 plus an error message indicating an inconsistency in input options

RECEIPTS AND ALLOCATIONS DURING REVIEW PERIOD

FIGURE 11-II.3
CONTINUED

18. RECEIPTS AND ALLOCATIONS BY SECTOR

RECEIPTS

SOURCE	AMOUNT (£)	% OF INITIAL FUND
NET CONTRIBUTIONS	4846067	11.25
INVESTMENT INCOME-	COMPLETE FIGURES NOT PROVIDED	
GILTS	225706	.53
OTH FIXD INT	0	0
EQUITIES	230204	.54
OVERSEAS	0	0
PROPTY TST	0	0
CASH	156809	.36
TOTAL INCOME (MAIN FUND)	597936	1.39
EXCLUDED SECTOR	-0	0
TOTAL INCOME	597936	1.39
TOTAL RECEIPTS	5444003	12.63

ALLOCATIONS

SOURCE	AMOUNT (£)		% OF INITIAL FUND
NET PURCHASES -			
GILTS	2676000		6.21
OTH FIXD INT	-36000		-.08
EQUITIES	2651000		6.15
OVERSEAS	1388000		3.22
PROPTY TST	0		0
TOTAL PURCHASES (MAIN FUND)	6679000		15.50
EXCLUDED SECTOR	0		0
TOTAL PURCHASES		6679000	15.50
INCREASE IN CASH		-1632933	-4.25
PAYMENTS TO TRUSTEES		597936	1.39
TOTAL ALLOCATIONS		5444003	12.63

19. RECEIPTS AND ALLOCATIONS BY TIME

MONTH	RECEIPTS: NET CONTRIBUTIONS	RECEIPTS: INVESTMENT INCOME (NET OF ANY REPAID)	RECEIPTS: TOTAL (£)	RECEIPTS: TOTAL AS % OF INITIAL FUND	ALLOCATIONS: NET PURCHASES (MAIN FUND)	ALLOCATIONS: INCREASE IN CASH	ALLOCATIONS: NET PURCHASES IN EXCLUDED SECTOR	ALLOCATIONS: TOTAL (£)	ALLOCATIONS: TOTAL AS % OF INITIAL FUND
JUL	2110535	0	2110535	4.90	-1863000	3973535	-0	2110535	4.90
AUG	1809120	0	1809120	4.20	2.04000	-694880	-0	1809120	4.20
SEP	926412	0	926412	2.15	3538000	-2611588	-0	926412	2.15
TOTALS	4846067	0	4846067	11.25	6679000	-1832933	0	4846067	11.25

Calling routine in main part of PRFORM2

```
C
C PERFORM INVESTMENT SIMULATION FOR THIS FUND
C
C  IF INCOME FIGURES ARE UNAVAILABLE,DO SEPARATE SIMULATION WITH ACTUAL
C     INVESTMENT TRANSACTION PARAMETERS TO CALCULATE NOTIONAL INCOME 'SIMINC'
 2403 IF( INCOM_X.EQ.BLANK ) GOTO 2406
      IF( INCOM_T.EQ.BLANK ) GOTO 2406
      CALL SIMUL(4,6,TOTVAL,GROSIN,REPAID,1)
      WRITE(4,2004)
 2004 FORMAT(/,25HSIMULATED NOTIONAL INCOME)
      WRITE(4,1001) ( ( SIMINC(I,J),J=1,9 ),I=1,N )
C  ADJUST SIMULATED INCOME TO BE CONSISTENT WITH KNOWN FIGURES.
      CALL ADJUST(SIMINC,GROSIN)
      WRITE(4,4070) ( ( I,( SIMINC(I,J),J=1,9 ) ),I=1,N+1 )
C
C
      SUBROUTINE ADJUST(SIMINC,GROSIN)
      REAL NUM
      INTEGER SIMINC(13,9),GROSIN(13,9),N,S,PARTAL(6),TOTLIN,
     1 TOTEXT(4),SUM,PARTIN,SKIP(6)
      COMMON N,S
      COMMON /G38/ PARTAL,TOTLIN,TOTEXT,PARTIN
      DATA SKIP /6*0/
C
C  ENSURES NOTIONAL INCOME 'SIMINC' IS CONSISTENT WITH KNOWN INCOME FIGURES
C   CERTAIN ELEMENTS OF 'GROSIN' AS INDICATED BY 'TOTLIN','PARTIN' AND 'PARC
C
      IF( TOTLIN.EQ.TOTEXT(1) .OR. PARTIN.EQ.TOTEXT(1) ) GOTO 201
      IF( TOTLIN.EQ.TOTEXT(2) .OR. PARTIN.EQ.TOTEXT(2) ) GOTO 301
      IF( TOTLIN.EQ.TOTEXT(3) .OR. PARTIN.EQ.TOTEXT(3) ) GOTO 401
      IF( TOTLIN.EQ.TOTEXT(4) ) GOTO 501
C  NO INCOME TOTALS CONSTRAIN INCOME ESTIMATION,SO SUM 'SIMINC'.
      GOTO 901
C  MONTHLY TOTALS FOR WHOLE FUND KNOWN.
  201 DO 1 I=1,N+1
      SIMINC(I,7) = GROSIN(I,7)
    1 CONTINUE
      IF( TOTLIN.EQ.TOTEXT(4) ) GOTO 501
      CALL BYMNTH(SIMINC,SKIP)
      GOTO 901
C  GRAND TOTAL FOR WHOLE FUND OVER ALL MONTHS KNOWN.
  301 SIMINC(N+1,7) = GROSIN(N+1,7)
      IF( TOTLIN.EQ.TOTEXT(4) ) GOTO 501
      CALL GRAND(SIMINC,SKIP)
      GOTO 901
C  SECTOR TOTAL OVER ALL MONTHS KNOWN FOR EACH SECTOR.
  401 DO 2 J=1,7
      SIMINC(N+1,J) = GROSIN(N+1,J)
    2 CONTINUE
      IF( TOTLIN.EQ.TOTEXT(4) ) GOTO 501


      CALL BYSEC(SIMINC,SKIP)
      GOTO 901
C  INCOME FIGURES FOR SECTORS IN 'PARTAL' KNOWN AS WELL AS POSSIBLY TOTALS.
  501 DO 3 J=1,S
      IF( PARTAL(J).EQ.0 ) GOTO 3
      DO 4 I=1,N+1
      SIMINC(I,J) = GROSIN(I,J)
    4 CONTINUE
    3 CONTINUE
      IF( PARTIN.EQ.TOTEXT(1) ) CALL BYMNTH(SIMINC,PARTAL)
      IF( PARTIN.EQ.TOTEXT(2) ) CALL GRAND(SIMINC,PARTAL)
      IF( PARTIN.EQ.TOTEXT(3) ) CALL BYSEC(SIMINC,PARTAL)
  901 CALL SUMMAT(SIMINC)
      RETURN
      END
C
C
      SUBROUTINE BYMNTH(TABLE,SKIP)
      REAL NUM
      INTEGER TABLE(13,9),SKIP(6),N,S,SUM,FIXD
      COMMON N,S
C
C  ADJUSTS 'TABLE' TO BE CONSISTENT WITH MONTHLY TOTALS, IGNORING SECTORS
C    IN 'SKIP'.
C
      DO 4 I=1,N
      FIXD = 0
      SUM=0
      DO 5 J=1,S
      IF( SKIP(J).NE.0 ) GOTO 101
C THIS SECTOR'S FIGURES NOT KNOWN.
      SUM = SUM + TABLE(I,J)
      GOTO 5
  101 FIXD = FIXD + TABLE(I,J)
    5 CONTINUE
C 'SUM' IS TOTAL NOTIONAL INCOME OF UNKNOWN SECTORS FOR THIS MONTH.
      NUM = FLOAT( TABLE(I,7) - FIXD ) / FLOAT(SUM)
      DO 6 J = 1,S
      IF( SKIP(J).NE.0 ) GOTO 6
      CALL RATIO(I,I,J,J,TABLE,NUM)
    6 CONTINUE
    4 CONTINUE
      RETURN
      END
```

```
C
C
      SUBROUTINE GRAND(TABLE,SKIP)
      REAL NUM
      INTEGER TABLE(13,9),SKIP(6),N,S,SUM,FIXD
      COMMON N,S
C
C  ADJUSTS 'TABLE' TO BE CONSISTENT WITH GRAND TOTAL, IGNORING SECTORS
C   IN 'SKIP'.
C
      WRITE(4,1000) SKIP
 1000 FORMAT(/,27HSKIP SECTORS WITH NON-ZEROS,6I5)
      FIXD = 0
      SUM = 0
      DO 10 J=1,S
      IF( SKIP(J).NE.0 ) GOTO 101
C THIS SECTOR'S FIGURES NOT KNOWN.
      DO 11 I=1,N
      SUM = SUM + TABLE(I,J)
   11 CONTINUE
      GOTO 10
  101 FIXD = FIXD + TABLE(N+1,J)
   10 CONTINUE
C 'SUM' IS TOTAL OF ALL NOTIONAL INCOME OF UNKNOWN SECTORS.
      NUM = FLOAT( TABLE(N+1,7) - FIXD ) / FLOAT(SUM)
      WRITE(4,1010) TABLE(N+1,7),FIXD,SUM,NUM
 1010 FORMAT(12HKNOWN TOTAL=,I10,21HSUM OF KNOWN SECTORS=,I10,/,
     1 23HSUM OF UNKNOWN SECTORS=,I10,11HSO RATIO IS,F10.4)
      DO 12 J=1,S
      IF( SKIP(J).NE.0 ) GOTO 12
      CALL RATIO(1,N,J,J,TABLE,NUM)
   12 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE BYSEC(TABLE,SKIP)
      REAL NUM
      INTEGER TABLE(13,9),SKIP(6),N,S,SUM
      COMMON N,S
C
C ADJUSTS 'TABLE' TO BE CONSISTENT WITH SECTOR TOTALS, IGNORING SECTORS

C    IN 'SKIP'.
C
      DO 8 J=1,S
C IF FIGURES FOR THIS SECTOR ARE KNOWN, DO NOT ADJUST.
      IF( SKIP(J).NE.0 ) GOTO 8
      SUM=0
      DO 9 I=1,N
      SUM = SUM + TABLE(I,J)
    9 CONTINUE
      NUM = FLOAT( TABLE(N+1,J) ) / FLOAT(SUM)
      CALL RATIO(1,N,J,J,TABLE,NUM)
    8 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE RATIO(ROW1,ROW2,COL1,COL2,TABLE,NUM)
      REAL NUM
      INTEGER TABLE(13,9),ROW1,ROW2,COL1,COL2
C
C  ADJUSTS EACH ENTRY IN 'TABLE' FOR ROWS 'ROW1' TO 'ROW2' AND COLUMNS 'COL1'
C    TO 'COL2' BY RATIO 'NUM'.
C
      WRITE(4,1000) ROW1,ROW2,COL1,COL2,NUM
 1000 FORMAT(37HRATIO PARAMETERS ROW1,ROW2,COL1,COL2=,4I10,/,
     1 4HNUM=,F10.4)
      WRITE(4,1010) ( ( TABLE(I,J),J=1,9 ),I=1,4 )
 1010 FORMAT(9I10)
      DO 1 I=ROW1,ROW2
      DO 2 J=COL1,COL2
      TABLE(I,J) = FLOAT( TABLE(I,J) ) * NUM
    2 CONTINUE
    1 CONTINUE
      RETURN
      END
```

COMPUTER ROUTINES CONCERNED WITH OVERSEAS SECTOR INVESTMENT SIMULATION

On the left below is the calling routine in the main part of PRFORM2 which calls subroutine OVSEAS. Subroutine OSINV appears in Appedix 11-I.

```
C
C ANALYSE OVERSEAS SECTOR PERFORMANCE
C
C ONLY DO IF REQUIRED
 1707 IF( OSEAS.GT.5 ) GOTO 3302
      IF(PRINT3.NE.0 ) GOTO 3302
      OSVAL = AVALU(1,OSEAS)
      OSSIZE = FLOAT(AVALU(1,OSEAS))
      RTEMP1 = FLOAT( AVALU(2,OSEAS) )
      GRATE = RATE(1,1)
      ERATE = RATE(N+2,1)
C  TEMP1 = 1 IS INITIAL EXCHANGE RATES AND PENALTY.  TEMP1 =2 IS ACTUAL
C     RATES BUT INITIAL PENALTY. TEMP1=3 IS ACTUAL RATES AND ACTUAL PENA
      DO 61 TEMP1 = 1,3
      IF( TEMP1.EQ.3 .AND. PENEX.EQ.BLANK ) GOTO 3401
C USE SIMULATED NOTIONAL INCOME IF OPTED TO.
      IF( INCOPT.EQ.BLANK ) CALL OVSEAS(II,TEMP1,OSVAL,GROSIN,REPAID,
     1                                  SIMVAL)
      IF( INCOPT.NE.BLANK ) CALL OVSEAS(II,TEMP1,OSVAL,SIMINC,SIMINC,
     1                                  SIMVAL)
      OSVALU(TEMP1) = SIMVAL
   61 CONTINUE
C COMPUTE PENALTY CHANGE COMPONENT.
      OSPREM(1) = OSVALU(3) - OSVALU(2)
      GOTO 3501
C IF PENALTY HAS NOT CHANGED , SET COMPONENTS APPROPRIATELY.
 3401 OSVALU(3) = OSVALU(2)
      OSPREM(1) = 0.0
C COMPUTE OTHER COMPONENTS
 3501 WRITE(4,1079) OSPREM(1)
 1079 FORMAT(25HPENALTY CHANGE COMPONENT=,F10.3)
      OSSEL(1) = RTEMP1 - OSVALU(3)
      OSEXCH(1) = OSVALU(2) - OSVALU(1)
      WRITE(4,6080) OSSEL(1)
 6080 FORMAT(20HSELECTION COMPONENT=,F10.3)
      WRITE(4,6090) OSEXCH(1)
 6090 FORMAT(25HEXCHANGE RATE COMPONENT=,F10.3)
      OSPRFT(1) = RTEMP1 - FLOAT(OSVAL) - FLOAT( APURCH(N+1,OSEAS) )
      WRITE(4,6100) OSPRFT(1)
 6100 FORMAT(13HTOTAL PROFIT=,F13.3)
      OSSTRT(1) = OSVALU(1) - FLOAT(OSVAL) - FLOAT( APURCH(N+1,OSEAS) )
      WRITE(4,6110) OSSTRT(1)
 6110 FORMAT(20HSTRATEGIC COMPONENT=,F13.3)
      OSSIZE = OSSIZE + AVAM(OSEAS) - AVPAID(OSEAS)
      WRITE(4,6120) OSSIZE
 6120 FORMAT(10HNEW SIZE=,F14.2)
      RTEMP1 = OSSIZE / 100.0
C COMPUTE COMPONENTS AS PERCENTAGES
      OSPRFT(2) = OSPRFT(1) / RTEMP1
      OSSEL(2) = OSSEL(1) / RTEMP1
      OSEXCH(2) = OSEXCH(1) / RTEMP1
      OSPREM(2) = OSPREM(1) / RTEMP1
      OSSTRT(2) = OSSTRT(1) / RTEMP1
      WRITE(4,6130) OSPREM(2),OSSEL(2),OSEXCH(2),OSPRFT(2),OSSTRT(2)
 6130 FORMAT(25HCOMPONENTS AS PERCENTAGES,/,5X,5F12.2)
      GOTO 3301
 3302 WRITE(4,1140)
 1140 FORMAT(21HANALYSIS NOT REQUIRED)
```

```
C
C
C
C
      SUBROUTINE OVSEAS(II,FLAG,OSVAL,GROS,N,REPAID,SIMVAL)
      REAL PENLTY(14),PRMPEN(14),RATE(14,3),WAIT,VALUNT(6),INDEX(14,6),
     1  NM(6),OSRATE(3),OSMINC(3),SIMVAL,EXCH(14,3)
     2  ,AVWGHT(12),NINDEX(12,6),OSMINC
      INTEGER FLAG,K,J,N,OSVAL,II,OSEAS,S,APURCH(13,9),SECTR(6),
     1 REPAID(13,9),BLANK,INCMEX,PAIDEX,VALPAD(3),III,
     2 GROSIN(13,9),SECTEX(2,6),SIMINC(13,9),INCOPT
      COMMON N,S
      COMMON /G1/ NINDEX,SIMINC,BLANK,K,
     1  NM,VALUNT,OSMINC
      COMMON /G2/ INDEX
      COMMON /G5/ PRMPEN,OSEAS,OSRATE
      COMMON /G8/ INCMEX,PAIDEX,VALPAD,INCOPT
      COMMON /G12/ SECTR
      COMMON /G15/ APURCH
      COMMON /G17/ RATE
      DATA AVWGHT / 12*0.5 /
C SUBROUTINE TO ANALYSE OVERSEAS SECTOR PERFORMANCE INTO COMPONENTS
C     BY SIMULATION OF ACTUAL INVESTMENT STRATEGY UNDER CERTAIN MARKET
C       CONDITIONS, AS INDICATED BY 'FLAG'.
C DEPENDING ON THE TYPE OF SIMULATION, SET PARAMETERS.
C  FLAG=1 IS INITIAL PENALTY/INITIAL EXCH RATES ; FLAG=2 IS INITIAL PENALTY/
C     ACTUAL EXCH RATES ; FLAG=3 IS ACTUAL PENALTY/ACTUAL EXCH RATES.
      WRITE(4,1000) FLAG,OSVAL
 1000 FORMAT(//,15HSIMULATION TYPE,I5,/,20(1H-),/,15HSTARTING VALUE=,
     1 I5)
      I = 4
      IF(FLAG.GT.2 ) GOTO 101
C SET PENALTIES TO ITS INITIAL VALUE.
      DO 1 K=1,N+2
      PENLTY(K) = PRMPEN(1)
    1 CONTINUE
      GOTO 201
  101 DO 2 K=1,N+2
      PENLTY(K) = PRMPEN(K)
    2 CONTINUE
  201 WRITE(4,1010) ( PENLTY(J),J=1,N+2 )
 1010 FORMAT(14HPENALTY VALUES,/,2(5X,6F10.3,/) )
      IF( FLAG.NE.1 ) GOTO 301
      DO 3 K=1,N+2
      EXCH(K,1) = RATE(1,1)
      EXCH(K,2) = RATE(1,2)
    3 CONTINUE
      GOTO 401
  301 DO 4 K=1,N+2
      DO 4 J=1,2
      EXCH(K,J) = RATE(K,J)
    5 CONTINUE
    4 CONTINUE
  401 WRITE(4,1020) ( EXCH(I,1),I=1,N+2 )

 1020 FORMAT(13HPREMIUM RATES,/,2(5X,6F10.3,/) )
      WRITE(4,1030) ( EXCH(I,2),I=1,N+2 )
 1030 FORMAT(14HORDINARY RATES,/,2(5X,6F10.3,/) )
      CALL EXCHNG(EXCH,PENLTY)
      WRITE(4,1040) ( EXCH(I,3),I=1,N+2 )
 1040 FORMAT(15HPENALISED RATES,/,2(5X,6F10.3,/) )
C SET PARAMETERS FOR SUBROUTINE 'OSINV'.
      VALUNT(OSEAS) = FLOAT( OSVAL ) / INDEX(1,4)
C FOR EACH MONTH DO SIMULATION.
      DO 6 K=1,N
      WRITE(4,1060) K
 1060 FORMAT(//,9HMONTH NO.,I3)
      NM(OSEAS) = FLOAT( APURCH(K,OSEAS) )
      DO 7 J=1,3
      OSRATE(J) = EXCH(K+1,J)
    7 CONTINUE
      WRITE(4,1050) VALUNT(OSEAS),NM(OSEAS)
 1050 FORMAT(23HINITIAL INDEX UNITS=,F12.3,/,10HNEW MONEY=,F12.3)
      CALL OSINV(II,INDEX,AVWGHT,GROSIN,REPAID,0,EXCH,OSMINC,WAIT)
    6 CONTINUE
C PASS RESULT BACK BY MULTIPLYING NUMBER OF INDEX UNITS BY OVERSEAS
C       INDEX VALUE AND APPROPRIATE EXCHANGE RATE.
      WRITE(4,1060) VALUNT(OSEAS),INDEX(N+2,4),EXCH(N+2,3)
 1060 FORMAT(13HTOTAL INDEX UNITS ACCUMULATED=,F14.2,/,
     1 24HCONVERTED AT INDEX LEVEL,F10.2,9H AND RATE,F10.3 )
      SIMVAL = VALUNT(OSEAS) * INDEX(N+2,4) / EXCH(N+2,3)
      WRITE(4,1090) SIMVAL
 1090 FORMAT(23HTO YIELD FINAL VALUE OF,F14.2)
      RETURN
      END
```

COMPUTER ROUTINES CONCERNED WITH RATE OF RETURN ESTIMATION

This page shows the calling routine in the main part of PRFORM2 while the subroutines involved are shown on the next page.

```
C
C COMPUTE  MONEY AND TIME WEIGHTED RATES OF RETURN
C
 3201 RTEMP4 = FLOAT (N)
C   CALCULATE NEW MONEY INTO CASH SECTOR FROM
C       INCOME RETAINED OF OTHER SECTORS.
      DO 534 K=1,N-1
      CASHNM(K) = ( AINCOM(K,7) - PAIDI(K,7) ) -
     1                ( AINCOM(K,S) - PAIDI(K,S) )
  534 CONTINUE
      DO 60 J=1,S
      JJ = SECTR(J)
C  NOTIONAL 1+TWR IN MARKET FOR PURPOSES OF THE CALCULATION IS 'MKTWR'.
C  ALLOW FOR NEWLY PURCHASED SECTORS AND COMPLETELY SOLD SECTORS BY TAKING
C  RETURN OVER ONLY LIFE OF THAT SECTOR VIA S/7 'INDEX'.
C IF ASSESSMENT ON CAPITAL VALUE ONLY, MARKET RETURNS CAPITAL ONLY RETURN.
      IF( INDEX.NE.BLANK .AND. INCOPT.EQ.BLANK ) GOTO 3104
      MKTWR(J) = 1.0 + MODTWR(JJ)
      GOTO 3103
 3104 MKTWR(J) = INDEX( SECTEX(2,J)+2,JJ ) / INDEX( SECTEX(1,J)+1,JJ )
      IF( JJ.EQ.4 ) MKTWR(J) = MKTWR(J) / RATE( SECTEX(2,J)+2,3 )
 3103 WRITE(4,1070) J,MKTWR(J)
 1070 FORMAT(/,6HSECTOR,I3,/,9(1H-),/,20HNOTIONAL FUND 1+TWR=,F10.4)
C   FOR A NON-CASH SECTOR, COMPUT AVERAGE NEW MONEY FROM ACTUAL PURCHASES
C     MADE IN THAT SECTOR. AVERAGE REPAID INCOME = AVERAGE OF ALL INCOME
C     EARNED SINCE ALL INCOME EITHER WITHDRAWN TO CASH OR TO TRUSTEES.
      IF( J.EQ.S ) GOTO 3206
      CALL AVFLOW( APURCH,J,AVNM(J) )
      IF( INCOPT.EQ.BLANK ) CALL AVFLOW( GROSIN,J,AVPAID(J) )
      IF( INCOPT.NE.BLANK ) CALL AVFLOW( SIMINC,J,AVPAID(J) )
      GOTO 3212


C  FOR CASH SECTOR, INCLUDE AS NEW MONEY ALL NON-CASH SECTOR RETAINED
C     INCOME EARNED. AVERAGE REPAID INCOME = ONLY THAT CASH INTEREST
C     WHICH IS REPAID TOTRUSTEES AND TAX.
 3206 DO 533 K = 1,N
      QUANT(K,J) = APURCH(K,J) + CASHNM(K)
  533 CONTINUE
      CALL AVFLOW( QUANT,J,AVNM(J) )
      IF( INCOPT.EQ.BLANK ) CALL AVFLOW( REPAID,J,AVPAID(J) )
      IF( INCOPT.NE.BLANK ) CALL AVFLOW( SIMINC,J,AVPAID(J) )
 3212 WRITE(4,1080) AVNM(J),AVPAID(J)
 1080 FORMAT(14HAV. NEW MONEY=,F14.2,10X,18HAV. REPAID INCOME=,F14.2 )
C   FOR NON-CASH SECTOR, NET GAIN ALLOWS FOR INCOME EARNED AND RECEIVED
C     NOT BEING PLOUGHED BACK INTO SAME SECTOR EXCEPT AS REFLECTED IN
C     'APURCH'. FOR CASH SECTOR, CORRECT FOR INFLOW OF OTHER SECTORS'
C     RETAINED INCOME.
      GAIN(J) = AVALU(2,J) - AVALU(1,J) - APURCH(N+1,J) + GROSIN(N+1,J)
      IF( J.EQ.S ) GAIN(J) = GAIN(J) - CASHNM(N+1) - GROSIN(N+1,J) +
     1  REPAID(N+1,J)
      RTEMP3 = FLOAT( GROSIN(N+1,J) )
      INYLD(J) = RTEMP3 /(FLOAT( AVALU(1,J) ) + AVNM(J) - AVPAID(J) )
      INYLD(J) = ANULIS( INYLD(J),PODAYS ) * 100.0
      IF( GAIN(J).EQ.0 ) GOTO 3205
      INGAIN(J) = FLOAT( GROSIN(N+1,J) ) / FLOAT( GAIN(J) )*100.0
      GOTO 3208
 3205 INGAIN(J) = 0.0
 3208 WRITE(4,1090) GAIN(J),INGAIN(J),INYLD(J)
 1090 FORMAT(14HABSOLUTE GAIN=,I10,9H, PERCENT,F10.3,20H OF WHICH WAS IN
     1COME,16H AND INCOME YIELD=,F10.3)
C   FOR A NON-CASH SECTOR, COUNT ALL INCOME EARNED AS REPAID INCOME. 'TEMP1'.
      IF( J.EQ.S ) GOTO 3209
      TEMP1 = GROSIN(N+1,J)
C IF NOTIONALINCOME OPTION, USE SIMULATED INCOME TO CALCULATE RETURN.
      IF( INCOPT.NE. BLANK ) TEMP1 = SIMINC(N+1,J)
      GOTO 3404
C   FOR CASH SECTOR, REPAID INCOME = CASH INTEREST REPAID TO TRUSTEES AND TAX.
C     ALSO INCLUDE IN TOTAL NEW MONEY RETAINED INCOME FORM OTHER SECTORS
 3209 TEMP1 = REPAID(N+1,J) - CASHNM(N+1)
      IF( INCOPT.NE.BLANK ) TEMP1 = SIMINC(N+1,S)
C APPROXIMATION TO TIME WEIGHTED RETURN UNLESS SECTOR NOT REPRESENTED WHOLE OF
C   REVIEW PERIOD, IN WHICH CASE TWR IS UNDEFINED, SO EQUATE TO MWR.
 3404 IF( AVALU(1,J).EQ.0 .OR. AVALU(2,J).EQ.0 ) GOTO 3102
      RTEMP1 = TROST4 * PROPNS(3,J)
      CALL TWROR( TEMP1,RTEMP1,J,TWR(J) )
C
C   COMPUTE MWR USING GROSSED UP INCOME.
C   FOR CASH SECTOR, NET GAIN IN NUMERATOR OF MWR INCLUDES OTHER SECTOR
C     RETAINED INCOME, REPAID CASH INTEREST TO TRUSTEES, AND THAT PART
C     OF GROSS CASH INTEREST NOT YET REFUNDED.
 3102 CALL MWROR(TEMP1,J,MWR(J) )
      IF( AVALU(1,J).EQ.0 .OR. AVALU(2,J).EQ.0 ) TWR(J) = MWR(J)
      ANTWR(J) = ANULIS( TWR(J),PODAYS )
      ANMWR(J) = ANULIS( MWR(J),PODAYS )
      WRITE(4,1120) ANTWR(J),ANMWR(J)
 1120 FORMAT(13HANNUALISED TWR,MWR=,2F10.4)
   60 CONTINUE
C DO SAME FOR TOTAL FUND
      MKTWR(S+1) = FVALU(S,7) / FLOAT( AVALU(1,S+1) )
      WRITE(4,1130) MKTWR(S+1)
```

```
      WRITE(4,1080) AVNM(S+1),AVPAID(S+1)
      GAIN(S+1) = AVALU(2,S+1)-AVALU(1,S+1)-APURCH(N+1,7) +REPAID(N+1,7)
      INYLD(S+1) = FLOAT( GROSIN(N+1,7) ) /(FLOAT( AVALU(1,S+1) ) +
     1 AVNM(S+1) - AVPAID(S+1) )
      INYLD(S+1) = ANULIS( INYLD(S+1),PODAYS ) * 100.0
      IF( GAIN(S+1).EQ.0 ) GOTO 3207
      INGAIN(S+1) = FLOAT( GROSIN(N+1,7) ) / FLOAT( GAIN(S+1) ) * 100.0
      GOTO 3406
 3207 INGAIN(S+1) = 0.0
 3406 WRITE(4,1090) GAIN(S+1),INGAIN(S+1),INYLD(S+1)
      TEMP1 = REPAID(N+1,7)
C  IF NOTIONAL INCOME OPTION, USE SIMULATED INCOME TO CALCULATE ROR.
C    INCORPORATE IT VIA REPAID INCOME PARAMETER 'TEMP1'.
      IF( INCOPT.NE.BLANK ) TEMP1 = SIMINC(N+1,7)
      CALL TWROR(TEMP1,TROST3,7,TWR(S+1))
      ANTWR(S+1) = ANULIS( TWR(S+1),PODAYS )
C  CALCULATE MWR FOR TOTAL MAIN FUND USING GROSSED-UP INCOME.  ADD THAT
C     PART OF GROSS INCOME WHICH WAS NOT RECEIVED THIS PERIOD.
      CALL MWROR(TEMP1,7,MWR(S+1))
      ANMWR(S+1) = ANULIS( MWR(S+1),PODAYS )
      WRITE(4,1120) ANTWR(S+1),ANMWR(S+1)
C  IF FUND SPECIFIED OWN MODEL PROFILE, PASS TOTAL ROR AS 'MKTOT'.
      MKTOT = MODTWR(7) * 100.0
      ANMOTW = ANMOTW(7)
      IF( MCOFLG.NE.1 ) GOTO 1707
      DO 63 J=1,6


      DUMMY(J) = PROPNS(1,J)
   63 CONTINUE
      CALL TOTROR(DUMMY,MKTOT,PROP)
      ANMKTOT = ANULIS( MKTOT,PODAYS ) * 100.0
```

```
C
C
      SUBROUTINE AVFLOW(QUANT,SECT,AVGE)
      REAL LIFE(7),RTEMP4,WAIT,AVGE
      INTEGER SECT,N,S,K,SECTEX(2,6),QUANT(13,9)
      COMMON N,S
      COMMON /G33/ LIFE,SECTEX
C
C  COMPUTES AVERAGE CASH INJECTIONS 'QUANT' FOR SECTOR 'SECT' USING WEIGHTS
C    BASED ON MID-MONTH TRANSACTIONS AND INVESTMENT LIFE OF THE SECTOR 'LIFE'.
C    AVERAGE RETURNED AS 'AVGE'.
C  'RTEMP4' IS END POINT OF INVESTMENT IN THIS SECTOR.

C
      RTEMP4 = FLOAT(N)
      AVGE = 0.0
C  IF LIFE LESS THAN HALF MONTH LEAVE 'AVGE' AT ZERO.
      IF( LIFE(SECT).LT.0.4 ) RETURN
      IF( SECT.EQ.7 ) GOTO 101
      IF( SECTEX(2,SECT).LT.N ) RTEMP4 = FLOAT( SECTEX(2,SECT) ) + 0.5
C  FOR EACH MONTH IN REVIEW PERIOD ....
  101 WRITE(4,1074) LIFE(SECT),RTEMP4
 1074 FORMAT(13HLIFE OF INVESTMENT=,F10.2,13H AND ENDED AT,F10.2)
      DO 61 K=1,N
      WAIT = ( RTEMP4 - FLOAT(K-1) - 0.5 ) / LIFE(SECT)
      AVGE = AVGE + FLOAT( QUANT(K,SECT) ) * WAIT
   61 CONTINUE
      WRITE(4,1000) AVGE
 1000 FORMAT(13HAVERAGE FLOW=,F14.2)
      RETURN
      END
C
C
      SUBROUTINE TWROR(INCOME,COSTS,SECT,TWR)
      REAL TWR,RTEMP3,AVNM(7),AVPAID(7),FVALU(5,7),MKTWR(7),COSTS
      INTEGER INCOME,APURCH(13,9),AVALU(2,7),N,S,JSECT,SECT,SIM
      COMMON N,S
      COMMON /G15/ APURCH
      COMMON /G34/ AVNM,AVPAID,AVALU,FVALU,MKTWR
C
C  CALCULATES TIME-WEIGHTED ROR 'TWR' OF SECTOR 'SECT' GIVEN TOTAL GROSS
C    INCOME EARNED 'INCOME', AVERAGE NEW MONEY 'AVNM' AND AVERAGE REPAID
C    INCOME 'AVPAID' AND TRANSACTION 'COSTS'  . FOR TOTAL FUND, 'SECT' =7
C
      IF( SECT.EQ.7 ) GOTO 101
      JSECT = SECT
      SIM = 4
      GOTO 201
  101 JSECT=S+1
      SIM=3
  201 RTEMP3 = FLOAT( APURCH(N+1,SECT) - INCOME ) -
     1                    ( AVNM(JSECT) - AVPAID(JSECT) )
      WRITE(4,1000) RTEMP3
 1000 FORMAT(7HC-OBAR=,F14.2)
      TWR = ( FLOAT( AVALU(2,JSECT) ) - RTEMP3 ) / ( ( FVALU(SIM,SECT) +
     1            COSTS*MKTWR(JSECT) ) - RTEMP3 ) * MKTWR(JSECT) - 1.0
      WRITE(4,1109) TWR
 1109 FORMAT(4HTWR=,F14.4)
      RETURN
      END
C
C
      SUBROUTINE MWROR(INCOME,SECT,MWR)
      REAL MWR,AVNM(7),AVPAID(7),FVALU(5,7),MKTWR(7)
      INTEGER SECT,INCOME,JSECT,N,S,AVALU(2,7),APURCH(13,9)
      COMMON N,S
      COMMON /G34/ AVNM,AVPAID,AVALU,FVALU,MKTWR
      COMMON /G15/ APURCH
C
C  CALCULATES MONEY-WEIGHTED ROR 'MWR' OF SECTOR 'SECT' GIVEN TOTAL GROSS
C    INCOME EARNED 'INCOME', AVERAGE NEW MONEY 'AVNM' AND AVERAGE REPAID
C    INCOME 'AVPAID'.  FOR TOTAL FUND, 'SECT'=7
      JSECT=SECT
      IF( SECT.EQ.7 ) JSECT=S+1
      MWR = FLOAT( AVALU(2,JSECT) - AVALU(1,JSECT) - APURCH(N+1,SECT)
     1          + INCOME ) / ( FLOAT( AVALU(1,JSECT) ) + AVNM(JSECT) -
     2                                  AVPAID(JSECT) )
      WRITE(4,1110) MWR
 1110 FORMAT(4HMWR=,F14.4)
      RETURN
      END
```

```
C
C  CALCULATE MODEL FUND RATE OF RETURN OVER CURRENT REVIEW PERIOD UNLESS
C    MODEL FUND ALREADY UPDATED FOR THIS PERIOD. IF UPDATED MODEL HISTORY FILE N
C   DOES NOT EXIST, DO NOT CHARGE FOR TRADING EXPENSE OF PROFILE ADJUSTMENT.
C
      IF( MODFLG.EQ.1 ) GOTO 301
C  FIND CHARGE TO MODEL FUND OF TRADING EXPENSE OF RE-ALIGNMENT OF PROFILE
C  AS 'WAIT'. DO NOT DEDUCT UNTIL COMBINE SECTOR RETURNS INTO MODEL FUND ROR.
      CALL CHARGE(1,1,TOTVAL,WAIT)
  203 WRITE(4,7698) TOTVAL
 7698 FORMAT(7HTOTVAL=,F15.1)
C  PERFORM INVESTMENT SIMULATION. PARAMETERS OF 'SIMUL' SET IN DATA
C    STATEMENTS TO II=5,M=6,GROSIN=REPAID=0,PROPNS(3,J) ALL TO ONE SIXTH.
      CALL SIMUL(II,M,TOTVAL,GROSIN,REPAID,0)
C  FIND TOTAL VALUES OF FINAL PORTFOLIOS
      DO 349 J=1,6
      FVALU(5,J) = VALUNT(J) * INDEX(N+2,J)
      IF( J.EQ.4 ) FVALU(5,4) = FVALU(5,4) / RATE(N+2,3)
      FVALU(5,7) = FVALU(5,7) + FVALU(5,J)
  349 CONTINUE
      WRITE(4,2040) ( FVALU(5,J),J=1,7 )
C  CALCULATE RATES OF RETURN AND ENDING PROFILE OF PORTFOLIO.
      DO 350 J=1,6
      MODTWR(J) = FVALU(5,J) / ( TOTVAL * PROPNS(M,J) ) - 1.0
      ANMDTW(J) = ANULIS( MODTWR(J),PODAYS )
      WRITE(4,1078) J,MODTWR(J)
 1078 FORMAT(/,6HSECTOR,I3,10X,15HMODEL FUND TWR=,F10.5)
  350 CONTINUE
C  COMBINE SECTOR RORS INTO MODEL FUND RORS VIA S/R 'TOTROR', ADJUSTING AFTER-
C  WARDS FOR TRADING EXPENSES. ALSO CALCULATE FINAL PROFILE OF MODEL IN 'PROP'
      CALL TOTROR(MODEL,RTEMP2,PROP)
      MODTWR(7) = (1.0 + RTEMP2) * ( 1.0 - WAIT/TOTVAL ) - 1.0
      ANMDTW(7) = ANULIS( MODTWR(7),PODAYS )
      WRITE(4,1078) PODAYS,MODTWR(7)
  301 CALL MODHST(HIST)
      DO 354 J=1,7
      ANMDTW(J) = ANMDTW(J) * 100.0
  354 CONTINUE
```

```
C
C
      SUBROUTINE TOTROR(PROPN,TROR,FPROP)
      REAL PROPN(6),TROR,ANMDTW(7),MODTWR(7),RTEMP1,FPROP(6),NUMER(6)
      INTEGER N,S,J,SECTR(6),JJ
      COMMON N,S
      COMMON /G12/ SECTR
      COMMON /G25/ ANMDTW,MODTWR
C
C  CALCULATES THE TOTAL ROR 'TROR' OF A FUND WITH NO NEW MONEY CONSISTING
C    OF 6 SECTORS IN PROPORTIONS 'PROPN' GIVEN SECTOR RORS IN 'MODTWR'.
C  ALSO RETURNS FINAL PROPORTIONS 'FPROP'.
C
      RTEMP1 = 0.0
      DO 1 J=1,6
      JJ = SECTR(J)
      NUMER(J) = PROPN(J) * MODTWR(JJ)
      RTEMP1 = RTEMP1 + NUMER(J)
    1 CONTINUE
      TROR = RTEMP1
      DO 2 J=1,6
      FPROP(J) = ( PROPN(J) + NUMER(J) ) / ( 1.0 + TROR )
    2 CONTINUE
      WRITE(4,1000) TROR,FPROP
 1000 FORMAT(10HTOTAL ROR=,F10.4,/,21HFINAL PROPORTIONS ARE,6F10.4)

      RETURN
      END
```

COMPUTER ROUTINES CONCERNED WITH SIMULATED CHARGES

Top left is the calling routine in the main part of PRFORM2. Bottom left is the subroutine to adjust the model fund ROR ex-post for simulated re-alignment charges as given by subroutine CHARGE (which appears in Appendix 11-I).

```
C
C  ACCESS HISTORY FILE FOR MODEL FUND INFORMATION TO CHECK DATE OF LAST
C      UPDATE AND READ ITS PROFILE AT END OF LAST REVIEW PERIOD.
C
C  PARAMETERS FOR PROCESSING OF MODEL FUND

      WAIT = 0.0
      S=6
      DO 345 J=1,5
      PATTN(J) = PATTNI(J)
  345 CONTINUE
      IF( MOHSTX.NE.BLANK ) GOTO 203
      CALL GET(SHTAPE1,OLMODFL)
      READ(RH,8000) MODATE
 8000 FORMAT(2I3,I5)
C  CHECK IF MODEL FUND HISTORY ALREADY UPDATED TO THIS PERIOD (MODFLG=1)
      DO 593 J = 1,3
      IF( MODATE(J).NE.PPDATE(2,J) ) GOTO 201
  593 CONTINUE
      MODFLG = 1
      GOTO 841
C  PRINT ERROR MESSAGE IF UPDATE INCORRECTLY VETOED.
  201 IF( MODUPD.EQ.BLANK ) GOTO 841
      WRITE(WO,8008) MODATE
 8008 FORMAT(///,5X, 35H***INPUT ERROR : UPDATE OF MODEL FUND RATES OF
     1 RETURN UP TO ENDING DATE OF THIS REVIEW PERIOD,/,35X,
     2 63HHAS NOT REQUESTED, YET THESE RATES HAVE BEEN UPDATED TO ONLY,
     3 2I3,I5,1H. )
  841 READ(RH,8011) ( PASTPR(1,J),J=1,6 )
 8011 FORMAT(6F10.5)
      WRITE(4,8012)
 8012 FORMAT(16HPAST PROPORTIONS)
      WRITE(4,8011) ( PASTPR(1,J),J=1,6 )
```

ABOVE: Calling routine to access and process model history file.

BELOW: Callling routine to access fund's history file.

```
C
C  LOCATE HISTORY FILE FOR THIS FUND
C
 2404 IF( HISTEX.NE.BLANK ) GOTO 2405
      CALL LOCATE( OLDHST,TEMP1 )
      IF( TEMP1.EQ.3 ) GOTO 9986
```

BELOW: Calling routine to process fund's history data.

```
C
C  DO HISTORICAL ANALYSIS
C
C   SET UP PARAMETERS FOR UPDATE SUBROUTINE AND LATER OUTPUT SUBROUTINES
 3301 TPOLCY = POLICY(2,7)
      TINSTR = INSTRT(2,7)
      TSUSTR = SUSTRT(2,7)
      TSTRT  = STRAT(2,7)
      TSCTSL = SCTSEL(2,7)
      TSCYSL = SCYSEL(2,7)
      TPROFT = PROFIT(2,7)
      IF( HFLAG.NE.3 ) GOTO 1705
      CALL UPDATE
```

```
C
      SUBROUTINE MODHST(HIST)
      REAL MODTHR(7),PASTHR(36),RORHST(12,7),PPOP(6),PASTPR(4,6),
     1 ANMDTH(7),RTEMP1,MODTAB(7,5),MODCUM(7,5),MCDANU(7,5),ANULIS,
     2 MODMAD(7)
      INTEGER PPDATE(2,3),MODUPD,J,BLANK,MODATC(3),TOTPD,PRO(12),
     1 NOBS,HSTDAT(12,3),PODAYS,TEMP1,WC,R,WH,PH,LASTOT(3),
     2 MODFLG,DAYS,PATTN(5),DAYNUM(12),MTHNUM(12),MONDAT(5,3),
     3 DATOUT(6,3),ANUALPRIST(2),MOHSTX,NUMDFL,K1
      COMMON /647/ PATTN,DAYNUM,MTHNUM
      COMMON /610/ PRO
      COMMON /611/ WH,PH
      COMMON /616/ PPDATE
      COMMON /667/ WO,R
      COMMON /621/ LASTOT,PASTPR
      COMMON /624/ MODUPD,MODATC,PPOP,MODFLG,MODTAB,MOHSTX,NUMDFL,MODMAD
      COMMON /625/ ANMDTH,MODTHR
      COMMON /623/ DATOUT,MONDAT
      COMMON /630/ MODCUM,MCDANU
      COMMON /635/ PODAYS
      DATA BLANK /6H      /
C
C  UPDATES MODEL FUND'S HISTORY FILE AND PRODUCES HISTORY AVERGAES ACCORDING
C    TO PATTERN OF ACCUMULATION 'PATTN', UPDATED FILE SAVED LATER IN MAIN PROG
C
C  READ RORS FOR PAST 12 ANALYSES
      DAYS = PODAYS
C  ADJUST PATTERN FOR ACCUMULATION IF HISTORY FILE ALREADY UPDATED
      DO 1 I = 1,5
      PATTN(I) = PATTN(I) + MODFLG
      IF( PATTN(I).GT.12 ) PATTN(I) = 12
    1 CONTINUE
      IF( MOHSTX.EQ.HIST(1) ) RETURN
      IF( MOHSTX.EQ.HIST(2) ) GOTO 101
      GOTO 201
C  SET PAST HISTORY INFO TO 0 AND -1 OIF CREATING NEW HISTORY FILE.
  101 DO 11 K=1,12
      DO 12 J=1,3
      HSTDAT(K,J) = 0
      RORHST(K,J) = -1.0
   12 CONTINUE
      DO 13 J=4,7
      RORHST(K,J) = -1.0
   13 CONTINUE
      PRO(K) = 0
   11 CONTINUE
      TOTPD = 0
      NOBS = 0
      GOTO 301
  201 READ(RH,1020) TOTPD
 1020 FORMAT(I10)
      DO 2 I=1,12
      READ(RH,1030) ( HSTDAT(I,J),J=1,3 ),PRO(I),( RORHST(I,J),J=1,7 )
 1030 FORMAT(2(I5,I9,/,7F10.5))
      WRITE(4,1030) ( HSTDAT(I,J),J=1,3 ),PRO(I),( RORHST(I,J),J=1,7 )
    2 CONTINUE
C  READ ALL PAST TOTAL THRS AND ASSOCIATED PERIOD LENGTHS.
      READ(RH,1020) NOBS
      WRITE(4,3000) NOBS
 3000 FORMAT(5HNOBS=,I10)
      IF( NOBS.EQ.0 ) GOTO 5000
      READ(RH,1040) ( ( TWDAY(J),PASTHR(J) ),J=1,NOBS )
 1040 FORMAT( 4(I10,F10.5) )
      WRITE(4,1040) ( ( TWDAY(J),PASTHR(J)),J=1,NOBS )
C  IF NO UPDATE REQUESTED, NOTE MODEL FUND ROR'S FOR USE IN OUTPUT
C    AS MARKET ROR'S.
 5300 IF( MODFLG.EQ.0 ) GOTO 5000
      DO 9 J=1,7
      MODTHR(J) = RORHST(1,J)
      ANMDTH(J) = ANULIS( RORHST(1,J),PODAYS ) * 100.0
    9 CONTINUE
C  PRODUCE COMPOUNDED RATES OF RETURN IN CASE OF FUTURE REQUEST BY A FUND.
 5000 K1 = MODFLG + 1
      CALL COMPND(K1,RORHST,MODTAB)
      WRITE(4,2070) ( ( MODTAB(I,J),J=1,5),I=1,7 )
 2070 FORMAT(19HAND RETURNED AS,/,7(5F10.4,/) )
      DO 10 I=1,5
      TEMP1 = PATTN(I)
      DO 14 J=1,3
      MONDAT(I,J) = HSTDAT(TEMP1,J)
   14 CONTINUE
   10 CONTINUE
      CALL CMPNOW(MODTAB,MODTHR,MODCUM)
      WRITE(4,1050) ( ( MODCUM(I,J),J=1,5 ),I=1,7 )
 1050 FORMAT(29HCOMBINED WITH CURRENT RESULTS,/,7(5F10.4,/) )
```

```
      CALL CMPANU(KS,MODTAB,RORHST,MODANU)
      WRITE(4,1060) ( ( MODANU(I,J),J=1,5 ),I=1,7 )
 1060 FORMAT(1H0ANNUALIZED A/E RATES,/,7(5F10.4,/) )
C PRODUCE RISK ESTIMATES.
      CALL RISK(RORHST,ANMTW,MODMAD)
      IF( MODUPD.NE.BLANK ) GOTO 5200
C  UPDATE INFORMATION.
  300 TOTPD = TOTPD - PRD(12) + DAYS
C MOVE EACH FIELD BACK ONE ANALYSIS INTO THE PAST.
      DO 3 I = 0,10
      PRD(12-I) = PRD(12-I-1)
      DO 4 J=1,3
      HSTDAT(12-I,J) = HSTDAT(12-I-1,J)
      RORHST(12-I,J) = RORHST(12-I-1,J)
    4 CONTINUE
      DO 5 J=4,7
      RORHST(12-I,J) = RORHST(12-I-1,J)
    5 CONTINUE
    3 CONTINUE
C  RECORD RESULTS FOR THIS REVIEW PERIOD.
      HSTDAT(1,1) = RPDATE(2,1)
      HSTDAT(1,2) = RPDATE(2,2)
      HSTDAT(1,3) = RPDATE(2,3)
      DO 6 J=1,3
      RORHST(1,J) = MODTWR(J)
      HSTDAT(1,J) = RPDATE(1,J)
      PASTPR(1,J) = PROP(J)
    6 CONTINUE
      DO 7 J=4,7
      RORHST(1,J) = MODTWR(J)
    7 CONTINUE
      PASTPR(1,4) = PROP(4)
      PASTPR(1,5) = PROP(5)
      PASTPR(1,6) = PROP(6)
      PRD(1) = DAYS
C  RECORD UPDATED RESULTS
 5200 WRITE(WH,1000) MODATE,( PASTPR(1,J),J=1,6 )
 1000 FORMAT(2X,I5,/,6F10.5)
      WRITE(WH,1020) TOTPD
      DO 8 I=1,12
      WRITE(WH,1030) ( HSTDAT(I,J),J=1,3 ),PRD(I),( RORHST(I,J),J=1,7)
    8 CONTINUE
      IF( MODUPD.NE.BLANK ) GOTO 5100
      TEMP1 = NOBS + 1
      WRITE(WH,1020) TEMP1
      IF( NOBS.EQ.0 ) GOTO 5400
      WRITE(WH,1040) ( (TWDAY(J),PASTWR(J)),J=1,NOBS),DAYS,MODTWR(7)
      GOTO 10000
 5100 WRITE(WH,1020) NOBS
      WRITE(WH,1040) ( (TWDAY(J),PASTWR(J)),J=1,NOBS )
      GOTO 10000
 5400 WRITE(WH,1040) DAYS,MODTWR(7)
10000 RETURN
      END
C
C
      SUBROUTINE LOCATE(FILE,FLAG)
      REAL PASTPR(4,6)
      INTEGER PFNUM,FILNUM,PLACE,LASTDT(3),BLANK,HSTMSG,RPDATE(2,3),
     1 FLAG,WH,RH,REPEAT,FLAG1,FILE
      COMMON /G11/ WH,RH
      COMMON /G16/ RPDATE
      COMMON /G20/ PFNUM,PLACE,HSTMSG
      COMMON /G21/ LASTDT,PASTPR
      DATA BLANK /6H      /
C
C  LOCATES THE HISTORY FILE FOR FUND 'PFNUM' ON OLD HISTORY FILE.
C
      REPEAT = 0
      FLAG1 = 0
C*************SYSTEM DEPENDENT*************ACCESS OLD HISTORY FILE
      CALL GETPF(INTAR1,FILE)
 4101 WRITE(4,2010)
 2010 FORMAT(23HACCESS OLD HISTORY FILE)
      READ(RH,5102      ) FILNUM
 5102 FORMAT(I13)
      WRITE(4,2020) FILNUM
 2020 FORMAT(7X,15HWITH PF NUMBER=,I10)
      IF( FILNUM.EQ.PFNUM ) GOTO 4201
      IF( FILNUM.EQ.PLACE ) GOTO 1009
      IF( FILNUM.EQ.0 ) GOTO 1000
      CALL NXTHST
      GOTO 4101
 4201 WRITE(4,2040) FILNUM
 2040 FORMAT(40HFOUND REQUIRED HISTORY FILE, WITH PF NO.,I10)
      PLACE = FILNUM
      WRITE(4,3000) PLACE
 3000 FORMAT(22HPLACE MARKED AS PF NO.,I10)
      READ(RH,5200      ) LASTDT
 5200 FORMAT(2I3,I5)
C  CHECK IF HISTORY FILE ALREADY UPDATED FOR THIS PERIOD. (WHENCE 'HSTMSG'=1
      DO 66 J=1,3
      IF( LASTDT(J).NE.RPDATE(2,J) ) GOTO 4301
   66 CONTINUE
      HSTMSG = 1
      WRITE(4,2050) HSTMSG
 2050 FORMAT(7HHSTMSG=,I5)
      FLAG1 = 2
      GOTO 4401
 4301 WRITE(4,2050) HSTMSG
      FLAG1 = 2
 4401 READ(RH,5000) ( ( PASTPR(I,J),J=1,6),I=1,4 )
 5000 FORMAT(6F10.5)
      WRITE(4,5010) ( ( PASTPR(I,J),J=1,6 ),I=1,4 )
 5010 FORMAT(1HPAST PROPORTIONS,/,4(6F10.5,/) )
      GOTO 1800
C 'REPEAT' ALLOWS ONLY ONE COMPLETE SEARCH OF HISTORY FILE FOR THIS FUND.
 1000 REPEAT = REPEAT + 1
      IF( REPEAT.GT.1 ) GOTO 1700
      REWIND RH
      GOTO 4101
 1009 CALL NXTHST
 1700 FLAG1= 3
 1800 FLAG = FLAG1
      RETURN
      END
C
C
      SUBROUTINE UPDATE
      REAL MWRHST(12,7),TWRHST(12,7),CMPHST(12,5),TWR(7),
     1 TWTAB(7,5),MWR(7),MWTAB(7,5),CMPTAB(7,5),TPOLCY,TINSTR,TSUSTR,
     2 TCTSL,MFSIZE(2),RTEMP1,TPROFT,TSTRT,PASTWR(36),
     3 PASTPR(4,6),FINALP(4,6),TWCUM(7,5),MWCUM(7,5),TWANU(7,5),
     4 MWANU(7,5),SELTAB(7,5),SELHST(12,6),SCYSEL(2,7),MAD(7),
     5 ANMWR(7),ANTWR(7)
      INTEGER HISTEX,BLANK,HIST(2),K,N,J,HSTDAT(12,3),PRD(12),RH,WH,
     1 FILNUM,PFNUM,TEMP1,PRINT8,RPDATE(2,3),
     2 HSTMSG,I,PATTN(5),INTVAL,JJ,SECTR(6),TOTPD,PODAYS,DAYNUM(12),
     3  MTHNUM(12),S,TEMP2,PLACE,DATOUT(5,3),TWDAY(36),NOBS,PRINT0,
     4 PRINT5,PRINT6,LASTDT(3),MOMDAT(5,3),PRINT9,K1,TEMP3
      COMMON /G3/ NOS
      COMMON /G5/ HISTEX,HIST,PRINT8,PRINT5,
     1 PRINT6,FINALP,PRINT9,PRINT0,CMPTAB,SELTAB,SCYSEL,MAD
      COMMON /G6/ PATTN,DAYNUM,MTHNUM
      COMMON /G9/ TWCUM,MWCUM
      COMMON /G10/ PRD
      COMMON /G11/ WH,RH
      COMMON /G12/ SECTR
      COMMON /G13/ ANMWR,ANTWR
      COMMON /G16/ RPDATE
      COMMON /G17/ MFSIZE
      COMMON /G18/ TPOLCY,TINSTR,TSUSTR,TSTRT,TSCTSL,TSCYSL,TPROFT
      COMMON /G20/ PFNUM,PLACE,HSTMSG
      COMMON /G21/ LASTDT,PASTPR
      COMMON /G22/ TWR,MWR
      COMMON /G26/ DATOUT,MOMDAT
      COMMON /G29/ TWANU,MWANU
      COMMON /G35/ PODAYS
      DATA BLANK / 6H      /
C SUBROUTINE STEPS CARRY OUT UPDATING OF HISTORY FILE FOR EACH FUND
C   IN TURN AND CALCULATE DESIRED CUMULATIVE RESULTS AS SPECIFIED
C   BY 'PATTN'.
C MODIFY PATTERN FOR ACCUMULATION IF FILE ALREADY UPDATED TO THIS PERIOD.
      DO 1 K=1,5
      PATTN(K) = PATTN(K) + HSTMSG
    1 CONTINUE
      K1 = HSTMSG + 1
C ONLY DO IF REQUIRED
      IF( HISTEX.EQ.HIST(1)) GOTO 1800
      IF( HISTEX.EQ.HIST(2) ) GOTO 3801
      GOTO 4401
 3801 WRITE(4,2060)
 2060 FORMAT(23HCREATE NEW HISTORY FILE)
      DO 63 K=1,12
      DO 63 J=1,3
C SET PAST HISTORY INFORMATION TO ZEROES AND MINUS ONES IF THIS RUN IS TO
C   CREATE A NEW HISTORY FILE.
      HSTDAT(K,J) = 0
      MWRHST(K,J) =-1.0
      TWRHST(K,J) =-1.0
      CMPHST(K,J) =0.0
```

```
      SELHST(K,J) = 0.0
   64 CONTINUE
      DO 65 J=4,6
      MWRHST(K,J) = -1.0
      TWRHST(K,J) = -1.0
      SELHST(K,J) = 0.0
   65 CONTINUE
      MWRHST(K,7) = -1.0
      TWRHST(K,7) = -1.0
      CMPHST(K,4) = 0.0
      CMPHST(K,5) = 0.0
      PRD(K) = 0
   63 CONTINUE
      TOTPD = 0
      NOBS = 1
      GOTO 3901
C READ HISTORIC INFORMATION
 4401 WRITE(4,2060)
 2060 FORMAT(/,37HREAD REQUIRED HISTORY FILE AS FOLLOWS)
      READ(RH,5300)                                  TOTPD,MHFSIZ
 5300 FORMAT(I10,F10.1)
      WRITE(4,5300) TOTPD,MHFSIZ
      DO 67 I = 1,12
      READ(RH,5400) ( HSTDAT(I,J),J=1,3 ), PRD(I),( MWRHST(I,J),J=1,7)
 5400 FORMAT(2I3,I5,I9,/,7F10.5)
      WRITE(4,5400) ( HSTDAT(I,J),J=1,3 ),PRD(I),( MWRHST(I,J),J=1,7 )
      READ(RH,5500) ( TWRHST(I,J),J=1,7 ),( CMPHST(I,J),J=1,5 ),
     1 ( SELHST(I,J),J=1,6 )
 5500 FORMAT(7F10.5,/,5F10.5,/,6F10.5 )
      WRITE(4,5500) ( TWRHST(I,J),J=1,7 ),( CMPHST(I,J),J=1,5 ),
     1 ( SELHST(I,J),J=1,6 )
   67 CONTINUE
C  READ FIELDS CONTAINING DETAILS OF PAST TOTAL FUND TWRS
      READ(RH,5102) NOBS
 5102 FORMAT(I10)
      READ(RH,3020) ( STWDAY(J),PASTWR(J)),J=1,NOBS )
 3020 FORMAT( 2(I10,F10.5) )
C  DETERMINE DATES OF PAST PERIODS FOR WHICH RESULTS WILL BE ACCUMULATED.
      DO 82 I = 1,5
      TEMP1 = PATTN(I)
      DO 83 J=1,3
      DATOUT(I,J) = HSTDAT(TEMP1,J)
   83 CONTINUE
   82 CONTINUE
      IF( PRINT5.NE.0 .AND. PRINT6.NE.0 .AND. PRINT9.NE.0 ) GOTO 3901
C  IF DO NOT WANT CUMULATIVE PAST RORS PRINTED, SKIP THAT ANALYSIS.
      IF( PRINT5.NE.0 .AND. PPINT9.NE.0 ) GOTO 1700
C USE HISTORIC INFORMATION TO PRODUCE DESIRED STATISTICS. FIRST COMPOUND
C      RATES OF RETURN.
      WRITE(4,2140)
 2140 FORMAT(5H1*MWR)
      CALL COMPND(K1,TWRHST,TWTAB)
      WRITE(4,2070) ( ( TWTAB(I,J),J=1,5 ),I=1,7 )
 2070 FORMAT(15HAND RETURNED AS,7(5F10.4,/))
      WRITE(4,2150)
 2150 FORMAT(7,5H1*MWR)
      CALL COMPND(K1,MWRHST,MWTAB)
      WRITE(4,2070) ( ( MWTAB(I,J),J=1,5 ),I=1,7 )
C  COMBINE CUMULATIVE PAST RORS WITH CURRENT RESULTS, IF THIS TABLE
C     REQUESTED, TO GET 'TWCUM' AND 'MWCUM'.
      IF( PRINT5.NE.0 ) GOTO 1704
      CALL CMPNOW(TWTAB,TWR,TWCUM)
      WRITE(4,2065) ( ( TWCUM(I,J),J=1,5 ),I=1,7 )
 2065 FORMAT(20HCOMBINED WITH CURRENT RESULTS,/,7(5F10.4,/) )
      CALL CMPNOW(MWTAB,MWR,MWCUM)
      WRITE(4,2065) ( ( MWCUM(I,J),J=1,5 ),I=1,7 )
 1704 IF( PRINT9.NE.0 ) GOTO 1709
C  FIND AVERAGE ANNUAL RORS, BY ANNUALIZING CUMULATIVE PAST RORS.
      CALL CMPANU(K1,TWTAB,MWRHST,TWANU)
      WRITE(4,2075) ( ( TWANU(I,J),J=1,5 ),I=1,7 )
 2075 FORMAT(11HANNUALIZED AVERAGES,/,7(5F10.4,/) )
      CALL CMPANU(K1,MWTAB,MWRHST,MWANU)
      WRITE(4,2075) ( ( MWANU(I,J),J=1,5 ),I=1,7 )
C  IF THIS TABLE HAS BEEN REQUESTED, FIND TIME WEIGHTED AVERAGE OF COMPON
 1709 IF( PRINT9.NE.0 ) GOTO 3901
      DO 71 I=1,7
      DO 72 J=1,5
      CMPTAB(I,J) = 0.0
      SELTAB(I,J) = 0.0
   72 CONTINUE
   71 CONTINUE
C
C  FIND TIME-WEIGHTED ARITHMETIC AVERAGES OF COMONENTS
C
C  FOR EACH PAST PERIOD OF ACCUMULATION.......
      DO 66 J=1,5
      JJ= PATTN(J)
C  FRO EACH SECTOR FIND AVERAGE SELECTION COMPONENT.
      DO 4 I=1,6
      TEMP3 = SECTR(I)
      INTVAL = 0
C  FOR EACH ANALYSIS IN THIS PAST PERIOD......
      DO 5 K=K1,JJ
      TEMP2 = PRD(K)
      IF( TEMP2.EQ.0 ) GOTO 4407
C  IF SECTOR WAS NOT REPRESENTED IN THIS PERIOD, DO NOT INCLUDE IN AVERAGE.
      IF( TWRHST(K,TEMP3).EQ.-1.0 ) GOTO 5
      INTVAL = INTVAL + TEMP2
      SELTAB(I,J) = SELTAB(I,J) + SELHST(K,TEMP3) * FLOAT(TEMP2)
    5 CONTINUE
 4407 IF( INTVAL.EQ.0 ) GOTO 4
      SELTAB(I,J) = SELTAB(I,J) / FLOAT(INTVAL)
    4 CONTINUE
C  FIND AVERAGES OF OTHER COMOONENTS.
      INTVAL = 0
C FOR EACH ANALYSIS IN THIS PAST PERIOD....
      DO 69 K=K1,JJ
      TEMP2 = PRD(K)
      IF( TEMP2.EQ.0 ) GOTO 4405
      INTVAL = INTVAL + TEMP2
C FOR EACH COMPONENT...
      DO 70 I=1,5
      CMPTAB(I,J) = CMPTAB(I,J) + CMPHST(K,I) * FLOAT( TEMP2 )
   70 CONTINUE
   69 CONTINUE
 4405 IF( INTVAL.EQ.0 ) GOTO 68
      DO 73 I=1,5
      CMPTAB(I,J) = CMPTAB(I,J) / FLOAT( INTVAL )
   73 CONTINUE
   68 CONTINUE
      WRITE(4,2080) ( ( CMPTAB(I,J),J=1,5 ),I=1,5 )
 2080 FORMAT(/,32HTIME WEIGHTED AVERAGE COMPONENTS,/,5(5F12.4,/))
C COMPUTE TOTAL STRATEGY AND SECTOR SELECTION AVERAGE COMPONENTS
      DO 74 J=1,5
      CMPTAB(2,J) = CMPTAB(2,J) + CMPTAB(3,J)
      CMPTAB(7,J) = CMPTAB(6,J) + CMPTAB(1,J)
   74 CONTINUE
      WRITE(4,2090) ( ( CMPTAB(I,J),J=1,5 ),I=6,7 )
 2090 FORMAT(13HTOTALS OF WEIGHTED COMPONENTS=,2(5F12.4,/))
C  PRODUCE RISK ESTIMATES IF NOT VETOED.
 3901 IF( PRINT10.NE.0 ) GOTO 4001
      CALL RISK(TWRHST,ANTWR,MAD)
C NOW UPDATE HISTORY FILE, FOR EACH PAST ANALYSIS STARTING WITH THE MOST
C          DISTANT.
 4001 IF( PRINT8.NE.BLANK ) GOTO 1705
      WRITE(4,3010) TOTPD
 3010 FORMAT(13HTOTPD BEFORE UPDATE=,I10)
      TOTPD = TOTPD - PRD(12) + PDDAYS
      DO 75 I=1,10
C FOR EACH FIELD, MOVE IT BACK ONE ANALYSIS INTO THE PAST
      DO 76 J=1,3
      HSTDAT(12-I,J) = HSTDAT(12-I-1,J)
      MWRHST(12-I,J) = MWRHST(12-I-1,J)
      TWRHST(12-I,J) = TWRHST(12-I-1,J)
      CMPHST(12-I,J) = CMPHST(12-I-1,J)
      SELHST(12-I,J) = SELHST(12-I-1,J)
   76 CONTINUE
      CMPHST(12-I,4) = CMPHST(12-I-1,4)
      CMPHST(12-I,5) = CMPHST(12-I-1,5)
      DO 77 J=5,6
      MWRHST(12-I,J) = MWRHST(12-I-1,J)
      TWRHST(12-I,J) = TWRHST(12-I-1,J)
      SELHST(12-I,J) = SELHST(12-I-1,J)
   77 CONTINUE
      MWRHST(12-I,7) = MWRHST(12-I-1,7)
      TWRHST(12-I,7) = TWRHST(12-I-1,7)
      PRD(12-I) = PRD(12-I-1)
   75 CONTINUE
C RECORD RESULTS FOR THIS REVIEW PERIOD
      MHFSIZ = MFSIZE(1)
      LASTOT(1) = RPDATE(2,1)
      LASTOT(2) = RPDATE(2,2)
      LASTOT(3) = RPDATE(2,3)
      DO 90 I=1,4
      DO 91 J=1,6
      PASTPR(I,SECTR(J)) = FINALP(I,J)
   91 CONTINUE
   90 CONTINUE
      DO 78 I=1,6
      MWRHST(1,J) = -1.0
      TWRHST(1,J) = -1.0
      SELHST(1,J) = 0.0
```

```
   79 CONTINUE
      MWRHST(1,7) = -1.0
      TWRHST(1,7) = -1.0
      DO 79 J=1,S
      JJ = SECTR(J)
      MWRHST(1,JJ) = MWR(J)
      TWRHST(1,JJ) = TWR(J)
      SELHST(1,JJ) = SECYSEL(2,J)
   79 CONTINUE
      MWRHST(1,7) = MWR(S+1)
      TWRHST(1,7) = TWR(S+1)
      WRITE(4,2100) ( MWRHST(1,J),J=1,7 ),( TWRHST(1,J),J=1,7 ),
     1 ( ( FINALP(I,J),J=1,6 ),I=1,4 )
 2100 FORMAT(2,23HRESULTS FOR THIS PERIOD,/,3HMWR,7F10.4,/,3HTWR,7F10.
     1 /,17HFINAL PROPORTIONS,/,4(6F10.5,/) )
      DO80 J=1,3
      HSTDAT(1,J) = RPDATE(1,J)
   80 CONTINUE
      PRD(1) =  PODAYS
      WRITE(4,2110)(HSTDAT(1,J),J=1,3 ),TOTPD
 2110 FORMAT(6HHSTDAT,2I3,I5,7H TOTPD=,I10)
      CMPHST(1,1) =  TPOLCY
      CMPHST(1,2) =  TINSTR
      CMPHST(1,3) =  TSUSTR
      CMPHST(1,4) =  TSCYSL
      CMPHST(1,5) = TPROFT
      WRITE(4,2120) ( CMPHST(1,J),J=1,5 ),( SELHST(1,J),J=1,6 )
 2120 FORMAT(10HCOMPONENTS,6F12.4,/,6F12.4)
C OUTPUT UPDATED INFORMATION TO NEW MASTER FILE
 1705 WRITE(WH,5600  ) PERNUM,LASTOT,
     1 ( ( PASTPR(I,J),J=1,6 ),I=1,4 ),TOTPD,HMFSIZ
 5600 FORMAT(F10,/,2I3,I5,/,4(6F10.5,/ ),(10,F10.1)
      DO 81 I=1,12
      WRITE(WH,5400) ( HSTDAT(I,J),J=1,3 ),PRD(I),( MWRHST(I,J),J=1,7
      WRITE(WH,5500) ( TWRHST(I,J),J=1,7 ),( CMPHST(I,J),J=1,5 ),
     1 (SELHST(I,J),J=1,6 )
   81 CONTINUE
      IF( HISTEX.EQ.HISTT(2) ) GOTO 1651
      IF( PRINTO.EQ.BLANK ) GOTO 1707
      TEMP2 = NOBS + 1
      WRITE(WH,5102) TEMP2
      WRITE(WH,3020) ( (TWDAY(J),PASTWR(J)),J=1,NOBS ),PODAYS,TWR(S+1
      GOTO 1600
 1707  WRITE(WH,5102) NOBS
       WRITE(WH,3020) ( (TWDAY(J),PASTWR(J)),J=1,NOBS )
      GOTO 1600
C  IF CREATING A NEW HISTORY FILE, RECORD ONLY CURRENT TOTAL TWR.
 1651 WRITE(WH,5102) NOBS
      WRITE(WH,3020) PODAYS,TWR(S+1)
 1600 RETURN
      END
C
C
      REAL FUNCTION ANULIS(ROR,PODAYS)
      REAL ROR
      INTEGER PODAYS
C
C  ANNUALISES RATE OF RETURN 'ROR' GIVEN IT APPLIES TO REVIEW PERIOD
C   'PODAYS'.
C
      ANULIS = ( 1.0 + ROR ) ** ( 365.0/FLOAT(PODAYS) ) - 1.0
      RETURN
      END
C
C
      SUBROUTINE NXTHST
      REAL RTEMP1
      INTEGER IDUM(4),WH,RH,I,J,TEMP1,NOBS
      COMMON /S11/ WH,RH
C SKIP TO JUST BEFORE NEXT FILEHDR .
      READ(RH,5000) IDUM,RTEMP1
 5000 FORMAT(2,4I5,/,4(/),I1),F10.1)
      WRITE(4,2030) IDUM
 2030 FORMAT(32HSKIP THIS RECORD, BEGINNING WITH,/,2I3,I5,I10)
      DO 101 I=1,12
      READ(RH,5100)
 5100 FORMAT( 5(/) )
  101 CONTINUE
      READ(RH,5200) NOBS
      IF( NOBS.EQ.0 ) RETURN
 5200 FORMAT(I10)
      READ(RH,5300) ( (TEMP1,RTEMP1),J=1,NOBS )
 5300 FORMAT( 4(I10,F10.5) )
      RETURN
      END
C
C
      SUBROUTINE ACCUM(K1,K2,ROR,TAB)
      REAL ROR(12,7),TAB(7)
      INTEGER K1,K2,J,N,S
      COMMON N,S
C SUBROUTINE TO ACCUMULATE RATES OF RETURN 'ROR' OVER A PERIOD 'K1' TO 'K2'.
C  COMPOUNDED 1+ROR 'S RETURNED AS 'TAB'.
C
      DO 3 J=1,7
      TAB(J) = 1.0
    3 CONTINUE
C FOR EACH PERIOD,.....
      DO 1 K=K1,K2
      DO 2 J=1,7
C  IF ROR FOR THIS SECTOR IN THIS PERIOD IS UNDEFINED,SKIP THIS PERIOD
C    ALTOGETHER IN THE CALCULATIONS FOR THIS SECTOR.
      IF( ROR(K,J).EQ.-1.0 ) GOTO 2
C ACCUMULATE ROR FOR THE SECTORS
      TAB(J) = TAB(J) * ( 1.0 + ROR(K,J) )
    2 CONTINUE
    1 CONTINUE
      WRITE(4,1000) ( TAB(J),J=1,7 )
 1000 FORMAT(7F10.4)
      RETURN
      END
C
C
      SUBROUTINE COMPND(K1,ROR,TABROR)
      REAL ROR(12,7),TABROR(7,5),TAB(7)
      INTEGER PATTN(5),K1,PRD(12),I,II,MTHNUM(12),DAYNUM(12),N,S
      COMMON N,S
      COMMON /S4/ PATTN,DAYNUM,MTHNUM
      COMMON /S10/ PRD
C SUBROUTINE TO COMPOUND AND ANNUALISE PAST RATES OF RETURN FOR FIVE
C      SPECIFIC GROUPS OF CONSECUTIVE PAST ANALYSES (SPECIFIED BY 'PATTN'(
C
C FOR EACH GROUP OF ANALYSES........
      DO 1 I=1,5
      II = PATTN(I)
      WRITE(4,1000) II
 1000 FORMAT(/,29HCOMPOUND RATES OF RETURN OVER,I5,
     1 18H PAST ANALYSES ARE )
C CALCULATE ANNUALISED COMPOUNDED RATES FOR THIS GROUP.
      CALL ACCUM(K1,II,ROR,TAB)
C STORE IN TABLE ACCORDING TO RELEVANT PAST ANALYSIS.
      DO 2 II=1,7
      TABROR(I,II) = TAB(II)
    2 CONTINUE
    1 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE CMPNOW(TABROR,NOWROR,RORCUM)
      REAL TABROR(7,5),NOWROR(7),RORCUM(7,5)
      INTEGER N,S,I,J,SECTR(6),TEMP1
      COMMON N,S
      COMMON /S12/ SECTR
C
C  COMBINES CURRENT ROR'S  'NOWROR' WITH CUMULATIVE PAST RORS 'TABROR'
C   TO PRODUCE COMPOUND RORS AS PERCENTAGES 'RORCUM'.
C  MARK 'TEMP1' AS LOCATION OF LAST SECTORS EVEN IF ALL 6 SECTORS ARE REPRESENTE
      TEMP1 = 0
      IF( S.EQ.6 ) TEMP1 = 7
      DO 2 J=1,S
      JJ = SECTR(J)
      IF( JJ.GT.5 ) GOTO 1001
      RORCUM(JJ,I) = ( TABROR(JJ,I) * ( 1.0 + NOWROR(J) ) - 1.0 ) *
     1 100.0
      GOTO 1
C  FOR SECTORS NOT REPRESENTED THIS PERIOD, EQUATE TO CUMULATIVE PAST RETURN
 1001 IF( J.EQ.7 ) GOTO 1101
      RORCUM(JJ,I) = TABROR(JJ,I) * 100.0
      IF( J.GE.S+1 ) GOTO 1101
      GOTO 1
 1101 RORCUM(7,I) = ( TABROR(7,I) * ( 1.0 + NOWROR(J) ) - 1.0 ) *
     1 100.0
    1 CONTINUE
    2 CONTINUE
      RETURN
      END
```

```
C
C
      SUBROUTINE CMPANU(K1,RORTAB,RORHST,ANROR)
      REAL RORTAB(7,5),RORHST(12,7),ANROR(7,5)
      INTEGER I,J,K,PATTN(5),DAYNUM(12),MTHNUM(12),II,TOTPD(7),PRD(12),
     1 K1
      COMMON /G4/ PATTN,DAYNUM,MTHNUM
      COMMON /G10/ PRD
C
C  ANNUALISES CUMULATIVE PAST RORS 'RORTAB' TO PERCENTAGES 'ANROR'
C
C  FOR EACH PERIOD OF ACCUMULATION......
      DO 1 I=1,5
      II = PATTN(I)
C  ....PROCESS EACH SECTOR.
      DO 2 J=1,7
      TOTPD(J) = 0
C  EXAMINE PAST RORS DURING PERIOD OF ACCUMULATION TO DETERMINE RELEVANT
C     PERIOD FOR ANNUALISATION FACTOR
      DO 3 K=K1,II
      IF( RORHST(K,J).EQ.-1.0 ) GOTO 3
      TOTPD(J) = TOTPD(J) + PRD(K)
    3 CONTINUE
      IF( TOTPD(J).EQ.0 ) GOTO 11
      ANROR(J,I) = ANULIS( RORTAB(J,I)-1.0,TOTPD(J) ) * 100.0
      GOTO 2
C  IF SECTOR WAS UNREPRESENTED OVER WHOLE PERIOD OF ACCUMULATION, SET
C     ANNUALISED RETURN TO ZERO.
   11 ANROR(J,I) = 0.0
    2 CONTINUE
C  REPEAT IT ALL FOR NEXT PERIOD OF ACCUMULATION
    1 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE RISK(RORHST,ROR,MAD)
      REAL MAD(7),RTEMP1,RORHST(12,7),ANROR(12,7),ANULIS,ROR(7)
      INTEGER TOTPRD,I,J,PRD(12),K,SECTR(6),PODAYS,REP,N,S
      COMMON N,S
      COMMON /G10/ PRD
      COMMON /G12/ SECTR
      COMMON /G35/ PODAYS
C
C  COMPUTES MEAN ABSOLUTE DEVIATION 'MAD' OF PAST RORS 'RORHST' (AFTER
C  BEING ANNUALISED) AND CURRENT ANNUALISED ROR 'ROR' FROM THEIR ARITHMETIC
C  AVERAGE.  AVERAGE ROR AND AVERAGE DEVIATION ARE WEIGHTED BY TIME.
C
C  ANNUALISE PAST RETURNS
      DO 1 K=1,12
      DO 2 J=1,7
      ANROR(K,J) = 0.0
      IF( RORHST(K,J).EQ.-1.0 ) GOTO 2
      ANROR(K,J) = ANULIS( RORHST(K,J),PRD(K) ) * 100.0
    2 CONTINUE
    1 CONTINUE
      DO 5 J=1,7
      MAD(J) = 0.0
      TOTPRD = 0
      RTEMP1 = 0.0
      DO 6 K=1,12
C  DO NOT INCLUDE ANY PERIOD WHEN SECTOR WAS UNREPRESENTED.
      IF( RORHST(K,J).EQ.-1.0 ) GOTO 6
      RTEMP1 = RTEMP1 + ANROR(K,J) * FLOAT( PRD(K) )
      TOTPRD = TOTPRD + PRD(K)
    6 CONTINUE
C INCLUDE CURRENT RESULT IF SECTOR CURRENTLY REPREASENTED.
      IF( J.EQ.7 ) GOTO 101
      DO 3 I=1,5
      IF( SECTR(I).EQ.J ) GOTO 201
    3 CONTINUE
C SECTOR NOT CURRENTLY REPRESENTED, SO DO NOT COUNT.
      REP = 0
      GOTO 401
  101 I=I+1
C SECTOR CURRENTLY REPRESENTED.
  201 RTEMP1 = RTEMP1 + ROR(I) *100.0 * FLOAT( PODAYS )
      TOTPRD = TOTPRD + PODAYS
      REP = 0
C IF SECTOR NOT REPRESENTED AT ALL EITHER PAST OR CURRENTLY, LEAVE 'MAD(J)'=0
  401 WRITE(4,1000) J,TOTPRD
 1000 FORMAT(/,23HRISK MEASURE FOR SECTOR,I3,5X,7HTOTPRD=,I10)
      IF( TOTPRD.EQ.0 ) GOTO 5
      RTEMP1 = RTEMP1 / FLOAT(TOTPRD)
      WRITE(4,1010) RTEMP1
 1010 FORMAT(8HAVERAGE=,F10.4)
      DO 7 K=1,12
      IF( RORHST(K,J).EQ.-1.0 ) GOTO 7
      MAD(J) = MAD(J) + ABS( ANROR(K,J) - RTEMP1 ) * FLOAT( PRD(K) )
    7 CONTINUE
C IF SECTOR CURRENTLY REPRESNTED, INCLUDE DEVIATION OF CURRENT ROR.
      IF( REP.NE.0 ) GOTO 501
      MAD(J) = MAD(J) + ABS( ROR(I)*100.0 - RTEMP1 ) * FLOAT(PODAYS)
  501 MAD(J) = MAD(J) / FLOAT(TOTPRD)
      WRITE(4,1020) MAD(J)
 1020 FORMAT(4HMAD=,F10.4)
    5 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE HSTEOF(PASTFL,NEWHST)
      INTEGER PASTFL,WH,RH,NEWHST
      COMMON /G11/ WH,RH
C
C PUTS '0' ON 'PASTFL' AS END OF FILE MARKER AND SAVES 'PASTFL'.
C
      WRITE(WH,1000)
 1000 FORMAT(9X,1H0)
C*****************SYSTEM DEPENDENT SAVE ******************************
      REWIND WH
      CALL SAVE(5HTAPE2,PASTFL)
      PASTFL = NEWHST
      RETURN
      END
```

PROGRAM

"WRITER"

```
      PROGRAM WRITER(OUTPUT,TAPE3,TAPE2=OUTPUT)
      NOLIST
C
C ***********************************************************************
C
C  REPORT WRITER FOR PROGRAM 'PREFORM'.   GENERATES A REPORT FOR EACH OF
C  ANY NUMBER OF FUNDS WHOSE PERFORMANCE ANALYSIS RESULTS FROM 'PREFORM'
C  ARE ON INPUT FILE 'TAPE1'.   LENGTH AND CONTENTS OF REPORT ARE DETERMINED
C  BY PRINT OPTIONS ON FUND'S SECTION OF INPUT FILE.
C
C ***********************************************************************
C
      REAL PRMPEN(14),MFSIZE(2),PROFIT(4,6),DUMMY(6),OSRATE(3),
     3NINCOM(5,7),PROFIT(2,7),SCYSTL(2,7),SUSTRT(2,7),TSTRT(2,7),
     4   STRAT(2,7),SCTSEL(2,7),TPROFT(4),ISCYSL(4),ISCTSL(4),
     5   ,ISCTSL(4),AVLN(7),MKTWR(7),INGAIN(7),TWR(7),ANTWR(7),ANMWR(7)
      REAL   OSPRL(2),OSSEL(2),OSEXCH(2),OSSIZE,
     6 OSPPFT(2),OSSTRT(2),CAPTAB(7,5),PTEMP1,FVALU(5,7),MWR(7)
      REAL POLICY(2,7),IPOLCY(4),ANMKTW(7),PTEMP2,TWTAB(7,5),
     2  TOTVAL,PTEMP3,IPOLCY,TINSTRT,TSUSTRT,TSTRT,
     3 TSCTSL,TSCYSL,TPROFT,TAB(7,7),INVLD(7),
     4 MODTWR(7),ANMOTW(7),MKTOT,PTEMP4,TWCUM(7,5),
     5 MWCUM(7,5),TWANU(7,5),MWANU(7,5),MODCUM(7,5),MODANU(7,5),
     6 ANDLIS,SELTAB(7,5),TPCST3,TPCST4,MAD(7),MODMAD(7),
     7 AMKTOT,OSRATE,ENRATE
      INTEGER P,M,N,RPDATE(2,3),K,MTHNUM(12),
     1PODAYS,DAYNUM(12),OSEAS,PRINT1,PRINT2,PRINT3,PRINT4,PENUM,S,SECTR(
     26),AVALU(2,7),APURCH(13,9),AINCOM(13,9),PAIDI(13,9),PRINT9,
     3 TEMP2,GAIN(7),NUTSGO,PATTN(5),PAGE,TEMP1,XLAST,PRINT8,
     5 DATOUT(5,3),PRINT5,PRINT6,PRINT7,HFLAG,TAX,
     6 GROSIN(13,9),CASHNM(13),REPAID(13,9),MONDAT(5,3),MODPR,
     7 INCOPT,TOTLIN,SIMINC(13,9),MOHSTX,TOTEXT(4),PARTIN,PARTAL(4)
      INTEGER PFNAME(7),HISTEX,EXCLNA(7),POLEX,MODDES(7),INCMEX,PENEX,
     1 PAIDEX,VALPAD(3),PRINT8,POLDES(7),NMAMT(13,2),NAME(7,2),BLANK,
     2  ADHED(3),RETHED(3),PREFNT(2),RETFNT(2),PRFASP,RETASP,MODFLG
      COMMON N,P
      COMMON /G4/ PATTN,DAYNUM,MTHNUM
      COMMON /G5/ PRMPEN,OSEAS,OSRATE
      COMMON /G6/ M,P
      COMMON /G7/ PAGE,PFNAME
      COMMON /G8/ INCMEX,PAIDEX,VALPAD,INCOPT
      COMMON /G9/ TWCUM,MWCUM
      COMMON /G12/ NAME,SECTR
      COMMON /G13/ ANMWR,ANTWR
      COMMON /G14/ AINCOM,TOTVAL
      COMMON /G15/ APURCH
      COMMON /G16/ RPDATE
      COMMON /G17/ MFSIZE
      COMMON /G18/ TPOLCY,TINSTR,TSUSTR,TSTRT,TSCTSL,TSCYSL,TPROFT
      COMMON /G19/ POLEX
      COMMON /G25/ ANMOTW,MODTWR
      COMMON /G26/ CASHNM
      COMMON /G27/ TWR,MWR
      COMMON /G28/ DATOUT,MOHDAT
      COMMON /G29/ TWANU,MWANU
      COMMON /G30/ MODCUM,MODANU
      COMMON /G35/ PODAYS
      COMMON /G36/ PARTAL,TOTLIN,TOTEXT,PARTIN
      DATA ABHLD,BTHLD,PRFASP,RETASP,PREFNT,RETFNT
     1 /5HABSOL,5HOTHL  ,5HGAINS,5H    R,5HRETURN,5H     ,6HPROFIT,
     2 6HRETURN,6H  E '0,6HJ'S' ,6HPERCEN,6HTAGES' /
      DATA BLANK / 6H      /
      DATA
     1  VALPAD,NAME(1,1),NAME(1,2),NAME(2,1),NAME(2,2),NAME(3,1),
     2  NAME(3,2),NAME(4,1),NAME(4,2),NAME(5,1),NAME(5,2),NAME(6,1),
     3 NAME(6,2),NAME(7,1),NAME(7,2),TOTEXT
     4 / 6HALL    ,6HNONE    ,
     5  6HSOME  ,6H  EQUI,6HTIES  ,6H    GIL,6HTS    ,6HOTH 2X,6HNO INT,
     6  6H  OVER,6HGEAS  ,6H PROPT,6HY TST ,6H     CA,6HSH    ,6H MAIN ,
     7 6H FUND ,6HMONTHL,6HGRAND ,6HSECTOR,6HPARTIA /
      DATA DAYNUM,P,M
     4  /33,28,31,30,31,30,31,31,30,31,30,31,3,2 /
C
C  READ RESULTS INPUT FILE FOR NEXT FUND.
C
C RE/IEW PERIOD DATA
 4901 PAGE = 0
      READ(R,8005) PFNUM
 8005 FORMAT(I10)
C
C  IF REACHED END OF INFORMATION, STOP.
      IF( PFNUM.EQ.0 ) STOP
      READ(R,8010) RPDATE,N,( MTHNUM(I),I=1,N ),PODAYS
 8010 FORMAT( 4(I2,1X),1X,2(I4,1X),2X,I5,12I3,4X,I10 )
      READ(R,8015) PENEX,( PRMPEN(I),I=1,N+2 )
 8015 FORMAT(A6,4X,14F5.2)
C FUND'S RAW DATA
      READ(R,8020) PFNAME,S,SECTR
 8020 FORMAT(7A6,I6,5I1)
      READ(R,8025) POLEX,INCMEX
 8025 FORMAT(7A6,8X,I1)
      READ(R,8030) MODFLG,MODDES
 8030 FORMAT(I6,4X,7A6)
      READ(R,8035) POLEX,POLDES
 8035 FORMAT(A6,4X,7A6)
      READ(R,8040) ( ( AVALU(I,J),J=1,S+1 ),I=1,2 )
 8040 FORMAT(7I10)
      READ(R,8045) ( ( APURCH(I,J),J=1,9 ),I=1,N+1 )
 8045 FORMAT(9I10)
      READ(R,8050) INCMEX,TAX,INCOPT,TOTLIN,PARTIN
 8050 FORMAT( 5(A6,4X) )
      READ(R,8040) PARTAL
      READ(R,8045) ( ( AINCOM(I,J),J=1,9 ),I=1,N+1 )
      READ(R,8055) ( ( NMAMT(I,J),J=1,2 ),I=1,N+1 )
 8055 FORMAT(2I10)
      READ(R,8060) PAIDEX
 8060 FORMAT(A6)
      READ(R,8045) ( ( PAIDI(I,J),J=1,9 ),I=1,N+1 )
      READ(R,8065) PRINT1,PRINT2,PRINT3,PRINT4,PRINT5,PRINT6,PRINT7,
     1                 PRINT9,PRINT8
 8065 FORMAT(9I10,4X,A6)
C DERIVED FUND DATA
      READ(R,8070) TOTVAL,MFSIZE
 8070 FORMAT(3F15.2)
      READ(R,8075) PROFNS
 8075 FORMAT(4F10.4)
      READ(R,8045) ( ( GROSIN(I,J),J=1,9 ),I=1,N+1 )
      READ(R,8045) ( ( REPAID(I,J),J=1,9 ),I=1,N+1 )
      READ(R,8080) ( CASHNM(I),I=1,N+1 )
C COMPONENT INTERMEDIARIES.
      READ(R,8115) NINCOM
 8115 FORMAT(6F15.1)
      READ(R,8120) FVALU
 8120 FORMAT(5F15.1)
      IF( INCOPT.NE.BLANK ) READ(R,8045) SIMINC
C COMPONENTS.
      READ(R,8080) TPOLCY,TINSTR,TSUSTR,TSTRT,TSCTSL,TSCYSL,TPROFT
 8080 FORMAT(7F10.4)
      READ(R,8110) POLICY,INSTRT,SUSTRT,STRAT,SCTSEL,SCYSEL,PROFIT
 8110 FORMAT( 4(F15.1,F10.4) )
      READ(R,8085) OSEAS
      IF( OSEAS.LT.0 .AND. PRINT3.EQ.0 ) READ(R,8105) OSSIZE,
     1          OSSEL,OSPRL,OSEXCH,OSSTRT,OSPRFT,OSRATE,ENRATE
 8105 FORMAT(F15.1,/,4(F10.1,F10.4),/,F15.1,3F10.4)
      IF( PRINT4.NE.0 ) GOTO 4903
      IF( INCMEX.EQ.BLANK ) GOTO 4904
      IF( TOTLIN.EQ.TOTEXT(1) .OR. PARTIN.EQ.TOTEXT(3) ) GOTO 4904
      GOTO 4903
 4904 READ(R,8085) IPOLCY, ISTRGY,ISCTSL,ISCYSL,IPROFT
 8085 FORMAT(12F10.4)
C GAINS AND YIELDS
 4903 READ(R,8080) ( GAIN(J),J=1,S+1 )
      READ(R,8080) ( INGAIN(J),J=1,S+1 )
      READ(R,8080) ( INYLD(J),J=1,S+1 )
C RATES OF RETURN
      READ(R,8080) ( MWR(J),J=1,S+1 )
      READ(R,8080) ( TWR(J),J=1,S+1 )
      READ(R,8080) MODTWR,MKTOT
 8090 FORMAT(8F10.4)
      READ(R,8080) ( ANMWR(J),J=1,S+1 )
      READ(R,8080) ( ANTWR(J),J=1,S+1 )
      READ(R,8080) ANMOTW,AMKTOT
C HISTORY INFORMATION
      READ(R,8095) HISTEX,HFLAG,HSTNGS,PATTN,MOHSTX
 8095 FORMAT(A6,4X,2(I6,4X),5I5,5X,A6)
      IF( HFLAG.NE.0 .OR. HISTEX.NE.BLANK ) GOTO 4902
      READ(R,8100) DATOUT
 8100 FORMAT( 5(I2,1X),1X,5(I4,1X),1X,5(I4,1X) )
      IF( PRINT5.EQ.0 ) READ(R,8080) MWCUM,TWCUM
      IF( PRINT6.EQ.0 ) READ(R,8080) MWANU,TWANU
      IF( PRINT7.EQ.0 ) READ(R,8080) CAPTAB,SELTAB
      IF( PRINT8.EQ.0 ) READ(R,8080) MAD
 4902 IF( MOHSTX.NE.BLANK ) GOTO 1705
      READ(R,8100) MOHDAT
      READ(R,8080) MODCUM,MODANU
      READ(R,8080) MODMAD
C
C PRODUCE OUTPUT FOR CURRENT FUND
C
C TABLE ONE ( NON-OPTIONAL ).
 1705 CALL HEAD
      IF( INCOPT.EQ.BLANK ) CALL OUT1( AVALU(1,S+1),AVALU(2,S+1),
     1 NMAMT(N+1,2),GROSIN(N+1,7),REPAID(N+1,7),APURCH(N+1,8),
```

```
     2 EXLAMT,MINCOM(1,7),FVALU(1,7),EXCLNA,TAX)
       IF( INCOPT.NE.BLANK ) CALL OUT1( AVALU(1,S+1),AVALU(2,S+1),
     1 NMAMT(N+1,9),SIMINC(N+1,7),SIMINC(N+1,7),APURCH(N+1,8),
     2 EXLAMT,MINCOM(1,7),FVALU(1,7),EXCLNA,TAX)
C TABLE NO. (COMPULSORY)
C
      TEMP1 = S + 1
      RTEMP1 = 1.0
      CALL PERCNT(ANMWR,TEMP1,RTEMP1,ANMWR)
      CALL PERCNT(ANTWR,TEMP1,RTEMP1,ANTWR)
      TEMP1 = 7
      CALL PERCNT(MODTWR,TEMP1,RTEMP1,MODTWR)
      CALL OUT2(AMKTOT)
C
C TABLE 3. (COMPULSORY)
      CALL OUT3
C
C TABLE 4. (COMPULSORY)
      CALL HEAD
      RTEMP1 = 1.0
      TEMP1 = S+1
      CALL PERCNT(MWR,TEMP1,RTEMP1,MWR)
      CALL PERCNT(TWR,TEMP1,RTEMP1,TWR)
      CALL OUT4(GAIN,INGAIN,INYLD,MKTOT)
C
C TABLE 5. (OPTIONAL). PRINT IF ANY PERFORMANCE ANALYSIS TO BE PRINTED.
      IF( PRINT1.EQ.0 ) GOTO 4001
      IF( PRINT2.EQ.0 ) GOTO 4001
      IF( PRINT4.EQ.0 ) GOTO 4001
      GOTO 4101
C PRINT FUND PROFILE TABLE
 4001 CALL HEAD
      CALL OUT5(PROPNS,MODDES,POLDES,
     1 MODPR = 1
C
C TABLE 6. (OPTIONAL). SET UP PARAMETERS
 4101 IF( PRINT1.NE.0 ) GOTO 4201
      DO 71 J=1,7
      TAB(1,J) = POLICY(2,J)
      TAB(2,J) = INSTRT(2,J)
      TAB(3,J) = SUSTRT(2,J)
      TAB(4,J) = STRAT(2,J)
      TAB(5,J) = SOTSEL(2,J)
      TAB(6,J) = SOYSEL(2,J)
      TAB(7,J) = PROFIT(2,J)
   71 CONTINUE
      TEMP1 = 6
      CALL HEAD
      CALL OUT67(TEMP1,TAB,RETHED,RETASP,RETONT)
C
C TABLE 7. (OPTIONAL). SET UP PARAMETERS.
 4201 IF( PRINT2.NE.0 ) GOTO 4301
      DO 70 J=1,7
      TAB(1,J) = POLICY(1,J)/ 1000.0
      TAB(2,J) = INSTRT(1,J)/ 1000.0
      TAB(3,J) = SUSTRT(1,J)/ 1000.0
      TAB(4,J) = STRAT(1,J)/ 1000.0
      TAB(5,J) = SOTSEL(1,J)/ 1000.0
      TAB(6,J) = SOYSEL(1,J)/ 1000.0
      TAB(7,J) = PROFIT(1,J)/ 1000.0
   70 CONTINUE
      TEMP1 = 7
      CALL HEAD
      CALL OUT67(TEMP1,TAB,ABHED,PRFASP,PRFONT)
C
C TABLE 8. (OPTIONAL).
 4301 IF( PRINT3.NE.0 ) GOTO 4401
      IF( OSLAG.GT.0 ) GOTO 4501
      CALL HEAD
      CALL OUT8(OSSEL,OSPREM,OSEXCH,OSSTRT,OSPRFT,OSSIZE,PENEX,BGRATE,
     1 ENRATE)
      GOTO 4401
C PRINT ERROR MESSAGE IF REQUESTED OVERSEAS ANALYSIS WITH NO OVERSEAS S
 4501 WRITE(W,8950)
 8950 FORMAT(///,6X,106HERROR MESSAGE **** ANALYSIS OF OVERSEAS SECTOR
     1 PERFORMANCE WAS REQUESTED BUT FUND WAS RECORDED AS HAVING,/,
     2 10X,30HNO SUCH SECTOR.   CHECK INPUT.)
C
C TABLE 9. (OPTIONAL).
 4401 IF( PRINT4.NE.0 ) GOTO 4605
C PRINT WARNING IF INCOME PERFORMANCE ANALYSIS WAS REQUESTED BUT NO
C     INCOME EARNED FIGURES ON A SECTOR BASIS WERE GIVEN.
      IF( INCMEX.EQ.BLANK ) GOTO 4601
      IF( TOTLIN.EQ.TOTEXT(3) ) GOTO 4601
      IF( TOTLIN.EQ.TOTEXT(4) .AND. PARTIN.EQ.TOTEXT(3) ) GOTO 4601
      WRITE(W,8960)
 8960 FORMAT(///,5X,112H**** INPUT ERR R :  ANALYSIS OF INCOME PERFORMANC
     1E RELATIVE TO MODEL FUND WAS REQUESTED BUT INCOME EARNED FIGURES,
     2 /,20X,55HON A SECTOR BASIS WERE NOT PROVIDED FOR THIS FUND. )
      GOTO 4605
 4601 CALL HEAD
      CALL OUT9(IPOLCY,ISTRGY,ISCTSL,ISCYSL,IPROFT)
C
C  DETECT IF AN UPDATE HAS BEEN WRONGLY IGNORED OR REQUESTED, UNLESS ALREADY
C      KNOW THAT COULD NOT FIND HISTORY FILE FOR THIS FUND (VIA 'HFLAG').
 4605 IF( HFLAG.NE.0 .OR. HISTEX.NE.BLANK ) GOTO 4801
      IF( PRINT3.EQ.BLANK ) GOTO 4606
      IF( HSTUPD.EQ.0 .AND. PRINT8.NE.BLANK ) WRITE(W,8865)
 8865 FORMAT(///,10X,106H**** INPUT ERROR:  NO UPDATE OF THIS FUND'S HIST
     1ORY FILE WAS REQUESTED YET ITS HISTORY FILE IS NOT RECORDED.
     2 /,20X,104HAS' HAVING BEEN UPDATED FOR THIS REVIEW PERIOD.   CHECK
     3IF THIS FUND'S HISTORY FILE SHOULD BE UPDATED FOR,   /,20X,
     4 100HTHIS PERIOD'S RESULTS AND IF SO, RESUBMIT INPUT WITH NO UPDAT
     5E OPTION REMOVED FROM LAST FIELD OF PRINT,   /,20X,
     6 12HOPTION CARD. )
C
C  PRINT PAST RESULTS HEADING AND TABLES UNLESS VETOED IN OPTIONS.
 4606 IF( PRINT5.NE.0 .AND. PRINT9.NE.0 .AND. PRINT6.NE.0 ) GOTO 4801
      CALL HEAD
      WRITE(W,8864)
 8864 FORMAT(/,35X,
     1 30HC O M P A R I N G   C O M P A R E D   T O   P A S T   R E S U L T S
     2 ,/,35X,63(1H-) )
C
C TABLES 10 AND 11 AND 12 (OPTIONAL). COMPOUND RATES OF RETURN. TABLE 12 ONLY IF
C     MODEL FUND COMPOUND ANALYSIS ALSO REQUESTED ('TEMP2'=1)
      IF( PRINT5.NE.0 ) GOTO 4701
      IF( HISTEX.NE.BLANK ) GOTO 4607
      CALL PASTCM(MODPR)
      GOTO 4701
 4607 WRITE(W,8860)
 8860 FORMAT(///,10X,                    92H**** INPUT ERROR:  ANALYSIS OF THI
     1S FUND'S HISTORY FILE WAS REQUESTED BUT INPUT ON FIRST CARD,
     2 /,20X,96HFOR THIS FUND  INDICATED THAT NO HISTORY FILE EXISTS FOR
     3THIS FUND.   CHECK INPUT AND RESUBMIT IF,   /,20X,
     4 49HAN UPDATE OF THIS FUND'S HISTORY FILE IS DESIRED. )
      GOTO 4801
C
C  TABLES 13,14 AND 15. AVERAGE ANNUAL RATES OF RETURN. TABLE 15 ONLY
C     IF MODEL ANALYSIS ALSO.
 4701 IF( PRINT5.NE.0 ) GOTO 4705
      IF( HISTEX.NE.BLANK ) GOTO 4607
      CALL PASTAR(MODPR,PRINT5)
C
C TABLE 16 (OPTIONAL).
 4705 IF( PRINT6.NE.0 ) GOTO 5001
      IF( HISTEX.NE.BLANK ) GOTO 4607
      CALL HEAD
      CALL OUT16(CMPTAB,SELTAB,SOYSEL)
C
C  TABLE 17. 'RISK MEASURES' (OPTIONAL).
C
 5001 IF( PRINT7.NE.0 ) GOTO 4801
      IF( HISTEX.EQ.BLANK .AND. HFLAG.EQ.0 ) GOTO 5101
      WRITE(W,8870)
 8870 FORMAT(///,10X,95H**** INPUT ERROR:  RISK MEASURES REQUESTED BUT T
     1HIS FUND WAS INDICATED TO HAVE NO HISTORY FILE. )
      GOTO 4801
 5101 CALL HEAD
      CALL OUT17(MAD,MODMAD,MDHSTX)
C
C TABLES 18 AND 19 (OPTIONAL).
 4801 IF( PRINT7.NE.0 ) GOTO 5201
      CALL HEAD
      CALL OUT18(PAIDI(N+1,9),PAIDI(N+1,S),NMAMT(N+1,1))
      CALL HEAD
      CALL OUT19(PAIDI,NMAMT)
C
C INDICATE END OF REPORT AND GO TO PROCESS NEXT FUND.
C
 5201 CALL ENDPR
      GOTO 4901
C
      END
C
C
      SUBROUTINE HEAD
      INTEGER PAGE,W,R,WH,RH,RPDATE(2,3),PFNAME(7)
      COMMON /C6/ W,R
      COMMON /C7/ PAGE,PFNAME
      COMMON /C16/ RPDATE
```

```
C SUBROUTINE TO PRINT PAGE HEADING
      PAGE = PAGE + 1
      WRITE(W,1000) ( PFNAME(J),J=1,7 ),((RPDATE(I,J),J=1,3),I=1,2 ),
     1     PAGE
 1000 FORMAT(1H1,//,7X,22HPERFORMANCE REPORT FOR,1X,7A6,1X,11HOVER PERIO
     1D,   1X,2I3,I5,2X,2HTO,1X,2I3,I5,7X,4HPAGE,I3,//)
      RETURN
      END
C
C
      SUBROUTINE OUT(INITVL,ENDVL,NN,INC,REPAID,EXLPUR,EXLAMT,
     1 NINC,NENDVL,EXCLNA,TAX)
      REAL RTEMP1,TA31(11),TA32(11),TA33(11),TAB4(11),NINC,NENDVL
      INTEGER TEMP1,INITVL,ENDVL,NN,INC,JJ,EXLAMT,II,RPDATE(2,3),
     1 W,INCMEX,BLANK,PAIDEX,VALPAD(3),TEMP4,EXCLNA(7),NAME(7,2),
     2 SECTR(6),AST,ASTRIX(2),TAX,REPAID,EXLPUR,INCOPT,PARTAL(6),
     3 TOTLIN,TOTEXT(4),PARTIN
      COMMON /G6/ W,P
      COMMON /G8/ INCMEX,PAIDEX,VALPAD,INCOPT
      COMMON /G12/ NAME,SECTR
      COMMON /G16/ RPDATE
      COMMON /G38/ PARTAL,TOTLIN,TOTEXT,PARTIN
      DATA BLANK ,ASTRIX /6H      ,2H  ,2H**/
C
C SUBROUTINE TO PRINT TABLE ONE
C
      AST = ASTRIX(1)
      IF( TAX.NE.BLANK .OR. TOTLIN.NE.BLANK ) AST = ASTRIX(2)
      TEMP1 = 0
      RTEMP1 = FLOAT( INITVL ) / 1000.0
      RTEMP4 = FLOAT( ENDVL ) / 1000.0
C PRINT SUMMARY PAGE, FIRST TABLE ONE, ACTUAL FUND.
      TA31(1) = RTEMP1
      TA31(2)= FLOAT( NN ) / 1000.0
      TA31(3) = FLOAT( INC ) / 1000.0
      TA31(4) = -FLOAT( REPAID ) / 1000.0
      TA31(5) = TA31(3) + TA31(4)
      TA31(6) = RTEMP4 - TA31(5) - TA31(2) - TA31(1)
      TA31(7) = RTEMP4
      CALL PERCNT(TA31,TEMP1,RTEMP1,TA33)
C TABLE ONE,MODEL FUND.
      TA32(1) = TA31(1)
      TA32(2) = TA31(2)
      TA32(3) = NINC / 1000.0
      TA32(4) = TA31(4)
      TA32(5) = TA32(3) + TA32(4)
      TA32(6) = NENDVL / 1000.0 - TA32(5) - TA32(2) - TA32(1)
      TA32(7) = NENDVL / 1000.0
      CALL PERCNT(TA32,TEMP1,RTEMP1,TA34)
C PRINT HEADING.
      WRITE(W,3000)
 3000 FORMAT(/,32X,67HS U M M A R Y   O F   P E R F O R M A N C E   T H
     1I S   P E R I O D,/,32X,67(1H-),///,53X,15H1,   6SOURTH OF ,2A6,
     2  /,53X,27(1H-),//,23X,16HSOURCE OF GROWTH,16X,11HACTUAL FUND,24X,
     3 10HMODEL FUND,/,44X,32(1H-),4X,32(1H-) )
      WRITE(W,3010)
 3010 FORMAT(44X,2(13HAMOUNT (000),2X,17H% OF INITIAL FUND,4X),/,22X,
     1 19(1H-),4X,13(1H-),2X,17(1H-),4X,13(1H-),2X,17(1H-) )
      WRITE(W,3100)NAME(7,1),NAME(7,2),TA31(1),TA31(1),TA32(1),TA34(1)
 3100 FORMAT(/,22X,8HINITIAL ,2A6, 2X,F10.2,9X,F7.2,11X,F10.2,9X,
     1  F7.2 )
      WRITE(W,3200) TA31(2),TA33(2),TA32(2),TA34(2)
 3200 FORMAT(/,22X,13HNET NEW MONEY,9X,F10.2,9X,F7.2,11X,F10.2,9X,F7.2)
C DO NOT PRINT INCOME FIGURES IF THEY WERE NOT INPUT, UNLESS SPECIFIED N
C    OPTION.
      IF( INCMEX.NE.BLANK .AND. INCOPT.EQ.BLANK ) GOTO 5001
      WRITE(W,3300) AST,TA31(3),TA33(3),TA32(3),TA34(3)
 3300 FORMAT(/,22X,15H(INCOME EARNED ,A2,1H),3X,1H(,F10.2,1H),8X,F7.2,
     1 10X,1H(,F10.2,1H),8X,F7.2 )
      GOTO 5101
C  INCOME FIGURES NOT AVAILABLE + NOTNAL INC OPTION NOT SPECIFIED, SO PR
C    NOTIONAL INCOME BUT NOT ACTUAL.
 5001 WRITE(W,3400) TA32(3),TA34(3)
 3400 FORMAT(/,22X,17H(INCOME EARNED* ),7X,9HNOT GIVEN,25X,1H(,F10.2,
     1 1H), 8X,F7.2 )
 5101 IF( INCMEX.EQ.BLANK ) GOTO 5301
      IF( PAIDEX.NE.VALPAD(1) ) GOTO 5301
C RLPAID INCOME FIGURES ARE NOT AVAILABLE. IF NOTNAL INC OPTION, PRINT RE
      IF( INCOPT.NE.BLANK ) GOTO 5301
      WRITE(W,3500)
 3500 FORMAT(22X,18H(INCOME WITHDRAWN),6X,9HNOT GIVEN,25X,9HNOT GIVEN)
      WRITE(W,3600)
 3600 FORMAT(22X,18(1H-),8X,7(1H-),30X,7(1H-) )
      WRITE(W,3700)
 3700 FORMAT(22X,17HREINVESTED INCOME, 6X,13HNOT AVAILABLE, 22X,13HNOT A
     1VAILABLE)
      GOTO 5301
C  RLPAID INCOME FIGURES ARE AVAILABLE, EITHER AS ACTUAL OR NOTIONAL VALUES
 5301 WRITE(W,3800) TA31(4),TA33(4),TA32(4),TA34(4)
 3800 FORMAT(22X,18H(INCOME WITHDRAWN),3X,1H(,F10.2,1H),8X,F7.2,10X,1H(,
     1 F10.2,1H),8X,F7.2 )
      WRITE(W,3900)
      WRITE(W,3900) TA31(5),TA33(5),TA32(5),TA34(5)
 4000 FORMAT(22X,17HREINVESTED INCOME,5X,F10.2,9X,F7.2,11X,F10.2,9X,
     1        F7.2)
 5501 WRITE(W,4100) TA31(6),TA33(6),TA32(6),TA34(6)
 4100 FORMAT(/,22X,12HAPPRECIATION,10X,F10.2,9X,F7.2,11X,F10.2,9X,F7.2)
      WRITE(W,4200)
 4200 FORMAT(22X,18(1H-),4X,13(1H-),2X,17(1H-),4X,13(1H-),2X,17(1H-) )
      WRITE(W,4300) TA31(7),TA33(7),TA32(7),TA34(7)
 4300 FORMAT(22X,15HFINAL MAIN FUND,7X,F10.2,9X,F7.2,11X,F10.2,9X,F7.2)
      WRITE(W,4600)
 4600 FORMAT(22X,18(1H=),4X,13(1H=),2X,17(1H=),4X,13(1H=),2X,17(1H=) )
      IF( INCMEX.EQ.BLANK ) GOTO 5601
      IF( INCOPT.NE.BLANK ) GOTO 5601
      IF( PAIDEX.NE.VALPAD(1) ) GOTO 5601
      WRITE(W,4700)
 4700 FORMAT(/,22X,86H* BECAUSE NO INFORMATION ON INCOME EARNED IS AVAIL
     1ABLE FOR THIS FUND, ASSESSMENT IS ON,/,24X,
     2 8HTHE BASIS OF CAPITAL VALUE ONLY.  (ALL MARKET RATES OF RETURN
     3INCLUDE INCOME HOWEVER.) )
C  PRINT GROSSED-UP INCOME FOOTNOTE IF APPLICABLE.
 5601 IF( AST.NE.ASTRIX(2) ) GOTO 5901
      IF( TAX.EQ.BLANK ) GOTO 5901
      WRITE(W,4800)
 4800 FORMAT(/,22X,84H** BECAUSE INCOME WAS REPORTED ON AN AFTER TAX BAS
     1IS, INCOME OF ACTUAL FUND HAS BEEN,/,26X,
     2 8HGROSSED UP TO A BEFORE-TAX FIGURE IN ADVANCE OF TAX REFUNDS.
     3THIS MAKES IT DIRECTLY,/,26X,10HCOMPARABLE TO THE GROSS INCOME OF
     4 THE MODEL FUND.  'INCOME WITHDRAWN' INCLUDES TAX PAID THIS PERIOD
     5. )
      IF( INCOPT.NE.BLANK ) GOTO 5901
      GOTO 5801
 5901 IF( TOTLIN.NE.BLANK ) GOTO 6001
      WRITE(W,4900)
 4900 FORMAT(/,22X,89H** INCOME HAS BEEN ESTIMATED USING INDEX YIELDS AN
     1D IS ASSUMED TO HAVE BEEN REPAID IN ITS,/,25X,
     2 26HENTIRETY TO THE TRUSTEES. )
      GOTO 5801
 6001 WRITE(W,5000)
 5000 FORMAT(/,22X,87H** INCOME FIGURES WHICH WERE NOT PROVIDED HA
     1VE BEEN ESTIMATED USING INDEX YIELDS,,/,25X,
     2 2HTHE ESTIMATES WERE FORCED TO BE CONSISTENT WITH THE FIGURES PR
     3OVIDED.  ALL INCOME IS,/,25X,
     4 2HASSUMED TO HAVE BEEN REPAID IN ITS ENTIRETY TO TRUSTEES. )
C   PRINT QUALIFIER RE EXCLUDED SECTOR.
 5801 WRITE(W,4400) ( EXCLNA(J),J=1,7 )
 4400 FORMAT(/,22X,58H- THIS REPORT DOES NOT ASSESS THE FOLLOWING INVEST
     1MENTS:  ,7A6 )
      IF( EXLAMT.EQ.0 ) GOTO 5701
      TEMP4 = ENDVL + EXLPUR + EXLAMT
      TEMP1 = EXLPUR
      RTEMP1 = FLOAT( EXLAMT + TEMP1 ) / FLOAT( TEMP4 ) * 100.0
      WRITE(W,4500) (RPDATE(2,J),J=1,3 ),EXLAMT,TEMP1,RTEMP1
 4500 FORMAT(25X,23HWITH ESTIMATED VALUE AT,2I3,I5,5H OF ,6,I8,
     1 38H.  COUNTING PURCHASES THIS PERIOD OF ,6,I8,1H.,/,25X,
     2 17H THIS AMOUNTS TO ,F5.1,46H PERCENT OF THE FINAL VALUE OF THE T
     3OTAL FUND. )
 5701 RETURN
      END
C
C
      SUBROUTINE OUT2(MKTOT)
      REAL ANHWR(7),ANTHWR(7),MKTOT,ANPOR(7),ANMD7W(7),MODTWR(7)
      INTEGER I,J,W,P,NAME(7,2),SECTR(6)
      COMMON /G6/ W,P
      COMMON /G12/ NAME,SECTR
      COMMON /G13/ ANHWR,ANTHWR
      COMMON /G25/ ANMDTW,MODTWR
C PRINTS TABLE NO. 2 'RATES OF RETURN' SUMMARY.
      WRITE(W,1000) ((NAME( SECTR(I),J),J=1,2 ),I=1,6 ),NAME(7,1),
     1 NAME(7,2)
 1000 FORMAT( 5(/),35X,62HO.    ANNUALISED  RATE  OF  RETURN  OVER  THIS
     1 PERIOD  (P.A.),/,35X,62(1H-),/,
     1 58X,3HG E O T O R S   O F   M A I N   F U N D,/,3X,
     2 30HTYPE OF RATE OF RETURN MEASURE,6X,77(1H-),5X,5HTOTAL,/,39X,
     3 6(2A6,1X),1X,2A6,/,2X,34(1H-),3X,6(12H------------,1X),12(1H-) )
      CALL SQRT(ANHWR,ANROR)
      WRITE(W,1010) ANROR
 1010 FORMAT(2X,32HACHIEVED ORDINARY RATE OF RETURN,/,2X,
     1 33H(EFFECTED BY TIMING OF NEW MONEY),6X,6(F7.2,6X),1X,F7.2)
      CALL SQRT(ANTHWR,ANROR)
```

```
      WRITE(W,1020) ANFOR
 1020 FORMAT(/,3X,34HACHIEVED TIME WEIGHTED RETURN (NOT,/,2X,
     3 32HAFFECTED BY TIMING OF NEW MONEY),7X,6(F7.2,6X),1X,F7.2)
      WRITE(W,1040)
 1040 FORMAT(/,2X,127(1H-) )
      DO 1 J= 1,6
      ANFOR(J) = ANMOTW(SECTR(J))
    1 CONTINUE
      ANFOR(7) = MKTOT
      WRITE(W,1030) ANFOR
 1030 FORMAT(/,2X,32HHISTORICAL MARKET RATE OF RETURN,83X,
     5 12H(MODEL FUND),/2X,18HACCORDING TO INDEX:21X,6(F7.2,6X),1X,F7.2)
      WRITE(W,1040)
      RETURN
      END
C
C
      SUBROUTINE OUT3
      REAL TPOLCY,TSTRT,TSCTSL,TPROFT,TSUSTR,TINSTR,TSCYSL
      INTEGER I,J,K,W,POLEX,BLANK
      COMMON /G6/ W,R
      COMMON /G18/ TPOLCY,TINSTR,TSUSTR,TSTRT,TSCTSL,TSCYSL,TPROFT
      COMMON /G19/ POLEX
      DATA BLANK /6H     /
C  PRINTS TABLE NO.3  'ANALYSIS OF RETURN RELATIVE TO MODEL FUND '(SUMM
      WRITE(W,1000)
 1000 FORMAT(5(/),41X,52H3.   ANALYSIS  OF  RETURN  RELATIVE  TO  MODEL
     1 FUND,/,41X,52(1H-),//,4X,2(30HRELATIVE RETURN FROM,6X),2X,
     2 21HTOTAL RELATIVE RETURN,9X,21HTOTAL RELATIVE RETURN,6X,
     3 21HTOTAL RELATIVE RETURN,/,1X,26HLONG-RUN INVESTMENT POLICY,1X,
     4 1H+,3X,26HCURRENT STRATEGY,4X,1H=,5X,21HFROM SECTOR SELECTION,2X,
     5 1X,1H:,2X,1H+,1X,23HFROM SECURITY SELECTION,2X,
     5 1H=,7X,12HON MAIN FUND )
      WRITE(W,1010) TPOLCY,TSTRT,TSCTSL,TSCYSL,TPROFT
 1010 FORMAT(/,10X,F7.2,1H/,10X,1H+,7X,F7.2,1H/,8X,1H=,10X,F7.2,1H/,11X,
     1 1H:,2X,1H+,6X,F7.2,1H/,13X,1H=,5X,F7.2,1H/)
      IF( POLEX.EQ.BLANK ) RETURN
      WRITE(W,1020)
 1020 FORMAT(6X,14H(NOT ASSESSED) )
      RETURN
      END
C
C
      SUBROUTINE OUT4(GAIN,INGAIN,INYLO,MKTOT)
      REAL MWR(7),TWR(7),MODTWR(7),INGAIN(7),INYLO(7),DIFF,RGAIN(7),
     1 ANMOTW(7),MKTOT
      INTEGER I,J,W,R,N,S,BLANK,INCMEX,PAIDEX,VALPAD,NAME(7,2),
     1 SECTR(6),GAIN(7),TEMP1,INCOPT,TOTLIN,TOTEXT(4),PARTIN,PARTAL(6)
      COMMON N,S
      COMMON /G27/ TWR,MWR
      COMMON /G6/ W,R
      COMMON /G3/ INCMEX,PAIDEX,VALPAD,INCOPT
      COMMON /G12/ NAME,SECTR
      COMMON /G25/ ANMOTW,MODTWR
      COMMON /G33/ PARTAL,TOTLIN,TOTEXT,PARTIN
C  TO  PRINT TABLE NO.4  'ACHIEVED R.O.F. FOR EACH SECTOR'.
      DATA BLANK /6H     /
      DO 2 J=1,S+1
      RGAIN(J) = FLOAT( GAIN(J) ) / 1000.0
    2 CONTINUE
      WRITE(W,1000)
 1000 FORMAT(19X,39H4.   ACHIEVED  RATE  OF  RETURN  (R.O.R.)  FOR  EACH
     1  SECTOR  OVER  THIS  REVIEW  PERIOD  (/),
     1  /,19X,93(1H-),//,25X,10HHISTORICAL,1X,
     2 15HACHIEVED MONEY-,7X,14HACHIEVED TIME-,6X,10HDIFFERENCE,6X,
     3 15HGROSS GAIN,5X,5HFROM,5X,10HPERCENTAGE,/,11X,6HSECTOR,11X,
     4 6HMARKET,5X,2(15HWEIGHTED R.O.R.,3X),12H(MONEY- LESS,7X,
     5 8H(000'S),5X,6HINCOME,6X,7HOF GAIN,/,27X,6HR.O.F.,7X,
     6 11H(See NOTE 1,7X,11H(SEE NOTE 2,5X,14HTIME-WEIGHTED,5X,
     7 10H(NET OF   ,4X,5H/ELD,5X,8HWHICH WAS,/,42X,6HBELOW),12X,
     8 6HBELOW),9X,11H(SEE NOTE 3),5X,11H(NEW MONEY)*,4X,8H(P.A.)*,4X,
     9 7HINCOME*,/,6X,15(1H-),4X,10(1H-),
     8 2(3X,15(1H-)),3X,14(1H-),3X,11(1H-),3X,9(1H-),3X,10(1H-) )
      DIFF = MWR(S+1) - TWR(S+1)
      IF( INCMEX.NE.BLANK .AND. TOTLIN.EQ.BLANK ) GOTO 2301
      IF( TOTLIN.EQ.TOTEXT(4). AND. PARTIN.EQ.BLANK ) GOTO 2301
C  INCOME EARNED (NO THERE FORE REPAID INCOME) FIGURES ARE AVAILABLE.
      IF( INGAIN(S+1).LT.-9999 ) GOTO 2101
      IF( INGAIN(S+1).GT.9999.99 ) GOTO 2101
      WRITE(W,1010) NAME(7,1),NAME(7,2),MKTOT,MWR(S+1),
     1 TWR(S+1),DIFF,RGAIN(S+1),INYLO(S+1),INGAIN(S+1)
 1010 FORMAT(/,6X,6HTOTAL ,2A6,F7.2,10X,F7.2,11X,F7.2,10X,
     1 F7.2,8X,F9.2,5X,F7.2,5X,F7.2,/,24X,12H(MODEL FUND) )
      WRITE(W,1020)
 1020 FORMAT(/,2X)
      GOTO 2201
 2101 WRITE(W,1010) NAME(7,1),NAME(7,2),MKTOT,MWR(S+1),
     1 TWR(S+1),DIFF,RGAIN(S+1),INYLO(S+1)
      WRITE(W,1030)
 1030 FORMAT(2X,12H(MODEL FUND),79X,14HNOT APPLICABLE./)
      GOTO 2201
 2301 WRITE(W,1010) NAME(7,1),NAME(7,2),MKTOT,MWR(S+1),
     1 TWR(S+1),DIFF,RGAIN(S+1),INYLO(S+1)
      WRITE(W,1040)
 1040 FORMAT(105X,25HN O T   A V A I L A B L E./)
 2201 DO 1 J=1,S
      JJ = SECTR(J)
      DIFF = MWR(J) - TWR(J)
      IF( INCMEX.EQ.BLANK ) GOTO 2105
      IF( TOTLIN.NE.TOTEXT(4) .AND. TOTLIN.NE.TOTEXT(3) ) GOTO 2301
      IF( TOTLIN.EQ.TOTEXT(3) .OR. PARTIN.EQ.TOTEXT(3) ) GOTO 2205
      IF( TOTLIN.EQ.TOTEXT(4) .AND. PARTAL(J).EQ.0 ) GOTO 2301
C TOTAL INCOME EARNED FIGURE AVAILABLE FOR THIS SECTOR.
 2205 IF( INGAIN(J).LT.-9999 ) GOTO 2401
      IF( INGAIN(J).GT.9999.99 ) GOTO 2401
      WRITE(W,1050) ( NAME(JJ,I),I=1,2 ),MODTWR(JJ),MWR(J),TWR(J),
     1 DIFF,RGAIN(J),INYLO(J)
 1050 FORMAT(6X,2A6,6X,F7.2,10X,F7.2,11X,F7.2,10X,F7.2,8X,F9.2,5X,F7.2,
     1 5X,F7.2 )
      WRITE(W,1020)
      GOTO 1
 2401 WRITE(W,1050) ( NAME(JJ,I),I=1,2 ),MODTWR(JJ),MWR(J),TWR(J),
     1 DIFF,RGAIN(J),INYLO(J)
      WRITE(W,1035)
 1035 FORMAT(115X,14HNOT APPLICABLE./)
      GOTO 1
C NO INCOME EARNED FIGURES AVAILABLE FOR THIS SECTOR.
 2301 WRITE(W,1050) ( NAME(JJ,I),I=1,2 ),MODTWR(JJ),MWR(J),TWR(J),
     1 DIFF,RGAIN(J)
      WRITE(W,1020)
    1 CONTINUE
      WRITE(W,1060)
 1060 FORMAT(//,6X,116HNOTE 1:  MONEY-WEIGHTED RATE OF RETURN IS AFFECT
     1ED BY THE TIMING OF NEW MONEY, AND SECTOR SWITCHES DURING THE PERIO
     2D.,/,15X,65HIT IS THE ORDINARY RATE OF RETURN, MEASURING INCREASE
     3IN WEALTH. )
      WRITE(W,1070)
 1070 FORMAT(/,6X,122HNOTE 2:  TIME-WEIGHTED RATE OF RETURN IS NOT AFFEC
     1TED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL S
     2ECTOR,/,15X,54HBY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECT
     3OR.,/,15X,79HIT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BE
     4TWEEN DIFFERENT PORTFOLIOS.)
      WRITE(W,1080)
 1080 FORMAT(/,6X, 116HNOTE 3:  IN THE CASE OF AN INDIVIDUAL SECTOR, A L
     1ARGE POSITIVE DIFFERENCE (E.G. 1/ OR GREATER) INDICATES THAT SWITC
     2HES,/,15X,108HINTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN T
     3HAT SECTOR WERE TIMED WELL.  A LARGE POSITIVE DIFFERENCE,/15X,88HF
     4OR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOU
     5RABLE TO PERFORMANCE. )
      WRITE(W,1090)
 1090 FORMAT(/,6X,123H*  ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP I
     INCOME, SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET
     2OF TAX. )
      IF( INCMEX.EQ.BLANK ) GOTO 2501
      IF( TOTLIN.EQ.TOTEXT(3) ) GOTO 2501
      IF( PARTIN.EQ.TOTEXT(3) ) GOTO 2501
      WRITE(W,2000)
 2000 FORMAT(9X,121HINCOME INFORMATION IS SHOWN ONLY FOR THOSE SECTORS F
     1OR WHICH INCOME FIGURES WERE GIVEN.  'GROSS GAIN' IS BASED ON CAPI
     2TAL,/,9X,69HVALUE ONLY IF NO INCOME FIGURE WAS PROVIDED FOR THAT
     3SECTOR. )
 2501 RETURN
      END
C
C
      SUBROUTINE OUT5(PROPNS,MODDES,POLDES)
      REAL PROPNS(4,6),PROCP(4,6)
      INTEGER I,J,W,R,RPDATE(2,3),SECTR(6),NAME(7,2),TEXT(7),POLEX,
     1 MODDES(7),POLDES(7),BLANK,JJ
      COMMON /G6/ W,R
      COMMON /G12/ NAME,SECTR
      COMMON /G16/ RPDATE
      COMMON /G19/ POLEX
      DATA TEXT ,BLANK / 6HNOT   ,6HUSED  ,6HIN THI,6HS ANAL,6HYSIS  ,
     1 6H    ,6H    ,6H    /
C  PRINTS TABLE NO.5 'COMPOSITION OF FUNDS USED IN ANALYSIS'.
      WRITE(W,1000) ( (RPDATE(I,J),J=1,3 ),I=1,2 )
 1000 FORMAT(//,20X,91HA N A L Y S I S   O F   P E R F O R M A N C E   R
     1 E L A T I V E   T O   M O D E L   F U N D,
     2 20X,91(1H-),////,43X,47HS.   COMPOSITION  OF  FUNDS  USED  IN  AN
     3ALYSIS,/,43X,47(1H-),//,112X,11HCOMPOSITION,/31X,65H/ OF MAIN FUND
     4 HYPOTHETICALLY INVESTED IN SECTORS IN THE CASE OF-,16X,11(1H-),/,
```

```
     40X,6HSECTOR,16X,64(1H-),16X,13HOF FINAL FUND,/,41X,1H*,22X,2H**,12
     5X,16HINITIAL STRATEGY,17X,13(1H-),/31X,10HMODEL FUND,12X,11HPOLICY
     6 FUND,13X,6H(AS AT,21X,15,1H),13X,6H(AS AT,21X,I5,1H),/,6X,12(1H-)
     7 ,13X,11(1H-),11X,13(1H-),11X,18(1H-),13X,18(1H-),// )
      DO 4 I = 1,6
      DO 5 J = 1,6
      RPROP(I,J) = PROPNS(I,J) * 100.0
    5 CONTINUE
    4 CONTINUE
      IF( POLEX.NE.BLANK ) GOTO 2001
      DO 1 J=1,6
      JJ = SECTR(J)
      WRITE(W,1010) ( NAME(JJ,I),I=1,2 ),( RPROP(I,J),I=1,4 )
 1010 FORMAT(6X,2A6,15X,F7.2,16X,F7.2,19X,F7.2,24X,F7.2,/ )
    1 CONTINUE
      GOTO 2101
 2001 DO 2 J=1,6
      WRITE(W,1020) ( NAME(J,I),I=1,2 ),RPROP(1,J),( RPROP(I,J),I=3,4 )
 1020 FORMAT(6X,2A6,15X,F7.2,42X,F7.2,24X,F7.2,/ )
    2 CONTINUE
 2101 WRITE(W,1030) ( MODDES(J),J=1,7 )
 1030 FORMAT(///,7X,33H* BASIS FOR MODEL FUND PROFILE:  ,7A6 )
      IF( POLEX.EQ.BLANK ) GOTO 2201
      DO 3 J=1,7
      POLDES(J) = TEXT(J)
    3 CONTINUE
 2201 WRITE(W,1040) ( POLDES(J),J=1,7 )
 1040 FORMAT(/,6X,35H** BASIS FOR POLICY FUND PROFILE:  ,7A6 )
      RETURN
      END
C
C
      SUBROUTINE OUT67(NUM,TAB,TABHED,ASPECT,QUANT)
      REAL TAB(7,7),MFSIZE(2)
      INTEGER I,J,TABHED(3),ASPECT,W,R,NAME(7,2),SECTR(6),QUANT(2),POLEX
     1 ,BLANK,PREA-P,NUM,ASPCT1
      COMMON /G12/ NAME,SECTR
      COMMON /G6/ W,R
      COMMON /G19/ POLEX
      COMMON /G17/ MFSIZE
      DATA BLANK ,PPFASP/6H      ,6HPROFIT /
C
C PRINTS TABLES NOS. 6 AND 7 WITH DATA 'TAB', TABLE HEADING 'TABHED' AND
C      CHARACTERISTIC 'ASPECT' (PROFIT OR RETURN) IN UNITS 'QUANT'.
C
      ASPCT1 = ASPECT
      WRITE(W,1000) NUM,TABHED,QUANT
 1000 FORMAT(//,28X,I1,17H.   ANALYSIS  OF ,3A5,29H RELATIVE  TO  MODEL
     1 FUND  (,2A6,1H),/,29X,75(1H-),////,54X,
     2 3HS E C T O R S   O F   M A I N   F U N D)
      WRITE(W,1010)
 1010 FORMAT(7X,19HSOURCE OF RELATIVE,9X,62(1H-),6X,5HTOTAL)
      WRITE(W,1020) ASPCT1,( ( NAME( SECTR(I),J),J=1,2),I=1,6 ),
     1 NAME(7,1),NAME(7,2)
 1020 FORMAT(13X,A6,15X,6(2A6,2X),1X,2A6,/1X,3D(1H-),3X,6(12(1H-),2X),
     1 1X,12(1H-) )
      IF( POLEX.EQ.BLANK ) GOTO 2001
      WRITE(W,1030) ASPCT1
 1030 FORMAT(/,1X,130(1H-),/,1X,7HPOLICY ,A6,6H (FROM,45X,
     1 25H(NO POLICY ANALYSIS DONE))
      GOTO 2101
 2001 WRITE(W,1040) ASPCT1
 1040 FORMAT(/,1X,130(1H-),/,1X,7HPOLICY ,A6,6H (FROM)
 2101 WRITE(W,1050) ( TAB(1,J),J=1,7 )
 1050 FORMAT(1X,27HLONG-RUN INVESTMENT POLICY),5X,5(F11.2,3X),F11.2,4X,
     1 F11.2,/,1X,130(1H-) )
      WRITE(W,1060) ASPCT1,( TAB(2,J),J=1,7 )
 1060 FORMAT(/,7X,17HINITIAL STRATEGIC,/,7X,A6,1HA (FROM COMPOSITION,2X,
     1 5(F11.2,3X),F11.2,4X,F11.2,/,7X,16HOF INITIAL FUND) )
      WRITE(W,1070) ASPCT1,( TAB(3,J),J=1,7 )
 1070 FORMAT(/,7X,20HSUBSEQUENT STRATEGIC,/,7X,A6,13H (FROM ACTION,7X,
     1 5(F11.2,3X),F11.2,4X,F11.2,/,7X,12HTHIS PERIOD) )
      WRITE(W,1080) ASPCT1,( TAB(4,J),J=1,7 )
 1080 FORMAT(/,1X,130(1H-),/,1X,16HTOTAL STRATEGIC ,A6,6H (FROM,/,1X,
     1 30HCURRENT DEVIATION FROM POLICY),2X,5(F11.2,3X),F11.2,4X,F11.2,
     2 /,1X,130(1H-) )
      WRITE(W,1090) ASPCT1,( TAB(5,J),J=1,7 )
 1090 FORMAT(/,1X,65(2H* ),/,1X,15HTOTAL  RELATIVE ,A6,/,1X,
     1 25HFROM SELECTION OF SECTORS,7X,5(F11.2,3X),F11.2,4X,F11.2,/,1X,
     2 20H(POLICY + STRATEGIC),/,1X,65(2H* ) )
      WRITE(W,1100) ASPCT1,( TAB(6,J),J=1,7 )
 1100 FORMAT(/,1X,65(2H* ),/,1X,15HTOTAL RELATIVE ,A6,/ 1X,
     1 25HFROM SELECTION OF SECURITIES,4X,5(F11.2,3X),F11.2,4X,F11.2,/,
     2 1X,65(2H* ),/ )
      WRITE(W,1110) ASPCT1,( TAB(7,J),J=1,7 )
 1110 FORMAT(//,1X,130(1H=),/,1X,15HTOTAL RELATIVE ,A6,/,1X,
     1 17H(SECTOR SELECTION,15X,5(F11.2,3X),F11.2,4X,F11.2,/,1X,
     2 21HSECURITY SELECTION),/,1X,130(1H=) )
      IF( ASPCT1.EQ.PRFASP ) GOTO 2201
      WRITE(W,1120) NAME(7,1),NAME(7,2),MFSIZE(1)
 1120 FORMAT(////,26X,33H* AS A PERCENTAGE OF AN AVERAGE ,2A6,
     1 35H SIZE DURING THIS REVIEW PERIOD OF E.F9.0)
 2201 RETURN
      END
C
C
      SUBROUTINE OUT8(OSSEL,OSPREM,OSEXCH,OSSTRT,OSPRFT,OSSIZE,PENEX,
     1 BGRATE,ENRATE)
      REAL OSSEL(2),OSPREM(2),OSEXCH(2),OSSTRT(2),OSPRFT(2),OSSIZE,
     1 PRMPEN(14),INDEX(4,6),RTEMP1,RTEMP2,OSRATE(3),BGRATE,ENRATE
      INTEGER I,J,W,R,OSEAS,N,S,PENEX,BLANK
      COMMON N,S
      COMMON /G5/ PRMPEN,OSEAS,OSRATE
      COMMON /G2/ INDEX
      COMMON /G6/ W,R
      DATA BLANK /6H      /
C
C  PRINTS TABLE NO.8 'OVERSEAS SECTOR PERFORMANCE'.
C
      OSSTRT(1) = OSSTRT(1) / 1000.0
      OSSEL(1) = OSSEL(1) / 1000.0
      OSEXCH(1) = OSEXCH(1) / 1000.0
      OSPREM(1) = OSPREM(1) / 1000.0
      OSPRFT(1) = OSPRFT(1) / 1000.0
      WRITE(W,1000)
 1000 FORMAT(///,43X,30H*.   PERFORMANCE  OF  OVERSEAS  SECTOR,/,45X,
     1 31(1H-),///26X,24HAMOUNT OF GAIN (6000),7X,24HMONEYWEIGHTED,7X,
     2 24H*,/,31X,21HSOURCE OF PERFORMANCE,17X,18H'NET OF NEW MONEY',7X,
     3 19HRATE OF RETURN (%),/,26X,31(1H-),11X,21(1H-),4X,19(1H-) )
      WRITE(W,1010) OSSTRT(2)
 1010 FORMAT(/,26X,27HSTRATEGY (RETURN FROM INDEX,/,28X,
     1 29H- AT OLD EXCH RATE + PENALTY),10X,F8.1,17X,F7.2)
      WRITE(W,1020) OSSEL(1),OSSEL(2)
 1020 FORMAT(/,26X,23HSELECTION OF SECURITIES,/,28X,
     1 26H(RETURN IN EXCESS OF INDEX),13X,F8.1,17X,F7.2,/,28X,
     2 29H-AT OLD EXCH RATES + PENALTY) )
      WRITE(W,1030) BGRATE,ENRATE,OSEXCH
 1030 FORMAT(/,26X,31HCHANGE IN PREMIUM EXCHANGE RATE,/,31X,
     1 9H(FROM $1= ,F4.2,9H TO $1= ,F4.2,1H),17X,F8.1,17X,F7.2,/,32X,
     2 25H- AT OLD PREMIUM PENALTY) )
      IF( PENEX.EQ.BLANK ) GOTO 101
      RTEMP1 = PRMPEN(1) * 100.0
      RTEMP2 = PRMPEN(N+2) * 100.0
      WRITE(W,1040) RTEMP1,RTEMP2,OSPREM
 1040 FORMAT(/,26X,25HCHANGE IN PREMIUM PENALTY,/,33X,6H(FROM ,F4.1,
     1 1H/ TO ,F4.1,1H/,20X,F8.1,17X,F7.2,/,35X, 22H- AT NEW EXCHANGE RAT
     2E )
  101 WRITE(W,1050)
 1050 FORMAT(/,26X,85(1H-) )
      WRITE(W,1060) OSPRFT
 1060 FORMAT(/,26X,28HTOTAL PROFIT SINCE BEGINNING,/,33X,
     1 16HOF REVIEW PERIOD,24X,F8.1,17X,F7.2 )
      WRITE(W,1070)
      WRITE(W,1070) OSSIZE
 1070 FORMAT(////,21X,88H*   AS A PERCENTAGE OF AN AVERAGE INVESTMENT IN
     1THIS SECTOR DURING THE REVIEW PEROID OF E.F8.0,/,24X,
     2 68H*THE ABOVE GAINS AND RETURNS DO NOT INCLUDE ANY UN-REINVESTED I
     3NCOME. )
      RETURN
      END
C
C
      SUBROUTINE OUT9(IPOLCY,ISTRGY,ISCTSL,ISCYSL,IPROFT)
      REAL IPOLCY(4),ISTRGY(4),ISCTSL(4),ISCYSL(4),IPROFT(4),MFSIZE(2)
      INTEGER I,J,W,R,NAME(7,2),SECTR(6),N,S,JJ,TITLE(2,2),POLEX,BLANK
      COMMON /G6/ W,R
      COMMON /G12/ NAME,SECTR
      COMMON /G17/ MFSIZE
      COMMON /G19/ POLEX
      DATA BLANK /6H      /
C
C PRINTS TABLE NO. 9 'INCOME PERFORMANCE RELATIVE TO MODEL FUND'.
C
      WRITE(W,1000)
 1000 FORMAT(//,101X,1H*,/,29X,74H9.   GROSS  INCOME  PERFORMANCE  RELAT
     1IVE  TO  MODEL  FUND  (PERCENTAGES ),/,29X,74(1H-),///,58X,
     2 3HS E C T O R S   O F   M A I N   F U N D,/,53X,49(1H-),7X,
     3 5HTOTAL)
      TTL = 0
      DO 1 J=1,6
      JJ = SECTR(J)
      IF( JJ.GT.2 ) GOTO 1
```

```
      I = I + 1
      TITLE(I,1) = NAME(JJ,1)
      TITLE(I,2) = NAME(JJ,2)
    1 CONTINUE
      WRITE(W,1010) ( ( TITLE(I,J),J=1,2),I=1,2 ),NAME(7,1),NAME(7,2)
 1010 FORMAT(13X,25HSOURCE OF RELATIVE INCOME,10X,2A6,4X,2A6,4X,
     1 17HOTHER (INCL CASH),4X,2A6,/,15X,30(1H-),5X,12(1H-),4X,12(1H-),
     2 4X,17(1H-),4X,12(1H-) )
      IF( POLCX.EQ.BLANK ) GOTO 101
      WRITE(W,1015)
 1015 FORMAT(/,15X,19HPOLICY INCOME (FROM,38X,25H(NO POLICY ANALYSIS DON
     1E) )
      GOTO 201
  101 WRITE(W,1018)
 1018 FORMAT(/,15X,19HPOLICY INCOME (FROM )
  201 WRITE(W,1020) IPOLCY
 1020 FORMAT(18X,
     127HLONG-RUN INVESTMENT POLICY),10X,F7.2,9X,F7.2,10X,F7.2,12X,F7.2)
      WRITE(W,1030) ISTRGY
 1030 FORMAT(/,15X,22HSTRATEGIC INCOME (FROM,/,15X,
     1 30HCURRENT DEVIATION FROM POLICY),10X,F7.2,9X,F7.2,10X,F7.2,12X,
     2 F7.2 )
      WRITE(W,1040)
 1040 FORMAT(/,15X,103(1H-) )
      WRITE(W,1050) ISCTSL
 1050 FORMAT(/,15X,21HTOTAL RELATIVE INCOME,/,20X,
     1 25HFROM SELECTION OF SECTORS,10X,F7.2,9X,F7.2,10X,F7.2,12X,F7.2,/
     2 ,25X,23H(POLICY + STRATEGIC) )
      WRITE(W,1040)
      WRITE(W,1040)
      WRITE(W,1060) ISCYSL
 1060 FORMAT(/,15X,21HTOTAL RELATIVE INCOME,/,17X,
     128HFROM SELECTION OF SECURITIES,10XF7.2,9X,F7.2,10X,F7.2,12X,F7.2)
      WRITE(W,1040)
      WRITE(W,1070)
 1070 FORMAT(/,15X,103(1H=) )
      WRITE(W,1080) IRFCT
 1080 FORMAT(/,15X,21HTOTAL RELATIVE INCOME,/,26X,
     1 19H(SECTOR SELECTION +,10X,F7.2,9X,F7.2,10X,F7.2,12X,F7.2,/,
     2 26X,19HSECURITY SELECTION))
      WRITE(W,1070)
      WRITE(W,1090) NAME(7,1),NAME(7,2),MFSIZE(1)
 1090 FORMAT(////,22X,32H* AS A PERCENTAGE OF AN AVERAGE ,2A6,
     1 36H SIZE DURING THIS REVIEW PERIOD OF ,F9.0)
      RETURN
      END
C
C
      SUBROUTINE OUTFOR(NOWROR,ROR,ASPECT,TITLE,TABNUM,DATES,S,MODL)
      REAL ROR(7,5),NOWROR(7)
      INTEGER I,J,W,R,N,S,NAME(7,2),TABNUM,DATES(5,3),TITLE,ASPECT
     1 ,SECTR(6),RDATE(2,3),HEDING(2,2),MODL
      COMMON /G6/ W,R
      COMMON /G12/ NAME,SECTR
      COMMON /G16/ RDATE
      DATA HEDING /6H    ACH,6H MODEL,6HIEVED ,6H FUND /
C
C  PRINTS TABLES NOS. 13 AND 14 IN SAME FORMAT, DIFFERING ONLY IN DATA
C   'NOWROR', 'ROR', AND TEXT 'TITLE', 'ASPECT' CONCERN TWR VS MWR. 'MODL'
C     PRINTS TABLE 15 FOR MODEL FUND.
C
      WRITE(W,1000) TABNUM,HEDING(MODL,1),HEDING(MODL,2),ASPECT,ASPECT,
     1 TITLE
 1000 FORMAT(//////,20X,I2,1H.,2A6,13H AVERAGE  ANNUAL  ,A5,
     1 36H WEIGHTED  RATE  OF  RETURN  (/P.A.),/,24X,74(1H-),/,23X,
     2 8H(NOTE:  ,A5,22H WEIGHTED RETURN IS ,A3,1X,
     3 39HAFFECTED BY THE TIMING OF NEW MONEY OR,,/,19X,
     493H IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES
     5 INTO AND OUT OF THAT SECTOR.) )
      WRITE(W,1010) ( RDATE(I,J),J=1,3 ),( ( DATES(I,J),J=1,3),I=1,5)
 1010 FORMAT(//,51X,67HA N N U A L I S E D  A V E R A G E  R E T U R N
     1  S A S E D  O N,
     1 /,38X,  77HC U M U L A T I V E  R E T U R N  O V E R  P R E
     1V I O U S  P E R I O D S,2X,4H(TO ,I2,1X,I2,1X,I4,1H),/,25X,
     2 5HVALUE,8X,94(1H-),/,5X,6HSECTOR,
     2 11X,11HTHIS PERIOD,2X,5(3X,5HSINCE,2I3,I5),/,2X,12(1H-),4X,
     3 11(1H-),2X,5(3X,16(1H-) ) )
      WRITE(W,1020) NAME(7,1),NAME(7,2),NOWROR(S+1),( ROR(7,J),J=1,5 )
 1020 FORMAT(/,2X,2A6,10X,F7.2,5(12X,F7.2),/)
      DO 1 J = 1,S
      JJ = SECTR(J)
      WRITE(W,1030) NAME(JJ,1),NAME(JJ,2),NOWROR(J),( ROR(JJ,I),I=1,5 )
 1030 FORMAT(/,2X,2A6,10X,F7.2,5(12X,F7.2) )
    1 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE PASTAN(MODPR,PRINT)
      REAL TWANU(7,5),MWANU(7,5),CMOTAD(6,5),ANMWR(7),ANTWR(7),
     1 NOWANU(7),MODCUM(7,5),MODANU(7,5),MODOTW(7),ANMOTW(7)
      INTEGER MODL,DATO(2,3),TABNUM,RORTYP(2),NEG(2),TITLE,ASPECT
     1 ,N,S,NAME(7,2),SECTR(6),MOHDAT(5,3),N,S,PRINT,TEMP1
      COMMON N,S
      COMMON /G6/ W,R
      COMMON /G13/ ANMWR,ANTWR
      COMMON /G12/ NAME,SECTR
      COMMON /G25/ ANMOTW,MODTWP
      COMMON /G28/ DATOUT,MOHDAT
      COMMON /G29/ TWANU,MWANU
      COMMON /G30/ MODCUM,MODANU
C
C  PRINTS TABLES NOS. 13 AND 14 VIA SUBROUTINE 'OUTROR'. ALSO TABLE 15
C   FOR MODEL FUND IF 'MODPR'=1 (IMPLIES 'MODL'=2 FOR S/R 'OUTROR'.
C
      DATA RORTYP,NEG / 5HTIME ,5HMONEY,3HNOT,3H   /
      MODL = 1
      TABNUM = 13
C PRINT MODEL WEIGHTED RATES OF RETURN.
      IF( PRINT.EQ.0  .AND. MODPR.EQ.0 ) CALL HEAD
      ASPECT = RORTYP(2)
      TITLE = NEG(2)
      CALL OUTFOR(ANMWR,MWANU,ASPECT,TITLE,TABNUM,DATOUT,S,MODL)
C  PRINT TIME WEIGHTED RATES OF RETURN.
      IF( PRINT.EQ.0  .AND. MODPR.EQ.1 ) CALL HEAD
      ASPECT = RORTYP(1)
      TITLE = NEG(1)
      TABNUM = TABNUM + 1
      CALL OUTFOR(ANTWR,TWANU,ASPECT,TITLE,TABNUM,DATOUT,S,MODL)
C  PRINT MODEL FUND'S ANNUAL USED RETURNS IF REQUESTED MODEL ANALYSIS DO.
      IF( MODPR.EQ.0 ) GOTO 2001
      IF( PRINT.NE.0 ) CALL HEAD
      TABNUM = TABNUM + 1
      TEMP1 = 6
      MODL = 2
      DO 1 J=1,6
      NOWROR(J) = ANMOTW( SECTR(J) )
    1 CONTINUE
      NOWROR(7) = ANMOTW(7)
      CALL OUTFOR(NOWROR,MODANU,ASPECT,TITLE,TABNUM,MOHDAT,TEMP1,MODL)
 2001 RETURN
      END
C
C
      SUBROUTINE OUTCUM(ROR,ASPECT,TITLE,TABNUM,DATES,S,MODL)
      REAL ROR(7,5)
      INTEGER ASPECT,TITLE,TABNUM,S,MODL,I,J,NAME(7,2),SECTR(6),
     1 W,R,HEDING(2,2),RDATE(2,3),DATES(5,3)
      COMMON /G6/ W,R
      COMMON /G12/ NAME,SECTR
      COMMON /G16/ RDATE
      DATA HEDING /6H    ACH,6H MODEL,6HIEVED ,6H FUND /
C
C  PRINTS TABLE NOS. 10 AND 11 'CUMULATIVE RETURNS'. ALSO TABLE
C   12 FOR MODEL FUND IF 'MODL' = 2
C
      WRITE(W,1000) TABNUM,HEDING(MODL,1),HEDING(MODL,2),ASPECT,ASPECT,
     1 TITLE
 1000 FORMAT(////,34X,I2,1H.,2A6,13H CUMULATIVE  ,A5,
     1 32H WEIGHTED  RATE  OF  RETURN  (/),/,34X,60(1H-),/,20X,
     2 8H(NOTE:  ,A5,22H WEIGHTED RETURN IS ,A3,1X,
     3 39HAFFECTED BY THE TIMING OF NEW MONEY OR,,/,19X,
     493H IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES
     5 INTO AND OUT OF THAT SECTOR.) )
      WRITE(W,1010) ( RDATE(I,J),J=1,3 ),( ( DATES(I,J),J=1,3 ),I=1,5)
 1010 FORMAT(/,33X,77HC U M U L A T I V E  R E T U R N  O V E R  P R E
     1 V I O U S  P E R I O D S,2X,4H(TO ,I2,1X,I2,1X,I4,1H),/,36X,
     2 9H(NOTE:),/,17X,6HSECTOR,
     2 2X,5(3X,5HSINCE,2I3,I5),/,24X,12(1H-),9X,
     3 5(3X,16(1H-) ) )
      WRITE(W,1020) NAME(7,1),NAME(7,2),( ROR(7,J),J=1,5 )
 1020 FORMAT(/,14X,2A6,5X,5(12X,F7.2),/)
      DO 1 J = 1,S
      JJ = SECTR(J)
      WRITE(W,1030) NAME(JJ,1),NAME(JJ,2),( ROR(JJ,I),I=1,5 )
 1030 FORMAT(/,14X,2A6,5X,5(12X,F7.2) )
    1 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE PASTCM(MODPR)
```

```
      REAL MWCUM(7,5),TWCUM(7,5),MOOCUM(7,5),MOOANU(7,5)
      INTEGER PORTYP(2),NEG(2),MOOPR,ASPECT,S,N,TEMP1,DATOUT(5,3),
     1 MONDAT(5,3),MODL,TITLE,TABNUM
      COMMON N,S
      COMMON /G9/ TWCUM,MWCUM
      COMMON /G30/ MOOCUM,MOOANU
      COMMON /G28/ DATOUT,MONDAT
      DATA PORTYP,NEG / 5HTIME ,5HMONEY,3HNOT,3H   /
C
C  PRINTS TABLES 10 AND 11 VIA S/R 'OUTCUM' FOR ANNUALISED AVERAGE PAST
C    RURS. ALSO TABLE 12 FOR MODEL FUND IF 'MOOPR'=1 ('MODL'=2 FOR 'MOOPC
C
      MODL = 1
      TABNUM = 10
C  PRINT MONEY WEIGHTED RATES OF RETURN
      ASPECT = PORTYP(2)
      TITLE = NEG(2)
      CALL OUTCUM(MWCUM,ASPECT,TITLE,TABNUM,DATOUT,S,MODL)
C  PRINT TIME WEIGHTED RATES OF RETURN.
      ASPECT = PORTYP(1)
      TITLE = NEG(1)
      TABNUM = TABNUM + 1
      CALL OUTCUM(TWCUM,ASPECT,TITLE,TABNUM,DATOUT,S,MODL)
C  PRINT MODEL FUND'S  CUMULATIVE RETURNS IF MODEL ANALYSIS BEEN REQUEST
      IF( MOOPR.EQ.0 ) GOTO 2001
      CALL HEAD
      MODL = 2
      TEMP1 = 6
      TABNUM = TABNUM + 1
      CALL OUTCUM(MOOCUM,ASPECT,TITLE,TABNUM,MONDAT,TEMP1,MODL)
 2001 RETURN
      END
C
C
      SUBROUTINE OUT16(CMPTAB,SELTAB,SCYSEL)
      REAL CMPTAB(7,5),TPOLCY,TINSTR,TSUSTR,TSTRT,SCYSEL(2,7),
     1 TSCTSL,TPROFT,TSCYSL,SELTAB(7,5)
      INTEGER I,J,N,S,RPDATE(2,3),MSTMSG,DATOUT(5,3),MONDAT(5,3),
     1 NAME(7,2),SECTR(6),JJ
      COMMON /G6/ W,R
      COMMON /G12/ NAME,SECTR
      COMMON /G16/ TPOLCY,TINSTR,TSUSTR,TSTRT,TSCTSL,TSCYSL,TPROFT
      COMMON /G16/ RPDATE
      COMMON /G28/ DATOUT,MONDAT
C
C  PRINTS TABLE NO. 16 'PAST COMPONENTS OF RETURN'
C
      WRITE(W,1000)
 1000 FORMAT(///31X,69H16.   COMPONENTS  OF  RETURN  RELATIVE  TO  MODEL
     1 FUND  (PERCENTAGES),/,31X,70(1H-),/ )
      WRITE(W,1010)( RPDATE(1,J),J=1,3 ),(( DATOUT(I,J),J=1,3),I=1,5 )
 1010 FORMAT(/,44X,57HA V E R A G E   O V E R   P R E V I O U S   P E R
     1I O D S,3X,5H( T O,1X,I2,1X,I2,1X,I4,1X,1H),
     1      /,24X,9HVALUE,7X,92(1H-),/,5X,9HCOMPONENT,11X,11HTHIS PERI
     200,1X,5(3X,5HSINCE,2.3,I5),/,1X,19(1H-),6X,11(1H-),1X,5(3X,16(1H-)
     3 ),/ )
      WRITE(W,1020)
 1020 FORMAT(1X,131(1H-))
      WRITE(W,1030) TPOLCY,( CMPTAB(1,J),J=1,5 )
 1030 FORMAT(1X,13HPOLICY RETURN,12X,F7.2,10X,4(F7.2,12X),F7.2 )
      WRITE(W,1020)
      WRITE(W,1040) TINSTR,( CMPTAB(2,J),J=1,5 )
 1040 FORMAT(/3X,7HINITIAL,/3X,16HSTRATEGIC RETURN,7X,F7.2,10X,
     1 4(F7.2,12X),F7.2 )
      WRITE(W,1050) TSUSTR,( CMPTAB(3,J),J=1,5 )
 1050 FORMAT(/,3X,10HSUBSEQUENT,/,3X,16HSTRATEGIC RETURN,7X,F7.2,
     1 10X,4(F7.2,12X),F7.2 )
      WRITE(W,1020)
      WRITE(W,1060) TSTRT,( CMPTAB(6,J),J=1,5 )
 1060 FORMAT(1X,5HTOTAL,/1X,16HSTRATEGIC RETURN,9X,F7.2,10X,4(F7.2,12X),
     1 F7.2 )
      WRITE(W,1020)
      WRITE(W,1070)
 1070 FORMAT(/,1X,131(1H=) )
      WRITE(W,1080) TSCTSL,( CMPTAB(7,J),J=1,5 )
 1080 FORMAT(1X,17HTOTAL RETURN FROM,/,3X,16HSECTOR SELECTION,7X,F7.2,
     1 10X,4(F7.2,12X),F7.2 )
      WRITE(W,1070)
      WRITE(W,1100) TSCYSL,( CMPTAB(4,J),J=1,5 )
 1100 FORMAT(//,1X,17HTOTAL RETURN FROM,/,1X,18HSECURITY SELECTION,7X,
     1 F7.2,10X,4(F7.2,12X),F7.2 )
      WRITE(W,1130)
 1130 FORMAT(3X,11HBY SECTOR =)
      DO 1 J=1,6
      JJ=SECTR(J)
      WRITE(W,1140) NAME(JJ,1),NAME(JJ,2),SCYSEL(2,J),
     1 ( SELTAB(J,I),I=1,5 )
 1140 FORMAT(7X,2A6,7(F7.2,10X,/(F7.2,12X),F7.2 )
     1 CONTINUE
      WRITE(W,1110)
 1110 FORMAT(//)
      WRITE(W,1070)
      WRITE(W,1120) TPROFT,( CMPTAB(5,J),J=1,5 )
 1120 FORMAT(1X,19HTOTAL  EXCESS RETURN,/,1X,15HOVER MODEL FUND,10X,
     1 F7.2,10X,4(F7.2,12X),F7.2 )
      WRITE(W,1070)
      RETURN
      END
C
C
      SUBROUTINE OUT17(MAD,MOODMAD,MONSTX)
      REAL MAD(7),MOODMAD(7),RTEMP1
      INTEGER J,W,R,NAME(7,2),SECTR(6),MONSTX,BLANK
      DATA BLANK /6H    /
      COMMON /G6/ W,R
      COMMON /G12/ NAME,SECTR
C
C PRINTS TABLE NO. 17 'RISK MEASURES'.
C
      WRITE(W,1000)
 1000 FORMAT(////,43X,45H17.   R I S K   M E A S U R E S   ( / P. A. ),
     2 /,43X,45(1H-),//,34X,
     2 50HRISK IS MEASURED AS THE VARIABILITY OF TIME-WEIGHTED RATE OF,
     3 /,34X,
     4 61HRETURN ABOUT THE AVERAGE RETURN OVER THE PAST 12 OR LESS REVIE
     5WS,/,34X,
     6 62HPLUS THIS ONE.   A RISK MEASURE OF 16.0/, FOR EXAMPLE, IMPLIES
     7,/,34X,63HTHAT, ON AVERAGE, PAST ANNUALISED TIME-WEIGHTED RATES OF
     8 RETURN,/,34X,
     9 62HHAVE DEVIATED FROM THEIR AVERAGE BY PLUS OR MINUS 15 PER CENT
     9,// )
      WRITE(W,1010)
 1010 FORMAT(56X,21HRISK  MEASURES (/P.A.),/,35X,11HS E C T O R,8X,
     1 26(1H-),7X,7HRATIO  1,/,75X,6HMARKET,9X,7HFUND TO,/,57X,6HFUND'S,
     2 ,7X,10H(ACCORDING,5X,12HMARKET RISK',/,54X,11HINVESTMENTS,6X,
     3 9HTO INDEX),/,34X,12(1H-),9X,11(1H-),5X,10(1H-),5X,12(1H-),/)
      IF( MONSTX.NE.BLANK ) GOTO 101
      IF( MOODMAD(7).LT.0.0001 ) GOTO 101
      RTEMP1 = MAD(7) / MOODMAD(7)
      WRITE(W,1020) NAME(7,1),NAME(7,2),MAD(7),MOODMAD(7),RTEMP1
 1020 FORMAT(/,34X,2A6,10X,F7.2,8X,F7.2,7X,F7.2)
      WRITE(W,1030)
 1030 FORMAT(63X,12H(MODEL FUND),//)
      GOTO 201
  101 WRITE(W,1020) NAME(7,1),NAME(7,2),MAD(7)
      WRITE(W,1040)
 1040 FORMAT(71X,25HN O T   A V A I L A B L E,//)
  201 DO 1 J=1,6
      IF( MONSTX.NE.BLANK ) GOTO 301
      IF( MOODMAD(J).LT.0.0001 ) GOTO 301
      RTEMP1 = MAD(J) / MOODMAD(J)
      WRITE(W,1020) NAME(J,1),NAME(J,2),MAD(J),MOODMAD(J),RTEMP1
      GOTO 1
  301 WRITE(W,1020) NAME(J,1),NAME(J,2),MAD(J)
    1 CONTINUE
      WRITE(W,1050)
 1050 FORMAT(///,25X,76H*   A RISK MEASURE LOWER THAN THAT OF THE MARKET
     1ALL, A RATIO LESS THAN 1.0),/,25X,
     2 73HINDICATES SUPERIOR RISK PERFORMANCE.  SUPERIOR RISK PERFORMANC
     3E, IF LARGE,/,28X,
     4 74HENOUGH, MAY COMPENSATE FOR INFERIOR RATE OF RETURN PERFORMANCE
     5 RELATIVE TO,/,28X,
     6 74HTHE MARKET.    THIS IS ON THE RATIONALE THAT A LOWER, MORE SECU
     7RE RETURN IS,/,28X,
     8 72HPREFERABLE TO A HIGHER BUT MORE VARIABLE (AND HENCE LESS SECUR
     9E)  RETURN. )
      RETURN
      END
C
C
C
      SUBROUTINE OUT18(NEPAID,CSHRPD,NM)
      REAL TOTVAL,TAB(2),DIVIS
      INTEGER I,J,NAME(7,2),NM,APURCH(13,9),AINCOM(13,9),
     1 NOTAV(3),INCMLX,PAIDEX,VALPAD(3),N,S,REPAID,BLANK,SECTR(6),W,R,JJ
     2 ,CASHNM(13),CSHRPD,INCOPT,TOTLIN,TOTEXT(4),PARTIN,PARTAB(6)
      COMMON N,S
      COMMON /G6/ W,R
      COMMON /G8/ INCMEX,PAIDEX,VALPAD,INCOPT
      COMMON /G12/ NAME,SECTR
      COMMON /G14/ AINCOM,TOTVAL
```

```
      COMMON /G15/ APURCH
      COMMON /G26/ CASHNM
      COMMON /G33/ PARTAL,TOTLIN,TOTEXT,PARTIN
      DATA NOTAV,BLANK / 6HNOT AV,6HAILABL,6HE      ,6H      /
C
C  PRINTS TABLE NO. 18 'RECEIPTS AND ALLOCATIONA BY SECTOR'.
C
      DIVIS= TOTVAL / 100.0
      WRITE(W,1000)
 1000 FORMAT(//,22X,38HR E C E I P T S  A N D  A L L O C A T I O N S
     1D U R I N G  R E V I E W  P E R I O D,/,22X,89(1H-),////,
     2 37X,44H14.   RECEIPTS  AND  ALLOCATIONS  BY  SECTOR,/,37X,
     3 44(1H-),//,26X,15HR E C E I P T S,45X,21HA L L O C A T I O N S,/
     4 ,26X,53(1H-),10X,53(1H-),/,45X,12H/ OF INITIAL,6X,12H/ OF INITIAL
     5 /,11X,11HS O U R C E,11X,10HAMOUNT (E),11X,4HFUND,7X,3H,
     6 11HS O U R C E,11X,10HAMOUNT (E),11X,4HFUND,7X,3H,
     7 18(1H-),4X,17(1H-),2X,12(1H-),10X,18(1H-),4X,
     8 19(1H-),2X,12(1H-) )
      TAB(1) = FLOAT( NM ) / DIVIS
      WRITE(W,1010) NM,TAB(1)
 1010 FORMAT(/,8X,17HNET CONTRIBUTIONS,13X,I3,4X,F7.2)
      IF( INCMEX.NE.BLANK .AND. TOTLIN.EQ.BLANK ) GOTO 1001
      IF( TOTLIN.NE.BLANK ) GOTO 1001
      WRITE(W,1020)
 1020 FORMAT(/,8X,18HINVESTMENT INCOME-,45X,15HNET PURCHASES -)
      GOTO 1101
 1001 WRITE(W,1025)
 1025 FORMAT(/,8X,18HINVESTMENT INCOME-,6X,
     1 29HCOMPLETE FIGURES NOT PROVIDED,16X,15HNET PURCHASES -)
 1101 DO 1 J=1,3-4
      TAB(1) = FLOAT( AINCOM(N+1,J) ) / DIVIS
      TAB(2) = FLOAT( APURCH(N+1,J) ) / DIVIS
      JJ = SECTR(J)
      WRITE(W,1030) NAME(JJ,1),NAME(JJ,2),AINCOM(N+1,J),TAB(1),NAME(JJ,
     1 1),NAME(JJ,2),APURCH(N+1,J),TAB(2)
 1030 FORMAT(14X,2A6,4X,I8,13X,F7.2,13X,2A6,4X,I9,14X,F7.2)
    1 CONTINUE
      JJ = SECTR(5)
      TAB(1) = FLOAT( AINCOM(N+1,5) ) / DIVIS
      WRITE(W,1040) NAME(JJ,1),NAME(JJ,2),AINCOM(N+1,5),TAB(1)
 1040 FORMAT(14X,2A6,4X,I8,13X,F7.2)
      WRITE(W,1050)
 1050 FORMAT(33X,9(1H-),13X,7(1H-),35X,9(1H-),14X,7(1H-) )
      TAB(1) = FLOAT( AINCOM(N+1,7) ) / DIVIS
      J = APURCH(N+1,7) - APURCH(N+1,5)
      TAB(2) = FLOAT( J ) /DIVIS
      WRITE(W,1060) NAME(7,1),NAME(7,2),AINCOM(N+1,7),TAB(1),
     1 NAME(7,1),NAME(7,2),J,TAB(2)
 1060 FORMAT(14X,12HTOTAL INCOME,45X,15HTOTAL PURCHASES,/,13X,2H(,
     1 2A6,1H),3X,I8,13X,F7.2,13X,1H(,2A6,1H),8X,I9,14X,F7.2)
      TAB(1) = FLOAT( AINCOM(N+1,8) ) / DIVIS
      TAB(2) = FLOAT( APURCH(N+1,8) ) / DIVIS
      WRITE(W,1070) AINCOM(N+1,8),TAB(1),APURCH(N+1,8),TAB(2)
 1070 FORMAT(14X,8HEXCLUDED,-9X,8HEXCLUDED,/,16X,6HSECTOR,4X,I8,13X,
     1 F7.2,15X,6HSECTOR,14X,I9,14X,F7.2 )
      TAB(1) = FLOAT( AINCOM(N+1,9) ) / DIVIS
      J = J + APURCH(N+1,8)
      TAB(2) = FLOAT( J ) / DIVIS
      WRITE(W,1050)
      WRITE(W,1080) AINCOM(N+1,9),TAB(1), J ,TAB(2)
 1080 FORMAT(6X,12HTOTAL INCOME,18X,I9,4X,F7.2,13X,15HTOTAL PURCHASES,
     1 16X,I10,4X,F7.2 )
      JJ = APURCH(N+1,5) + CASHNM(N+1) + AINCOM(N+1,5) - CSHRPO
      TAB(1) = FLOAT( JJ ) / DIVIS
      WRITE(W,1090) JJ,TAB(1)
 1090 FORMAT(71X,16HINCREASE IN CASH,15X,I10,4X,F7.2 )
      I = APURCH(N+1,9)
      TAB(2) = FLOAT( I )  / DIVIS
      IF( INCMEX.NE.BLANK .AND. TOTLIN.EQ.BLANK ) GOTO 1201
      IF( TOTLIN.EQ.TOTEXT(4) .AND. PARTIN.EQ.BLANK ) GOTO 1201
      TAB(1) = FLOAT( REPAID ) / DIVIS
      WRITE(W,1110) REPAID,TAB(1)
 1110 FORMAT(71X,11HPAYMENTS TO,/,74X,8HTRUSTEES,20X,I10,4X,F7.2 )
      I = APURCH(N+1,9) + REPAID  +CASHNM(N+1) + AINCOM(N+1,5) -CSHRPO
      TAB(2) = FLOAT( I ) / DIVIS
 1201 WRITE(W,1100)
 1100 FORMAT(/,8X,39(1H-),2X,12(1H-),10X,41(1H-),2X,12(1H-))
      J = NM + AINCOM(N+1,9)
      TAB(1) = FLOAT( J ) / DIVIS
      WRITE(W,1120) J,TAB(1),I,TAB(2)
 1120 FORMAT(8X,14HTOTAL RECEIPTS,16X,I9,4X,F7.2,13X,
     1 17HTOTAL ALLOCATIONS,15X,I9,4X,F7.2 )
      WRITE(W,1130)
 1130 FORMAT(38X,9(1H=),2X,12(1H=),41X,10(1H=),2X,12(1H=) )
      RETURN
      END
C
C
      SUBROUTINE OUT19(PAIDI,NMAMT)
      REAL TOTVAL,RTAB(2),DIVIS
      INTEGER K,J,MTHNUM(12),DAYNUM(12),LATTN(5),NMAMT(13,2),
     1 AINCOM(13,9),PAIDI(13,9),APURCH(13,9),BLANK,INCMEX,W,R,
     2NAME(7,2),SECTR(6),MTHNAM(12),TAB(3),N,S,NOTAV(3),PAIDEX,VALPAD(3)
     3 ,CASHNM(13),TEMP1,TEMP2,INCOPT
      COMMON N,S
      COMMON /G6/ W,R
      COMMON /G3/ INCMEX,PAIDEX,VALPAD,INCOPT
      COMMON /G4/ PATTN,DAYNUM,MTHNUM
      COMMON /G12/ NAME,SECTR
      COMMON /G14/ AINCOM,TOTVAL
      COMMON /G15/ APURCH
      COMMON/G26/ CASHNM
      DATA BLANK,NOTAV / 6H      ,6HNOT AV,6HAILABL,6HE      /
      DATA MTHNAM /3HJAN,3HFEB,3HMAR,3HAPR,3HMAY,3HJUN,3HJUL,3HAUG,
     1 3HSEP,3HOCT,3HNOV,3HDEC /
C
C  PRINTS TABLE NO. 19 'RECEIPTS AND ALLOCATIONS BY TIME'
C
      DIVIS = TOTVAL / 100.0
      WRITE(W,1000) NAME(7,1),NAME(7,2)
 1000 FORMAT(//,45X,42H1 ).   RECEIPTS  AND  ALLOCATIONS  BY  TIME,/,
     1 45X,42(1H-),///,1X,5HMONTH,25X,15HR E C E I P T S,45X,
     2 21HA L L O C A T I O N S,/,1X,5(1H-),5X,54(1H-),4X,63(1H-),/,
     3 22X,10HINVESTMENT,17X,9HTOTAL AS,11X,3HNET,7X,8HINCREASE,2X,
     4 13HNET PURCHASES,15X,8HTOTAL AS,/,14X,3HNET,9X,11HINCOME (NET,
     5 3/,9HTOTAL (E),2X,12H/ OF INITIAL,6X,9HPURCHASES,7X,2HIN,6X,
     6 11HIN EXCLUDED,3X,9HTOTAL (E),2X,12H/ OF INITIAL,/,11X,
     7 13HCONTRIBUTIONS,2X,14HOF ANY REPAID,17X,4HFUND,7X,1H(,2A6,
     8 1H),4X,4HCASH,8X,8HSECTOR,20X,4HFUND)
      WRITE(W,1010)
 1010 FORMAT(12X,13(1H-),2X,14(1H-),2X,9(1H-),2X,12(1H-),4X,13(1H-),
     1 2X,8(1H-),3X,13(1H-),2X,9(1H-),2X,12(1H-) )
      IF( INCMEX.EQ.BLANK ) GOTO 1001
      IF( PAIDEX.EQ.VALPAD(1) ) GOTO 1101
      WRITE(W,1020) NOTAV
 1020 FORMAT(20X,3A6)
      GOTO 1101
 1001 WRITE(W,1030)
 1030 FORMAT(/)
 1101 DO 1 K=1,N
      J = MTHNUM(K)
      TAB(3) = APURCH(K,7) - APURCH(K,5)
      RTAB(2) = FLOAT( APURCH(K,9) ) / DIVIS
      IF( INCMEX.NE.BLANK .AND. PAIDEX.NE.VALPAD(1) ) GOTO 1201
      TEMP1 = APURCH(K,5) + CASHNM(K) + AINCOM(K,5) - PAIDI(K,5)
      TEMP2 = APURCH(K,9) + CASHNM(K) + AINCOM(K,5) - PAIDI(K,5)
      RTAB(2) = FLOAT( TEMP2 ) / DIVIS
      TAB(1) = AINCOM(K,9) - PAIDI(K,9)
      TAB(2) = TAB(1) + NMAMT(K,1)
      RTAB(1) = FLOAT( TAB(2) ) / DIVIS
      WRITE(W,1040) MTHNAM(J),NMAMT(K,1),TAB(1),TAB(2),RTAB(1),TAB(3),
     1 TEMP1,APURCH(K,8),TEMP2,RTAB(2)
 1040 FORMAT(2X,A3,7X,I9,2X,I8,6X,I9,4X,F7.2,8X,I9,4X,I9,3X,I9,5X,
     1 I9,4X,F7.2,/ )
      GOTO 1
 1201 RTAB(1) = FLOAT( NMAMT(K,1) ) / DIVIS
      WRITE(W,1050) MTHNAM(J),NMAMT(K,1),RTAB(1),TAB(3),
     1 APURCH(K,5),APURCH(K,8),APURCH(K,9),RTAB(2)
 1050 FORMAT(2X,A3,7X,I9,21X,I9,4X,F7.2,8X,I9,4X,I9,3X,I9,5X,I9,4X,
     1 F7.2,/ )
    1 CONTINUE
      WRITE(W,1030)
      WRITE(W,1111)
      TAB(3) = APURCH(N+1,7) - APURCH(N+1,5)
      RTAB(2) = FLOAT( APURCH(N+1,9) ) / DIVIS
      IF( INCMEX.NE.BLANK .AND. PAIDEX.NE.VALPAD(1) ) GOTO 1301
      TEMP1 = APURCH(N+1,5) + CASHNM(N+1) + AINCOM(N+1,5) - PAIDI(N+1,5)
      TEMP2 = APURCH(N+1,9) + CASHNM(N+1) + AINCOM(N+1,5) - PAIDI(N+1,5)
      RTAB(2) = FLOAT( TEMP2 ) / DIVIS
      TAB(1) = AINCOM(N+1,9) - PAIDI(N+1,9)
      TAB(2) = TAB(1) + NMAMT(N+1,1)
      RTAB(1) = FLOAT( TAB(2) ) / DIVIS
      WRITE(W,1060) NMAMT(N+1,1),TAB(1),TAB(2),RTAB(1),TAB(3),
     1 TEMP1,APURCH(N+1,8),TEMP2,RTAB(2)
 1060 FORMAT(1X,6HTOTALS,5X,I9,7X,I9,6X,I9,4X,F7.2,8X,I9,4X,I9,3X,
     1 I9,5X,I9,4X,F7.2 )
      GOTO 1401
 1301 WRITE(W,1070) NMAMT(N+1,1),NMAMT(N+1,1),RTAB(1),TAB(3),
     1 APURCH(N+1,5),APURCH(N+1,8),APURCH(N+1,9),RTAB(2)
 1070 FORMAT(1X,6HTOTALS,5X,I9,21X,I9,4X,F7.2,8X,I9,4X,I9,3X,I9,
     1 5X,I9,4X,F7.2 )
 1401 WRITE(W,1080)
```

```
 1080 FORMAT(11X,13(1H=),2X,14(1H=),2X,9(1H=),2X,12(1H=),4X,13(1H=),
     1 2X,9(1H=),2X,13(1H=),2X,9(1H=),2X,12(1H=) )
      RETURN
      END
C
C
      SUBROUTINE SORT(ANRATE,ANROR)
      REAL ANRATE(7),ANROR(7)
      INTEGER JJ,J,S,N,SECTR(6),NAME(7,2)
      COMMON N,S
      COMMON /G12/ NAME,SECTR
C
C PLACES ZEROES IN UNUSED SECTORS AND RELOCATES TOTAL FUND RETURN INTO 7 TH
C   ARRAY ELEMENT. DOES NOT CHANGE 'ANRATE', THE ORIGINAL ARRAY.
      DO 2 J = 1,S
      ANROR(J) = ANRATE(J)
    2 CONTINUE
      IF(S.GT.6 ) GOTO 1001
      DO 3 J = S+1,6
      ANROR(J) = 0.0
    3 CONTINUE
 1001 ANROR(7) = ANRATE(S+1)
C
      RETURN
      END
C
C
      SUBROUTINE PERCNT(TAB,NN,NUM,PC)
      REAL TAB(11),PC(11),NUM3,NUM
      INTEGER NN,I
C SUBROUTINE TO CALCULATE A VECTOR OF 'NN' FIGURES ('TAB') AS PERCENTAGES
C     ('PC') OF A BASE NUMBER 'NUM().
      NUM3 = NUM/100.0
      DO 1 I=1,NN
      PC(I) = TAB(I) / NUM3
    1 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE ENDPR
      INTEGER W,R,PFNAME(7),PAGE
      COMMON /G6/ W,R
      COMMON /G7/ PAGE,PFNAME
C
C PRINTS INDICATION OF END OF REPORT FOR CURRENT FUND
C
      WRITE(W,8850) PFNAME
 8850 FORMAT(/////,1X,37(1H*),1X,18HEND OF REPORT FOR ,7A6,1X,36(1H*))
      RETURN
      END
```

PERFORMANCE REPORT FOR A NON-L.A. PUBLIC UTILITY CORPN. FUND (C) OVER PERIOD 1 4 1976 TO 31 3 1977 PAGE 2

4. ACHIEVED RATE OF RETURN (R.O.R.) FOR EACH SECTOR OVER THIS REVIEW PERIOD (%)

SECTOR	HISTORICAL MARKET R.O.R.	ACHIEVED MONEY-WEIGHTED R.O.R. (SEE NOTE 1 BELOW)	ACHIEVED TIME-WEIGHTED R.O.R. (SEE NOTE 2 BELOW)	DIFFERENCE (MONEY- LESS TIME-WEIGHTED, SEE NOTE 3)	GROSS GAIN (000'S) (% OF NEW MONEY)*	GROSS INCOME YIELD (%P.A.)*	PERCENTAGE OF GAIN WHICH WAS INCOME*
TOTAL MAIN FUND	15.67 (MODEL FUND)	16.95	14.08	2.87	8236.56	7.37	43.45
GILTS	20.96	35.33	24.74	10.59	5586.23	9.23	26.12
OTH FIXD INT	29.13	43.45	47.47	-4.02	163.61	13.49	31.04
EQUITIES	13.90	9.16	9.40	-.24	2122.72	6.21	67.79
OVERSEAS	3.82	-2.07	10.21	-12.28	-115.70	2.99	NOT APPLICABLE
PROPTY TST	6.95	9.45	9.23	.22	32.49	4.42	46.76
CASH	12.26	13.01	13.16	-.15	447.22	13.02	100.00

NOTE 1: MONEY-WEIGHTED RATE OF RETURN IS AFFECTED BY THE TIMING OF NEW MONEY AND SECTOR SWITCHES DURING THE PERIOD. IT IS THE ORDINARY RATE OF RETURN, MEASURING INCREASE IN WEALTH.

NOTE 2: TIME-WEIGHTED RATE OF RETURN IS NOT AFFECTED BY THE TIMING OF NEW MONEY, AND IN THE CASE OF AN INDIVIDUAL SECTOR, BY THE TIMING OF SWITCHES INTO AND OUT OF THAT SECTOR. IT IS THE RATE OF RETURN WHICH IS MORE COMPARABLE BETWEEN DIFFERENT PORTFOLIOS.

NOTE 3: IN THE CASE OF AN INDIVIDUAL SECTOR, A LARGE POSITIVE DIFFERENCE (E.G. 1% OR GREATER) INDICATES THAT SWITCHES INTO AND OUT OF THAT SECTOR AND NEW INVESTMENTS IN THIS SECTOR WERE TIMED WELL. A LARGE POSITIVE DIFFERENCE FOR THE TOTAL FUND INDICATES THAT THE TIMING OF NEW MONEY WAS FAVOURABLE TO PERFORMANCE.

* ALL THE ABOVE FIGURES ARE BASED ON GROSSED-UP INCOME, SHOULD ANY INCOME DURING THE PERIOD HAVE BEEN REPORTED NET OF TAX.

Extract form a Fund Performance Report over a review period of one year, showing large timing measures

19. RECEIPTS AND ALLOCATIONS BY TIME

MONTH	RECEIPTS				ALLOCATIONS				
	NET CONTRIBUTIONS	INVESTMENT INCOME (NET OF ANY REPAID)	TOTAL (E)	TOTAL AS % OF INITIAL FUND	NET PURCHASES (MAIN FUND)	INCREASE IN CASH	NET PURCHASES IN EXCLUDED SECTOR	TOTAL (E)	TOTAL AS % OF INITIAL FUND
APR	1405881	114478	1520359	3.80	448515	1071844	-0	1520359	3.80
MAY	1518385	252485	1770870	4.42	-3736230	5527100	-0	1770870	4.42
JUN	960327	217714	1178041	2.94	5215207	-4037166	-0	1178041	2.94
JUL	1712329	397606	2110535	5.27	-1863000	3973535	-0	2110535	5.27
AUG	1739119	70001	1809120	4.52	2704000	-896880	-0	1809120	4.52
SEP	741200	185212	926412	2.31	5838000	-4911588	-0	926412	2.31
OCT	2912801	134308	3047109	7.61	2283835	763274	-0	3047109	7.61
NOV	2728257	332014	3060271	7.64	1354478	1705793	-0	3060271	7.64
DEC	1132305	100435	1232740	3.08	4874550	-3641810	-0	1232740	3.08
JAN	1157348	463283	1620631	4.05	2506273	-885542	-0	1620631	4.05
FEB	1048493	52037	1100530	2.75	-130717	1231247	-0	1100530	2.75
MAR	1206902	163242	1370144	3.42	2011034	-640890	-0	1370144	3.42
TOTALS	18263947	2482815	20746762	51.81	21485945	-739183	0	20746762	51.81

********** END OF REPORT FOR A NON-L.A. PUBLIC UTILITY CORPN. FUND (C) **********

FUND COMPARISON REPORT FOR PERIOD 1 1 1978 TO 31 3 1978 PAGE 1

1. AVERAGES OF TIME WEIGHTED RETURNS (T.W.R.A.), EXCESS RETURNS AND RISK MEASURES OF ALL FUNDS

TYPE OF FUND	FUNDS REVIEWED THIS PERIOD		SIMPLE AVERAGES				WEIGHTED AVERAGES (WEIGHTED BY FUND SIZES)			
			RETURN THIS PERIOD (1 1 1978 TO 31 3 1978)		OVER PAST 12 REVIEWS	AVERAGE RISK MEASURE (FROM ALL PAST REVIEWS)	RETURN THIS PERIOD (1 1 1978 TO 31 3 1978)		OVER PAST 12 REVIEWS	AVERAGE RISK MEASURE (FROM ALL PAST REVIEWS)
	NO.	AMOUNT £ MILL	AVERAGE TWR (%)	AV. EXCESS RETURN OVER MODEL (%)	AVERAGE ANNUAL TWR (%PA)	(%P.A.)	AVERAGE TWR (%)	AV. EXCESS RETURN OVER MODEL (%)	AVERAGE ANNUAL TWR (%PA)	(%P.A.)
ACTUAL AND DUMMY	16	281.27	-2.54	.36	34.99	121.35	-4.56	.20	31 48	55 38
ONLY DUMMY	5	203.52	-1.95	08	20.73	48.09	-1.70	.07	16.80	27.75

MODEL FUND	1	AV. PRIVATE FUND	-1.59	21.32	25.48
MODEL FUND	2	AV. NON-L.A. FUND	-1.59	21.50	47.96
MODEL FUND	3	AV LOC. AUTH. FUND	-1 75	20.62	24.72

EXTRACT FROM A FUND COMPARISON REPORT WITH A LARGER NUMBER OF FUNDS

This appendix shows an extract form a Fund Comparison Report based on 21 funds which have been divided into two classes (using R8). It may better illustrate the appearance of the report when applied to a large number of funds.

2. ACTUAL AND DUMMY FUNDS - TIME WEIGHTED RATE OF RETURN THIS PERIOD AND EXCESS RETURN OVER MODEL FUND THIS PERIOD

FUND NAME	TIME WEIGHTED RATE OF RETURN THIS PERIOD			EXCESS MONEY WEIGHTED RETURN OVER MODEL FUND THIS PERIOD				MANAGER
	VALUE %	RANK	EXCESS OVER OFFICE AV. (%)*	WHICH MODEL	VALUE %	RANK	EXCESS OVER OFFICE AV. (%)**	
DUMMY FUND NO.10	1.69	1	4.23	1	.06	12	-.30	3
DUMMY FUND NO.6	1.53	2	4.07	1	-.06	15	-.42	3
DUMMY FUND NO.2	-.43	3	2.11	1	.05	14	-.31	3
A MANUFACTURING COMPANY'S STAFF FUND (D)	-.47	4	2.07	1	1.11	1	.75	1
A MANUF. COMPANY'S WORKMEN'S FUND (E)	-.54	5	2.00	1	1.04	5	.68	1
A CONSUMER GOODS MANUF.'S PENSION FUND (A)	-.57	6	1.97	1	1.11	2	.75	2
A NON-L.A. PUBLIC UTILITY CORPORATION (C)	-1.53	7	1.01	2	.06	8	-.30	3
MODEL FUND 1 AV. PRIVATE FUND	-1.59		.95					
MODEL FUND 2 AV. NON-L.A. FUND	-1.59		.95					
DUMMY FUND NO.9	-1.63	8	.91	1	1.06	6	.70	3
MODEL FUND 3 AV LOC. AUTH. FUND	-1.75		.79					
A LOCAL AUTHORITY SUPERANNUATION FUND (B)	-1.97	9	.57	3	-.25	16	-.51	2
DUMMY FUND NO.8	-2.53	10	.01	1	.06	11	-.30	3
DUMMY FUND NO.7	-2.53	11	.01	3	.06	10	-.30	3

FUND NAME	TIME WEIGHTED RATE OF RETURN THIS PERIOD			EXCESS MONEY WEIGHTED RETURN OVER MODEL FUND THIS PERIOD				MANAGER
	VALUE %	RANK	EXCESS OVER OFFICE AV. (%)*	WHICH MODEL	VALUE %	RANK	EXCESS OVER OFFICE AV. (%)**	
DUMMY FUND NO.4	-2.53	12	.01	1	.06	9	-.30	3
DUMMY FUND NO.3	-2.53	13	.01	1	.07	7	-.29	3
DUMMY FUND NO.1	-3.53	14	-.99	3	1.06	3	.70	3
DUMMY FUND NO.11	-11.53	15	-8.99	1	.06	13	-.30	3
DUMMY FUND NO.5	-11.53	16	-8.99	1	.16	6	-.20	3

NOTES :

* AVERAGE AMONGST ACTUAL AND DUMMY FUNDS WAS -2.54%.

** AVERAGE AMONGST ACTUAL AND DUMMY FUNDS WAS .36%.

3. ACTUAL AND DUMMY FUNDS - RISK / RETURN PERFORMANCE OVER PAST 12 REVIEWS

FUND NAME	AVERAGE ANNUAL TIME WEIGHTED RETURN OVER PAST 12 REVIEWS: DATE FROM WHICH RETURN AVERAGED	VALUE (P.A.)	RANK	EXCESS OVER OFFICE AV. (%)*	RISK MEASURE (AVERAGE FLUCTUATION OF RETURN)*: VALUE (P.A.)	RANK	EXCESS OVER OFFICE AV. (%)**	NO. OF PAST RETURNS	MANAGER
DUMMY FUND NO.9	1 4 1975	573.02	1	486.03	755.82	15	634.47	16	3
DUMMY FUND NO.1	1 4 1975	570.86	2	485.86	759.35	16	638.01	16	3
DUMMY FUND NO 10	1 4 1975	25.78	3	-59.71	21.69	2	-99.65	16	3
DUMMY FUND NO.4	1 4 1975	22.83	4	-62.18	44.37	13	-76.99	16	3
A MANUFACTURING COMPANY'S STAFF FUND (D)	1 7 1975	22.13	5	-62.83	32.79	9	-88.56	11	1
MODEL FUND 2 AV. NON-L.A. FUND	1 4 1975	21.50		-63.49	47.96		-73.39	16	
A MANUF. COMPANY'S WORKMEN'S FUND (E)	1 7 1975	21.49	6	-63.51	33.15	10	-88.20	11	1
MODEL FUND 1 AV. PRIVATE FUND	1 7 1975	21.32		-63.67	25.48		-95.88	11	
A CONSUMER GOODS MANUF.'S PENSION FUND (A)	1 4 1975	20.15	7	-64.14	35.85	12	-85.51	8	2
DUMMY FUND NO.5	1 4 1975	20.59	8	-64.30	47.82	14	-73.53	16	3
MODEL FUND 3 AV LOC. AUTH. FUND	1 4 1975	21.32		-64.37	24.72		-96.63	12	

FUND NAME	AVERAGE ANNUAL TIME WEIGHTED RETURN OVER PAST 12 REVIEWS: DATE FROM WHICH RETURN AVERAGED	VALUE (P.A.)	RANK	EXCESS OVER OFFICE AV. (%)*	RISK MEASURE (AVERAGE FLUCTUATION OF RETURN)*: VALUE (P.A.)	RANK	EXCESS OVER OFFICE AV. (%)**	NO. OF PAST RETURNS	MANAGER
DUMMY FUND NO.7	1 4 1975	16.20	12	-68.79	25.61	4	-95.88	16	3
DUMMY FUND NO.8	1 4 1975	15.93	13	-69.17	25.93	6	-95.42	16	3
DUMMY FUND NO.2	1 4 1975	15.23	14	-69.77	24.72	3	-96.63	16	3
DUMMY FUND NO.11	1 4 1975	.55	15	-84.44	34.46	11	-86.89	16	3
DUMMY FUND NO.6	1 4.1975	-15.94	16	-101.93	18.37	1	-102.09	16	3

NOTES :

* AVERAGE AMONGST ACTUAL AND DUMMY FUNDS WAS 84.99%.

** AVERAGE AMONGST ACTUAL AND DUMMY FUNDS WAS 121.35%

* THIS RISK MEASURE, TECHNICALLY KNOWN AS MEAN ABSOLUTE DEVIATION, MEASURES THE AVERAGE EXTENT TO WHICH THE FUND'S PER ANNUM TIME-WEIGHTED RATE OF RETURN HAS VARIED FROM ITS AVERAGE OVER THE PAST. THE HIGHER THE MEASURE, THE MORE 'RISKY' IS THE FUND, IN THE SENSE THAT ITS RETURN IS LESS RELIABLE. (N.B.: LITTLE EMPHASIS SHOULD BE PLACED ON A RISK MEASURE BASED ON LESS THAN SAY 8 PAST RETURNS.)

4. ACTUAL AND DUMMY FUNDS - AVERAGE PERFORMANCE FIGURES FOR PERSONNEL

(FIGURES ARE AVERAGES OF RESULTS FOR ALL FUNDS UNDER THE MANAGER'S CONTROL. THE RESULTS ARE WEIGHTED BY THE SIZE OF THE FUND IN EACH CASE.)

MANAGER AND FUNDS MANAGED	CURRENT RESULTS: AVERAGE TIME-WEIGHTED RATE OF RETURN			CURRENT RESULTS: AVERAGE EXCESS RETURNS OVER MODEL FUND			OVER PAST 12 REVIEWS: AVERAGE OF AV. ANNUAL TIME-WEIGHTED RETURNS			OVER PAST 12 REVIEWS: AVERAGE OF AV. PAST EXCESS RETURNS OVER MODEL			RISK MEASURE	
(NO., EMIL)	VALUE (%)	RANK	EXCESS OVER OFFICE AV. (%)*	VALUE (%)	RANK	EXCESS OVER OFFICE AV. (%)**	VALUE (%P.A.)	RANK	EXCESS OVER OFFICE AV (%PA)+	VALUE (%P.A.)	RANK	EXCESS OVER OFFICE AV (%PA)++	VALUE (%P.A.)	RANK
1 (2, 19.53)	-.50	1	4.07	1.09	1	.89	21.32	2	-9.56	.26	1	1.09	32.92	2
2 (2, 45.09)	-1.43	2	3.13	.27	2	07	18.99	3	-12.49	06	2	87	31 47	1
3 (12,216.65)	-5.58	3	-1.02	.11	3	-.09	34.94	1	3.46	-1.08	3	-.28	62.39	3

NOTES :

* AVERAGE AMONGST ACTUAL AND DUMMY FUNDS WAS -4.56%

** AVERAGE AMONGST ACTUAL AND DUMMY FUNDS WAS .20%

\+ AVERAGE AMONGST ACTUAL AND DUMMY FUNDS WAS 31.68%

++ AVERAGE AMONGST ACTUAL AND DUMMY FUNDS WAS -.80%

199

2. ONLY DUMMY FUNDS - TIME WEIGHTED RATE OF RETURN THIS PERIOD AND EXCESS RETURN OVER MODEL FUND THIS PERIOD

FUND NAME	TIME WEIGHTED RATE OF RETURN THIS PERIOD			EXCESS MONEY WEIGHTED RETURN OVER MODEL FUND THIS PERIOD				MANAGER
	VALUE %	RANK	EXCESS OVER OFFICE AV. (%)*	WHICH MODEL	VALUE %	RANK	EXCESS OVER OFFICE AV. (%)**	
DUMMY FUND NO.15	-.53	1	1.42	3	.06	4	-.02	1
DUMMY FUND NO.12	-1.53	2	.42	1	16	1	.08	2
MODEL FUND 1 AV. PRIVATE FUND	-1.59		.35					
MODEL FUND 2 AV. NON-L.A. FUND	-1.59		.35					
DUMMY FUND NO.13	-1.63	3	.32	1	.06	2	-.02	3
MODEL FUND 3 AV LOC. AUTH. FUND	-1.75		.20					
DUMMY FUND NO.14	-2.53	4	-.58	2	.06	3	-.02	3
DUMMY FUND NO.16	-3.53	5	-1.58	3	.06	5	-.02	1

NOTES :

* AVERAGE AMONGST ONLY DUMMY FUNDS WAS -1.95%

** AVERAGE AMONGST ONLY DUMMY FUNDS WAS .08%

3. ONLY DUMMY FUNDS - RISK / RETURN PERFORMANCE OVER PAST 12 REVIEWS

FUND NAME	AVERAGE ANNUAL TIME WEIGHTED RETURN OVER PAST 12 REVIEWS: DATE FROM WHICH RETURN AVERAGED	VALUE (%P.A.)	RANK	EXCESS OVER OFFICE AV (%)*	RISK MEASURE (AVERAGE FLUCTUATION OF RETURN): VALUE (%P.A.)	RANK	EXCESS OVER OFFICE AV (%)**	NO. OF PAST RETURNS	MANAGE
DUMMY FUND NO.12	1 4 1975	33.43	1	18.75	34.09	4	-14.01	16	2
MODEL FUND 1 AV. PRIVATE FUND	1 7 1975	21.50		.59	25.48		-22.62	11	
MODEL FUND 2 AV. NON-L.A. FUND	1 4 1975	21.32		.77	47.96		-.13	16	
MODEL FUND 3 AV LOC. AUTH. FUND	1 4 1975	20.62		-.11	24.72		-23.37	12	
DUMMY FUND NO.14	1 4 1975	19.86	2	-1.65	37.60	5	-10.49	16	3
DUMMY FUND NO.13	1 4 1975	16.32	3	-4.22	26.53	3	-21.46	16	3
DUMMY FUND NO.16	1 4 1975	15.43	4	-5.30	26.14	2	-21.96	16	1
DUMMY FUND NO.15	1 4 1975	13.14	5	-7.59	17.64	1	-30.25	16	1

NOTES :

* AVERAGE AMONGST ONLY DUMMY FUNDS WAS 20.73%

** AVERAGE AMONGST ONLY DUMMY FUNDS WAS 48.09%

* THIS RISK MEASURE, TECHNICALLY KNOWN AS MEAN ABSOLUTE DEVIATION, MEASURES THE AVERAGE EXTENT TO WHICH THE FUND'S PER ANNUM TIME-WEIGHTED RATE OF RETURN HAS VARIED FROM ITS AVERAGE OVER THE PAST. THE HIGHER THE MEASURE, THE MORE 'RISKY' IS THE FUND, IN THE SENSE THAT ITS RETURN IS LESS RELIABLE. (N.B.: LITTLE EMPHASIS SHOULD BE PLACED ON A RISK MEASURE BASED ON LESS THAN SAY 8 PAST RETURNS.)

PROGRAM

"REPORT"

```
      PROGRAM REPORT(OUTPUT,INPUT,REPDBG,TAPE2,TAPE3=OUTPUT,
     1 TAPE5,TAPE4=REPDBG,TAPE1=INPUT)
      REAL HMFSIZ,TWHST(12),TWR(50,2),TWSUM(2),TWHSUM(2),SIZSUM(2),
     1 MGRSUM(3,2),MGWSUM(6,2),MGMFSZ(6,2),TAD,CUMTWR(50,2),SUMWSM(2),
     2 CUMSUM(3),MTEMP1,RTEMP2,MAD(50,2),TWRAV( ),TWRWAV( ),CTWRAV(2),
     3 MGRAV(6,2),MGRWAV(6,2),TWRDEV(50,2),CTWD_V(50,2),
     4 PASTWR(60),MODXSM(12),
     5 MGRDEV(3,2),CTWWAV(2),MGAMAD(4,2),MGWCSM(8,2),
     7 MGWCAV(3,2),MGWCDV(8,2),
     8 MSUMAD(3,2),MADAV(6),VEXCOM(50),SORTED(50),MODTYP(3),
     9 CMDTWR(3),MODMAD(3),MODDOV(4,2),MODDOV(3,2)
      REAL AMT(2),AVXS(2),MGDXS(50,2),XSDU(2),XSWSU(2),MXSSU(8,2),
     1 MXHSUM(3,2),MCSUM(8,2),MAXSUM(8,2),AVMAD(2),AVMAD(2),
     2 MADSUM(2),MADDS(2),MDMADV(2,2),AMAVXS(2),MMAD(50,2),
     3 XSDEV(50,2),MADDEV(50,2),MXSDEV(8,2),MGRXS(3,2),
     4 MAVXS(8,2),MAVXSD(8,2),AVMXS(2),WORK(3)
C
      INTEGER RPDATE(2,3),NPAST,NMGRS,RP,DR,RH,W,FFNUM,DATE(3),DAYS,
     1 TOTPD,PLACE,REPLAT,CLASS,MGR,PRO(12),NAME1(50,7),NAME2(50,7),
     2 MGRNUM(8,2),MODNAM(2),MGRWHO(5),2),PAGE,NOBS,TWDAY(60),
     3 DATBG1(50,3),DATBG2(50,3),MADOBS(50,2),PFNAME(7),FFNUM,TEMP1,
     4 TITLE(2,4),IFAIL,RANK1(3),MODMGR(3),MODOBS(3),
     5 MODBGN(3,3),MDTITL(3,3),NCLASS,NMOD,MDHIST(3),HISTFL,
     6 POINT(50),WICHMD,RANK2(50),RANK3(50),RANK4(50),MPOINT(3),
     7 MODTYP(50,2),NUM(2),DATOUT(12,3),K,I,N1,N2,BLANK,IWORK(3)
C
      COMMON /G1/ TWRAV,NMOD,MODTWR
      COMMON /G2/ PRO,NOBS,PASTWR,TWDAY,DATOUT
      COMMON /G3/ NPAST
      COMMON /G4/ MGRWHO
      COMMON /G5/ CLASS
      COMMON /G6/ TWSUM,TWHSUM,XSSUM,XSWSUM,CUMSUM,SUMWSM,MADSUM,
     1 MADMGM,MGWSUM,MGWCSM,MGMFSZ,MXSSU1,MAXSUM,AVEXCS,CUMTWR,
     2 MSUMAD,DATBG1,DATBG2
      COMMON /G7/ MGRNUM,MGMFSZ
      COMMON /G8/ RPDATE
      COMMON /G9/ NUM,MODNAM,MDTITL
      COMMON /G10/ W,TITLE
      COMMON /G12/ AVTWR,TWRHST,MGR,WICHMD,HMFSIZ,PFNAME,MGDXSM
      COMMON /G13/ TWR
      COMMON /G14/ CTWRAV
      COMMON /G16/ AVMAD,CMDTWR,MODMAD
      COMMON /G17/ PAGE
      COMMON /G18/ TWRWAV,AVWXS,CTWWAV,AVWMAD
      COMMON /G19/ SORTED
      COMMON /G20/ MPOINT,RANK2
      COMMON /G21/ TWRDEV,XSDEV,MODDEV
      COMMON /G22/ CTWDEV,MADDEV,MODBGN,MODCOV,MDMADV,MODOBS
      COMMON /G23/ SIZSUM
      COMMON /G24/ NMGRS,MGRDEV,MGRXS,MXSDEV,MGWCAV,RANK3,MGWCDV,
     1 MAVXS,RANK4,MAVXSD,MGAMAD,RANK1,AMAVXS
      COMMON /G25/ RH
      COMMON /G26/ MODTYP,MODXS
      COMMON /G27/ NAME1,NAME2
      COMMON /G28/ MAD,MADOBS
      COMMON /G29/ POINT
      COMMON /G30/ AVXS
C
      DATA NUM,MGWSUM,MGMFSZ,MGRNUM,MXSSUM,MXWSUM,MAXSUM,CUMSUM,
     1 CUMWSM,MSUMAD,MGWCSM,PLACE,TWSUM,TWHSUM,SIZSUM,
     2 XSWSUM,XSSUM,MGRSUM,N1,N2,FAIL,MODNAM,BLANK,PAGE,MFLAG
     4 / 2*0,16*0.0,16*0.0,16*0.0,16*0.0,16*0.0,2*0.0,2*0.0,16*0.0,
     5 16*0.0,0.0,2*0.0,2*0.0,2*0.0,2*0.0,2*0.0,16*0.0,1.0,0,
     6 6H MODEL,6H FUND ,6H ,0,0 /
C SET MANAGER AVERAGES FOR FUND TO RANK LAST IN CASE NOT EVERY MGR REPRE
      DATA MGRAV,MGWCAV,MGTWAV,MGRXS,MAVXS,MGAMAD,MGSDEV,
     1 MGRDEV,MGWCDV
     2 / 16*-10000.0,16*-10000.0,16*-10000.0,16*-10000.0,
     3   16*-10000.0,16*10000.0,16*0.0,16*0.0,16*0.0 /
      DATA RH,2R,W,W,MSUMAD / 5,1,2,1,16*0.0 /
      DATA MADSUM,MADMSM,AMAVXS / 2*0.0,2*0.0,2*0.0 /
C SET MODEL FUND RESULTS TO UNPROBABLE VALUES IN CASE THERE ARE NO MODEL
      DATA MODTWR,CMDTWR / 3*-10000.0,3*-10000.0 /
C
C
C  READ PARAMETERS FROM INPUT: REVIEW PERIOD DATES,NO. OF
C     MANAGERS AND DEPTH OF ANALYSIS BACK IN TIME UP TO 12 PAST ANALYSES
      READ(RR,1000) ( ( RPDATE(I,J),J=1,3),I=1,2 ),NPAST,NMGRS
 1000 FORMAT( 2(2I2,I4,2X),2I10 )
      WRITE(4,1000) ( ( RPDATE(I,J),J=1,3 ),I=1,2 ),NPAST,NMGRS
C READ REFERENCE FILE FOR CLASS TITLES AND MODEL FUND NAMES AND THEIR
C     HISTORY FILE NAMES.
      READ(RR,1010) NCLASS
      WRITE(4,1010) NCLASS
      DO 16 I=1,NCLASS
      READ(RR,1005) ( TITLE(I,J),J=1,4)
 1005 FORMAT(4A6)
   16 CONTINUE
      READ(RR,1010) NMOD
      WRITE(4,1010) NMOD
      IF( NMOD.EQ.0 ) REPLAT=1
      IF(NMOD.EQ.0) GOTO 105
      READ(RR,1004) ( ( MDTITL(I,J),J=1,3 ),MDHIST(I) ),I=1,NMOD )
 1006 FORMAT(3A6,2X,A6)
      WRITE(4,1004) ( ( MDTITL(I,J),J=1,3 ),MDHIST(I) ),I=1,NMOD )
      DO 3 I=1,NMOD
C*****************************  SYSTEM DEPENDENT ACCESS OF HISTORY FILE *******
      CALL GETPF(5HTAPE5,MDHIST(I) )
C  PROCESS MODEL FUND, FOR WHICH NO REFERENCE FILE EXISTS.
      READ(RH,1060) DATE
 1060 FORMAT(2I3,I5)
      WRITE(4,1060) DATE
      CALL DIFF(DATE,DAYS)
      IF( DAYS.LT.14 ) GOTO 1001
      WRITE(W,2010) DATE
 2010 FORMAT(//,5X,67H***WARNING : MODEL FUND RATES OF RETURN QUOTED I
     1N THIS REPORT ARE FOR A PERIOD UP TO ,2I3,I5,/,10X,
     2 69H- A DIFFERENCE FROM DATE OF THIS COMPARISON REPORT OF OVER TWO
     3 WEEKS.)
 1001 READ(RH,1007) TOTPD
 1007 FORMAT(/,I12)
      DO 20 K=1,12
      READ(RH,1012) ( DATOUT(K,J),J=1,3 ), PRO(K),TWRHST(K)
 1012 FORMAT(2I3,I5,I9,/,(8X,F10.0)
   20 CONTINUE
      READ(RH,1015) NOBS,( ( TWDAY(K),PASTWR(K) ),K=1,NOBS )
 1015 FORMAT(I10,/,20(4(I10,F10.5),/) )
C
C SET UP PARAMETERS FOR SUBROUTINE TO PROCESS MODEL FUND. SET MODEL FUND
C   AS CLASS TWO (RESTRICTED) FOR THIS PURPOSE.
   16 CLASS = 2
      MGR = 0
      HMFSIZ = 0.0
      CALL PROCES(1)
      MODTWR(I) = TWR(1,2) * 100.0
      MODMGR(I) = MGR
      CMDTWR(I) = CUMTWR(1,2)
      MODMAD(I) = MAD(1,2)
      MODOBS(I) = MADOBS(1,2)
      DO 11 J=1,3
      MODBGN(I,J) = DATBG2(1,J)
   11 CONTINUE
      WRITE(4,1050) MODTWR(I),MODMGR(I),CMDTWR(I),MODMAD(I),MODOBS(I),
     1 ( MODBGN(I,J),J=1,3 )
 1050 FORMAT(1X,F10.4,I10,2F10.4,I10,2I3,I5)
    3 CONTINUE
C
C
C PROCESS FUNDS
C
C
C  READ RF NUMBER OF NEXT FUND ON REFERENCE FILE.
  105 REPEAT = 0
      READ(RR,1010) FFNUM
 1010 FORMAT(I10)
      WRITE(4,1010) FFNUM
      IF( FFNUM.EQ.0 ) GOTO 901
C  READ REST OF INFORMATION ON THIS RECORD OF REFERENCE FILE.
      READ(RR,1020) PFNAME,CLASS,MGR,WICHMD,HISTFL
 1020 FORMAT(7A6,6X,I2,3X,I2,3X,I2,A7 )
      WRITE(4,1020) PFNAME,CLASS,MGR,WICHMD,HISTFL
C ACCESS NEW HISTORY FILE UNLESS BLANK FIELD IMPLIES SAME FILE AS LAST FUND
      IF( HISTFL.EQ.BLANK ) GOTO 501
C*******************************  SYSTEM DEPENDENT ACCESS OF HISTORY FILE ***************
      CALL GETPF(5HTAPE5,HISTFL)
C  LOCATE THIS FUND ON HISTORY FILE.
  501 READ(RH,1010) FILNUM
      IF( FILNUM.EQ.FFNUM ) GOTO 201
      IF( FILNUM.EQ.PLACE ) GOTO 401
      IF( FILNUM.EQ.0 ) GOTO 301
      TEMP1 = 0
      CALL NXTHST(TEMP1)
      GOTO 501
C  REACHED END OF FILE, SO REWIND AND SEARCH BEGINNING IF HAVE NOT
C     ALREADY DONE SO.
  301 REPEAT = REPEAT + 1
      REWIND RH
      IF( REPEAT.LT.2 ) GOTO 501
  401 WRITE(W,2001) FFNUM,PFNAME
 2001 FORMAT(//,5X,15H***FUND NUMBER,I10,2H, ,7A6,/,9X,
     1 60HWAS NOT INCLUDED IN THE COMPARISONS BECAUSE ITS HISTORY FILE C
     2OULD NOT BE FOUND.)
```

```
      TEMP1 = 0
      CALL NXTHST(TEMP1)
      GOTO  105
C  HAVE FOUND HISTORY FILE, SO READ LAST UPDATE DATE AND CHECK FOR APPROX
C     EQUALITY WITH COMPARISON DATE (PLUS OR MINUS 2 WEEKS.
  201 READ(RH,1030) DATE
 1030 FORMAT(2I3,I5)
      WRITE(W,1030) DATE
      CALL DIFF( DATE,DAYS )
C  IF ENDING DATE OF LAST REVIEW PERIOD FOR WHICH THIS FUND WAS ASSESSED
C     IS NOT WITHIN 2 WEEKS OF DATE OF THIS COMPARISON, REJECT THIS FUND.
      IF( DAYS.LT.14 ) GOTO 601
      WRITE(W,2020) FFNUM,FFNAME,DATE,( RPDATE(2,J),J=1,3 )
 2020 FORMAT(//,5X,15H****FUND NUMBER,I10,2H, ,7A8,/,9X,
     1 72HWAS NOT INCLUDED IN THE COMPARISONS BECAUSE ITS HISTORY IS
     2DATED TO ,2I3,I5,35H, WHICH IS NOT WITHIN TWO WEEKS OF ,/,9X,
     3 2I3,I5,37H, THE DATE OF THIS COMPARISON REPORT. )
C  PROCESS NEXT FUND ON REFERENCE FILE.
      TEMP1 = 1
      CALL NXTHST(TEMP1)
      GOTO 105
C
C
C  PROCESS THIS FUND.  FIRST READ TWR'S OVER PAST 12 ANALYSES AFTER
C      HOW MANY FUNDS ARE IN THIS CLASS SO FAR.
C
C
  601 NUM(CLASS) = NUM(CLASS) + 1
      I = NUM(CLASS)
      READ(RH,1035) TOTPD,HMFSIZ
 1035 FORMAT(////,I10,F12.1)
C REDUCE MEAN FUND SIZE TO F MILLIONS FOR COMPUTATIONAL ACCURACY.
      HMFSIZ = HMFSIZ / 1000000.0
C  READ MOST RECENT RESULTS AND PAST RESULTS.
      DO 2 K = 1,12
      READ(RH,1040) ( DATOUT(K,J),J=1,3 ),PRD(K),TWRMST(K),MOOXSH(K)
 1040 FORMAT(2I3,I5,I9,//,60X,F10.5,/,49X,F10.5,/)
    2 CONTINUE
C  READ PAST ROR'S ON TOTAL FUND
      READ(RH,1010) NOBS
      IF( NOBS.EQ.0 ) GOTO 651
      READ(RH,1045) ( ( TWDAY(K),PASTWR(K) ),K=1,NOBS )
 1045 FORMAT( 15( 4(I10,F10.),/ ) )
C  PROCESS THIS FUND
  651 CALL PROCES(I)
      WRITE(W,1050) TWR(I,CLASS),MGRWHO(I,CLASS),CUMTWR(I,
     1  CLASS),MAD(I,CLASS),MADOBS(I,CLASS),
     2 ( DATBG1(I,J),J=1,3 )
C  PROCESS NEXT FUND.
      GOTO 105
C  NOW THAT HAVE FINISHED PROCESSING ALL FUNDS ON REFERENCE FILE, SEC
C     PARAMETERS FOR CLASS REPETITION
  901 IF( NUM(1).NE.0 ) GOTO 701
      N1 = 2
  701 IF( NUM(2).NE.0 ) GOTO 801
      N2 = 1
C  FOR EACH CLASS OF FUND PRESENT......
  801 DO 6 CLASS = N1,N2
C  CALCULATE VARIOUS AVERAGES PER FUND.
      RTEMP1 = FLOAT( NUM(CLASS) )
      TWRAV(CLASS) = TWSUM(CLASS) *100.0 / RTEMP1
      TWRWAV(CLASS) = TWWSUM(CLASS) *100.0 / SIZSUM(CLASS)
      AVXS(CLASS) = XSSUM(CLASS)   / RTEMP1
      AVWXS(CLASS) = XSWSUM(CLASS)  / SIZSUM(CLASS)
      CTWRAV(CLASS) = CUMSUM(CLASS) / RTEMP1
      CTWRWAV(CLASS) = CUMWSM(CLASS) / SIZSUM(CLASS)
      AVMAD(CLASS) = MADSUM(CLASS) / RTEMP1
      AVWMAD(CLASS) = MADWSM(CLASS) / SIZSUM(CLASS)
      WRITE(W,8000) TWRAV(CLASS),TWRWAV(CLASS),AVXS(CLASS),AVWXS(CLA
     1 CTWRAV(CLASS),CTWRWAV(CLASS),AVMAD(CLASS),AVWMAD(CLASS)
 8000 FORMAT(1X,8F15.4)
C  CALCULATE DEVIATIONS OF TWR'S AND COMPONENTS FROM OFFICE AVERAGES
      DO 8 I = 1,NUM(CLASS)
      TWR(I,CLASS) = TWR(I,CLASS) * 100.0
      TWRDEV(I,CLASS) = TWR(I,CLASS) - TWRAV(CLASS)
      CTWDEV(I,CLASS) = CUMTWR(I,CLASS) - CTWRAV(CLASS)
      XSDEV(I,CLASS) = MOOXS(I,CLASS) - AVXS(CLASS)
      MADDEV(I,CLASS) = MAD(I,CLASS) - AVMAD(CLASS)
    8 CONTINUE
C FOR EACH MODEL FUND.....
      DO 12 I=1,NMOD
      MODDEV(I,CLASS) = MOOTWR(I)- TWRAV(CLASS)
      MODCDV(I,CLASS) = CMOTWR(I)- CTWRAV(CLASS)
      MOMADV(I,CLASS) = MOOMAD(I) - AVMAD(CLASS)
   12 CONTINUE
C CALCULATE AVERAGES PER MANAGER.
      DO 7 I = 1,NMGRS
      IF( MGRNUM(I,CLASS).EQ.0 ) GOTO 7
      MGRXS(I,CLASS) = MGXSUM(I,CLASS) *100.0 / FLOAT(MGRNUM(I,CLASS))
      MGWCAV(I,CLASS) = MGWSUM(I,CLASS) / MGMFSZ(I,CLASS)
      MGRWAV(I,CLASS) = MGWSUM(I,CLASS) * 100.0 / MGMFSZ(I,CLASS)
      MGXSUM(I,CLASS) = MXWSUM(I,CLASS)   / MGMFSZ(I,CLASS)
      MAXS(I,CLASS) = MAXSUM(I,CLASS)   / MGMFSZ(I,CLASS)
      MGAMAD(I,CLASS) = MSUMAD(I,CLASS) / MGMFSZ(I,CLASS)
      AMAXS(CLASS) = AMAXS(CLASS) + MAXS(I,CLASS)*MGMFSZ(I,CLASS)
      WRITE(W,8000) MGRAV(I,CLASS),MGWCAV(I,CLASS),MGRWAV(I,CLASS),
     1 MGXSUM(I,CLASS),MAXS(I,CLASS),AMAXS(CLASS)
    7 CONTINUE
      AMAXS(CLASS) = AMAXS(CLASS) / SIZSUM(CLASS)
C  FOR EACH MANAGER, CALCULATE HIS DEVIATION FROM AVERAGE.
      DO 9 I = 1,NMGRS
      IF( MGRNUM(I,CLASS).EQ.0 ) GOTO 9
      MXSDEV(I,CLASS) = MGRXS(I,CLASS) - AVWXS(CLASS)
      MAXSD(I,CLASS) = MAXS(I,CLASS) - AMAXS(CLASS)
      MGRDEV(I,CLASS) = MGRWAV(I,CLASS) - TWRWAV(CLASS)
      MGRCDV(I,CLASS) = MGWCAV(I,CLASS) - CTWRAV(CLASS)
      WRITE(W,8000) MXSDEV(I,CLASS),MAXSD(I,CLASS),MGRDEV(I,CLASS),
     1 MGWCDV(I,CLASS)
    9 CONTINUE
C DO NEXT CLASS
    6 CONTINUE
C  OUTPUT TABLE ONE, SUMMARY OF PERFORMANCE OF ALL FUNDS.
      CALL HEAD
      CALL OUT1
C
C  OUTPUT NEXT 2 TABLES FOR BOTH CLASSES OF FUNDS.
      DO 15 CLASS = N1,N2
C  DERIVE RANKING OF FUNDS BASED ON EXCESS RETURN OVER MODEL IN 'RANK'.
      CALL RANKIT(MOOXS,50,NUM(CLASS),RANK2)
C  SORT FUNDS ON BASIS OF CURRENT TWR. RECORDER CURRENT TWRS INTO VECTOR
C   'SORTED' AND POINTERS 'POINT' TO ORIGINAL ORDER.
      CALL RECORDR(TWR,50,NUM(CLASS),SORTED,POINT)
C SORT MODEL FUND INTO DESCENDING ORDER OF CURRENT TWR
C*********************** USER-SUPPLIED SORT ROUTINE ***********************
      IFAIL =0
      CALL MC1AKF(MOOTWR,WORK,MPOINT,IWORK,3,3,IFAIL)
      IF( IFAIL.NE.0 ) WRITE(W,2030) MOOTWR
 2030 FORMAT(28HFAILED TO SORT MODEL RETURNS,/,3F10.4)
C*****************************************************************************
      CALL HEAD
      IF( CLASS.EQ.1 ) CALL OUT2(NAME1,MFLAG)
      IF( CLASS.EQ.2 ) CALL OUT2(NAME2,MFLAG)
C
C
C  DERIVE RANKING OF FUNDS BASED ON THEIR RISK MEASURES (MEAN ABSOLUTE
C     DEVIATION OF ANNUALIZED ROR'S).
C  NEGATE VECTOR OF M.A.D. VALUES IN ORDER TO RANK IN ASCENDING ORDER.
      DO 13 I = 1,NUM(CLASS)
      NEGMAD(I,CLASS) = -MAD(I,CLASS)
   13 CONTINUE
      CALL RANKIT(NEGMAD,50,NUM(CLASS),RANK2)
      CALL RECORDR(CUMTWR,50,NUM(CLASS),SORTED,POINT)
C SORT MODEL FUNDS INTO DESCENDING ORDER OF AVERAGE TWR.
C*********************** USER-SUPPLIED SORT ROUTINE ***********************
      TEMP1 = 0
      CALL MC1AKF(CMOTWR,WORK,MPOINT,IWORK,3,3,TEMP1)
      IF( TEMP1.NE.0 ) WRITE(W,2020) CMOTWR
C*****************************************************************************
      CALL HEAD
      IF( CLASS.EQ.1 ) CALL OUT3(NAME1,DATBG1,MFLAG)
      IF( CLASS.EQ.2 ) CALL OUT3(NAME2,DATBG2,MFLAG)
C  DERIVE RANKING OF MANAGERS BASED ON THEIR AVERAGE EXCESS RETURN OVER MODEL
C     AS 'RANK2'.
      CALL RANKIT(MGXXS,8,NMGRS,RANK2)
C  RANKING OF MANAGERS BASED ON AVERAGE ANNUAL TWR = 'RANK1'.
      CALL RANKIT(MGWCAV,8,NMGRS,RANK1)
C  RANKING OF MANAGERS BASED ON AVERAGE OF AVERAGE OF PAST EXCESS RETURNS OVER
C  MODEL FUND = 'RANK4'.
      CALL RANKIT(MAXXS,8,NMGRS,RANK4)
C RANKING OF MANAGERS BASED ON AVERAGE RISK MEASURE = 'RANK1'.  RANK IN
C  ASCENDING ORDER BY RANKING THE NEGATIVES OF 'MGAMAD'.
      DO 20 I = 1,NMGRS
      MSUMAD(I,CLASS) = -MGAMAD(I,CLASS)
   20 CONTINUE
      CALL RANKIT(MSUMAD,8,NMGRS,RANK1)
C  RECORDER AVERAGE CURRENT TWRS OF MANAGERS INTO DESCENDING ORDER OF MAGNITUDE.
      CALL RECORDR(MGRWAV,8,NMGRS,SORTED,POINT)
C
C  PRINT TABLE 4 'AVERAGE PERFORMANCE FIGURES BY PERSONNEL'
      CALL HEAD
      CALL OUT4
```

```
C  REPEAT FOR NEXT CLASS OF FUND
   15 CONTINUE
      STOP
      END
C
C
      SUBROUTINE DIFF(DATE,DAYS)
      INTEGER RPDA(2,3),M,N,DATE(3),DAYS,J,DATES(2,3),MTHNUM(12)
      COMMON /G8/ RPDATE
C
C  SUBROUTINE TO FIND NUMBER OF DAYS BY WHICH PERIOD TO WHICH FUND IS UP
C    DIFFERS FROM DATE O HF COMPARISON REPORT.
C
C  ORDER DATES IN CHRONOLOGICAL ORDER.
      IF( DATE(3).GT.RPDATE(2,3) ) GOTO 101
      IF( DATE(3).LT.RPDATE(2,3) ) GOTO 201
      IF( DATE(2).GT.RPDATE(2,2) ) GOTO 101
      IF( DATE(2).LT.RPDATE(2,2) ) GOTO 201
      IF( DATE(1).GT.RPDATE(2,1) ) GOTO 101
      IF( DATE(1).LT.RPDATE(2,1) ) GOTO 201
C  DATES ARE EXACTLY THE SAME
      M=1
      N=2
      GOTO 301
C  FUND'S LAST REVIEW PERIOD ENDED LATER THAN DATE OF COMPARISON REPORT
  101 M=1
      N=2
      GOTO 301
C  FUND'S LAST REVIEW PERIOD ENDED EARLIER THAN DATE OF COMPARISON REPOR
  201 M=2
      N=1
C  SET PARAMETERS FOR SUBROUTINE WHICH CALCULATES NUMBER OF DAYS BETWEEN
  301 DO 1 J=1,3
      DATES(M,J) = RPDATE(2,J)
      DATES(N,J) = DATE(J)
    1 CONTINUE
C  IDENTIFY CALENDAR MONTH NUMBERS OF INTERVENING MONTHS
      J=1
  501 MTHNUM(J) = DATES(1,2) + J - 1
      WRITE(4,1000) J,MTHNUM(J)
 1000 FORMAT(1X,5HMONTH,I3,5H NUM=,I10)
      IF( MTHNUM(J).GT.12 ) MTHNUM(J) = MTHNUM(J)-12
      IF( MTHNUM(J).EQ.DATES(2,2) ) GOTO 401
      J=J+1
      GOTO 501
  401 CALL PERIOD(DATES,DAYS,MTHNUM)
      RETURN
      END
C
C
      SUBROUTINE PROCES(POINT)
      REAL RTEMP1,AVTWR,TWRHST(12),TWR(50,2),TWSUM(2),TWWSUM(2),HMFSIZ,
     1 SIZSUM(2),MGRSUM(8,2),MODXS(50,2),XSSUM(2),XSWSUM(2),
     2 MGWSUM(8,2),MGHFSZ(8,2),MXSSUM(8,2),MXWSUM(8,2),TAB,SUMTWR(50,2),
     3 CUMSUM(2),CUMWSM(2),PASTWR(60),SUMABS,MAD(50,2),MSUMAD(8,2),
     4 MGMCSM(8,2),AVEXCS,ONE,MADSUM(2),MADWSM(2),
     5 MAXSUM(8,2),MODXSM(12)
C
      INTEGER MGR,MGRWHO(50,2),MGRNUM(8,2),NAME1(50,7),NAME2(50,7),
     1 PFNAME(7),NPAST,SUMPRD,NOBS,TWDAY(60),DATG1(50,3),DATG2(50,3),
     2 DATOUT(12,3),MADOBS(50,2),PRD(12),CLASS,MODTYP(50,2),WICHMD,
     3 J,K,POINT,OPAST
      COMMON /G2/ PRD,NOBS,PASTWR,TWDAY,DATOUT
      COMMON /G3/ NPAST
      COMMON /G4/ MGRWHO
      COMMON /G5/ CLASS
      COMMON /G6/ TWSUM,TWWSUM,XSSUM,XSWSUM,CUMSUM,CUMWSM,MADSUM,
     1 MADWSM,MGRSUM,MGWSUM,MGWSUM,MXWSUM,MAXSUM,AVEXCS,CUMTWR,
     2 MSUMAD,DATG1,DATG2
      COMMON /G7/ MGRNUM,MGHFSZ
      COMMON /G12/ AVTWR,TWRHST,MGR,WICHMD,HMFSIZ,PFNAME,MODXSM
      COMMON /G13/ TWR
      COMMON /G23/ SIZSUM
      COMMON /G26/ MODTYP,MODXS
      COMMON /G27/ NAME1,NAME2
      COMMON /G28/ MAD,MADOBS
      DATA ONE /1.0/
C
C  SUBROUTINE TO CALCULATE OUTPUT RESULTS FOR ONE FUND.
C
      RTEMP1 = 0.0
      AVTWR = 0.0
      SUMPRD = 0
      SUMABS = 0.0
      TWR(POINT,CLASS) = TWRHST(1)
      WRITE(4,1000) ( ( PRD(K),TWRHST(K) ),K=1,12 )
 1000 FORMAT( 12(1X,I10,F10.4 /) )
      WRITE(4,1090) ( ( PRD(K),PASTWR(K) ),K=1,NOBS )
 1090 FORMAT( 5(I10,F10.4 ) )
      WRITE(4,1070) NPAST, NOB
 1070 FORMAT(1X,10HNPAST=,MGR=,2I10)
C  ACCUMULATE AVERAGES ONLY IF FUND BEING PROCESSED IS NOT MODEL FUND.
      IF( MGR.EQ.0 ) GOTO 601
      MODTYP(POINT,CLASS) = WICHMD
      MODXS(POINT,CLASS) = MODXSM(1)
C  ACCUMULATE PER FUND AVERAGES
      TWSUM(CLASS) = SUMIT(TWSUM(CLASS),TWR(POINT,CLASS),ONE)
      TWWSUM(CLASS) = SUMIT(TWWSUM(CLASS),TWR(POINT,CLASS),HMFSIZ)
      SIZSUM(CLASS) = SUMIT(SIZSUM(CLASS),HMFSIZ,ONE)
      XSSUM(CLASS) = SUMIT(XSSUM(CLASS),MODXS(POINT,CLASS),ONE)
      XSWSUM(CLASS) = SUMIT(XSWSUM(CLASS),MODXS(POINT,CLASS),HMFSIZ)
      WRITE(4,1010) TWSUM(CLASS),TWWSUM(CLASS),SIZSUM(CLASS),
     1 XSSUM(CLASS),XSWSUM(CLASS)
 1010 FORMAT(5F15.4)
C  ACCUMULATE PER MANAGER AVERAGES.
      MGRSUM(MGR,CLASS) = SUMIT(MGRSUM(MGR,CLASS),TWRHST(1),ONE)
      MGWSUM(MGR,CLASS) = SUMIT(MGWSUM(MGR,CLASS),TWRHST(1),HMFSIZ)
      MGHFSZ(MGR,CLASS) = SUMIT(MGHFSZ(MGR,CLASS),HMFSIZ,ONE)
      MGRNUM(MGR,CLASS) = MGRNUM(MGR,CLASS) + 1
      MGRWHO(POINT,CLASS) = MGR
      MXSSUM(MGR,CLASS) = SUMIT(MXSSUM(MGR,CLASS),MODXS(POINT,CLASS),
     1 HMFSIZ )
      WRITE(4,1010) MGRSUM(MGR,CLASS),MGWSUM(MGR,CLASS),
     2 MGHFSZ(MGR,CLASS),MXSSUM(MGR,CLASS)
C  SAVE NAME OF FUND
      IF( CLASS.EQ.2 ) GOTO 401
      DO 2 J=1,7
      NAME1(POINT,J) = PFNAME(J)
    2 CONTINUE
      GOTO 601
  401 DO 3 J=1,7
      NAME2(POINT,J) = PFNAME(J)
    3 CONTINUE
C  ACCUMULATE CUMULATIVE PAST TIME WEIGHTED RETURNS AND TAKE TIME-WEIGHTED
C   AVERAGE OF EXCESS RETURNS OVER MODEL, SKIPPING REVIEWS FOR WHICH NO
C   RESULTS EXIST (PRD=0). NOTE LAST PERIOD OF RESULTS AS 'OPAST'.
  601 TAB = 1.0
      AVEXCS = 0.0
      OPAST = NPAST
      DO 4 K = 1,NPAST
      IF( PRD(K).EQ.0 ) GOTO 10
      TAB = TAB * (1.0 + TWRHST(K) )
      SUMPRD = SUMPRD + PRD(K)
      IF( MGR.EQ.0 ) GOTO 4
      AVEXCS = AVEXCS + MODXSM(K)*FLOAT( PRD(K) )
    4 CONTINUE
      GOTO 11
   10 OPAST = K-1
   11 WRITE(4,1050) SUMPRD,TAB
 1050 FORMAT(1X,7HSUMPRD=,I10,4HTAB=,F15.4)
      IF( SUMPRD.EQ.0 ) GOTO 701
      GOTO 501
C IF NO OBS REPORTED DURING PERIOD, SET AVERAGES TO ZERO.
  701 TAB=0.0
      AVEXCS=0.0
      GOTO 801
  501 TAB = ANULIS( TAB-1.0,OPAST,SUMPRD)
      AVEXCS = AVEXCS / FLOAT( SUMPRD )
      WRITE(4,1030) AVEXCS,TAB
 1030 FORMAT(1X,7HAVEXCS=,F15.4,15HANNUALISED TAB=,F15.4)
  801 CUMTWR(POINT,CLASS) = TAB
      IF( MGR.EQ.0 ) GOTO 101
      CUMSUM(CLASS) = SUMIT(CUMSUM(CLASS),TAB,ONE)
      CUMWSM(CLASS) = SUMIT(CUMWSM(CLASS),TAB,HMFSIZ)
      MGMCSM(MGR,CLASS) = SUMIT(MGMCSM(MGR,CLASS),TAB,HMFSIZ)
      MXSSUM(MGR,CLASS) = SUMIT(MXSSUM(MGR,CLASS),AVEXCS,HMFSIZ)
      WRITE(4,1010) CUMSUM(CLASS),CUMWSM(CLASS),MGMCSM(MGR,CLASS),
     1 MXSSUM(MGR,CLASS)
C
C  CALCULATE THE MEAN ABSOLUTE DEVIATION FOR THIS FUND OVER ALL AVAILABLE
C    PAST ANALYSES.  ANULIS ALL PAST RATES FIRST.
  101 IF(NOBS.EQ.0 ) GOTO 1001
      DO 5 K=1,NOBS
      PASTWR(K) = ANULIS(PASTWR(K),TWDAY(K))
      AVTWR = AVTWR + PASTWR(K)
    5 CONTINUE
      AVTWR = AVTWR / FLOAT(NOBS)
      WRITE(4,1060) NOBS,AVTWR
 1060 FORMAT(1X,8HBASED ON,I5,13HOBS, AV. TWR=,F15.4)
      DO 6 K =1,NOBS
      SUMABS = SUMABS + ABS(PASTWR(K) - AVTWR)
    6 CONTINUE
```

```
      MAD(POINT,CLASS) = SUMABS / FLOAT(NOBS)
      GOTO 901
 1001 MAD(POINT,CLASS) = 0.0
  901 MADOBS(POINT,CLASS) =NOBS
      WRITE(4,1040) MAD(POINT,CLASS)
 1040 FORMAT(1X,4HMAD=,F15.4)
      MADSUM(CLASS) = SUMIT(MADSUM(CLASS),MAD(POINT,CLASS),ONE)
      MADWSM(CLASS) = SUMIT(MADWSM(CLASS),MAD(POINT,CLASS),HMFSIZ)
C  ACCUMULATE AVERAGE M.A.D. PER MANAGER IF FUND IS NOT MODEL FUND
      IF( MGR.EQ.0 ) GOTO 201
      MONMAD(MGR,CLASS) = SUMIT(MSUMAD(MGR,CLASS),MAD(POINT,CLASS),
     1 HMFSIZ)
      IF( CLASS.EQ.2 ) GOTO 201
      DO 8 J=1,3
      DATBG1(POINT,J) = DATOUT(DPAST,J)
    8 CONTINUE
      GOTO 301
C  STORE BEGINNING DATE OF DPAST TH   REVIEW PERIOD.
  201 DO 7 J=1,3
      DATBG2(POINT,J) = DATOUT(DPAST,J)
    7 CONTINUE
C  RETURN TO PROCESS NEXT FUND WHICH APPEARS ON REFERENCE FILE.
  301 RETURN
      END
C
C
      SUBROUTINE HEAD
      INTEGER RPDATE(2,3),PAGE,W,I,J,TITLE(2,4)
      COMMON /G8/ RPDATE
      COMMON /G10/ W,TITLE
      COMMON /G17/ PAGE
C
C SUBROUTINE TO PRINT PAGE HEADING
C
      PAGE = PAGE + 1
      WRITE(W,1000) ( ( ( RPDATE(I,J),J=1,3 ),I=1,2 ),PAGE
 1000 FORMAT(1H1,///,30X,34HFUND COMPARISON REPORT FOR PERIOD ,2I3,I5,
     1 4H TO ,2I3,I5,25X,4HPAGE,I3,//)
      RETURN
      END
C
C
      SUBROUTINE PERIOD(DATES,DAYS,MTHNUM)
      INTEGER PRD(12),DAYNUM(12),DATES(2,3),MNTH,K,MAXY1,MAXY2,
     1   DAYS,MTHNUM(12),DAYS1
      DATA DAYNUM /31,28,31,30,31,30,31,31,30,31,31,30/
C SUBROUTINE TO CALCULATE THE EXACT NUMBER OF DAYS BETWEEN TWO DATES (INCL
      DAYS1= 0
      WRITE(4,1000) ( ( DATES(I,J),J=1,3 ),I=1,2 )
 1000 FORMAT(1H-,8HPERIOD BETWEEN,2I3,I5,4H AND,2I3,I5,3H IS)
C CHECK IF BOTH DATES ARE WITHIN THE ONE YEAR.
      IF( DATES(2,3).GT.DATES(1,3) ) GOTO 101
C COMPUTE NUMBER OF MONTHS BETWEEN DATES (INCLUSIVE) AND COUNT UP THEIR DA
      MAXY1 = DATES(2,2) - DATES(1,2) + 1
      WRITE(4,1010) MAXY1
 1010 FORMAT(7H(MAXY1=,I10,1H))
      IF( MAXY1.LT.1 ) GOTO 201
      DO 1 K=2,MAXY1+1
      MNTH = MTHNUM(K)
      DAYS1= DAYS1+ DAYNUM(MNTH)
    1 CONTINUE
  201 GOTO 201
C DO AS ABOVE BUT IN TWO STAGES TO BRIDGE THE YEARS .
  101 MAXY1 = 12 - DATES(1,2)
      DO 2 K=2,MAXY1+1
      MNTH = MTHNUM(K)
      DAYS1= DAYS1+ DAYNUM(MNTH)
    2 CONTINUE
      MAXY2 = DATES(2,2) - 1
      IF( MAXY2.LT.1 ) GOTO 201
      DO 3 K=1,MAXY2
      MNTH = MTHNUM(MAXY1+K)
      DAYS1= DAYS1+ DAYNUM(MNTH)
    3 CONTINUE
C ADD DAYS IN ENDING MONTH, SUBTRACT THOSE OF BEGINNING MONTH AND ADD
C       ONE TO ALLOW FOR INCLUSIVENESSS.
  201 MNTH = DATES(1,2)
      DAYS1 = DAYS1 + DAYNUM(MNTH) - DATES(1,1) + DATES(2,1) + 1
      IF( DATES(1,2).EQ.DATES(2,2) ) DAYS1 = DAYS1 + DAYNUM(MNTH)
      WRITE(4,1020) DAYS1
 1020 FORMAT(I10)
      DAYS = DAYS1
      RETURN
      END
C
C
      SUBROUTINE COPY(MATRIX,ROWNUM,VECTOR)
      REAL MATRIX(50,2),VECTOR(50)
      INTEGER I,CLASS,ROWNUM
      COMMON /G5/ CLASS
C
C  COPIES THE (CLASS) TH.   COLUMN OF 'MATRIX' INTO 'VECTOR'.
C
      DO 1 I =1,ROWNUM
      VECTOR(I) = MATRIX(I,CLASS)
    1 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE OUT1
      REAL SIZSUM(2),TWRAV(2),AVXS(2),CTWRAV(2),AVMAD(2),TWRWAV(2),
     1 AVWXS(2),CTWRAV(2),AVWMAD(2),MODTWR(3),CMODTWR(3),MODMAD(3)
      INTEGER RPDATE(2,3),NPAST,I,TITLE(2,4),MODNAM(2),W,NMOD,J,
     1 MOTITL(3,3),NUM(2)
      COMMON /G1/ TWRAV,NMOD,MODTWR
      COMMON /G3/ NPAST
      COMMON /G8/ RPDATE
      COMMON /G9/ NUM,MODNAM,MOTITL
      COMMON /G10/ W,TITLE
      COMMON /G14/ CTW-AV
      COMMON /G16/ AVMAD,CMODTWR,MODMAD
      COMMON /G18/ TWRWAV,AVWXS,CTWRAV,AVWMAD
      COMMON /G23/ SIZSUM
      COMMON /G30/ AVXS
C
      WRITE(W,1000)
 1000 FORMAT(14X,107H1.    AVERAGES  OF  TIME  WEIGHTED  RETURNS  (T.W.R.
     1),   EXCESS  RETURNS  AND  RISK  MEASURES  OF  ALL  FUNDS.
     2 /,14X,107(1H-),// )
      WRITE(W,1010) ( ( ( RPDATE(I,J),J=1,3 ),NPAST ),I=1,2 ),
     1 ( ( RPDATE(2,J),J=1,3 ),I=1,2 )
 1010 FORMAT(4X,29HS I M P L E   A V E R A G E S,11X,
     1 42HWEIGHTED AVERAGES (WEIGHTED BY FUND SIZES),/,11X,4HTYPE,15X,
     2 5HFUNDS,7X,42(1H-),4X,42(1H-),/,30X,8HREVIEWED,1X,
     3 2(4X,16HRETURN OVER PERIOD,4X,9HOVER PAST,4X,7HAVERAGE),/,
     4 12X,2(3F,19X,4HT.W.,2X,2(5X,1HM,2X,I5,3H TO,14X,I2,9X,
     5 4HA,I5),/,31X,6HPERIOD,2X,2(11X,2I3,I5,1H),4X,7HRLVIEWS,5X,
     6 7HMEASURE),/,11X,5HFUND,14X,10(1H-),4X,19(1H-),3X,9(1H-),
     6 4X,5H(FROM,6X,19(1H-),3X,9(1H-),4X,5H(FROM,
     7 /,30X,2(12X,13HAV.  EXCESS,5X,7HAV.PAGE,4X,
     8 8HALL PAST),/,33X,6HAMOUNT,2(4X,7HAVERAGE,1X,11HRETURN OVER,
     9 4X,6HANNUAL,5X,8HREVIEWS) ),/,29X,3HNO.,1X,5HE MILL,
     9 2(4X,7HTWR (/),2X,9HMODEL (/),4X,9HTWR (/PA),4X,7H(/P.A.)),
     1 /,1X,24(1H-),4X,3(1H-),2X,6(1H-),2(4X,7(1H-),1X,11(1H-),3X,
     2 9(1H-),3X,8(1H-) ),/ )
      DO 1 I=1,2
      IF( NUM(I).EQ.0 ) GOTO 1
      WRITE(W,1020) ( TITLE(1,J),J=1,4 ),NUM(I),SIZSUM(I),TWRAV(I),
     1 AVXS(I),CTWRAV(I), AVMAD(I),TWRWAV(I), AVWXS(I),CTWRAV(I),
     2 AVWMAD(I)
 1020 FORMAT(/,1X,4A6,6X,I2,1X,F7.2,2(4X,F7.2,1X,F7.2,7X,F7.2,4X,
     1 F7.2,2X ) )
    1 CONTINUE
      WRITE(W,1030)
 1030 FORMAT(///,1X,136(1H*),////)
      IF( NMOD.EQ.0 ) RETURN
      DO 2 I=1,NMOD
      WRITE(W,1040) MODNAM,I,(MOTITL(I,J),J=1,3),MODTWR(I),CMODTWR(I),
     1 MODMAD(I)
 1040 FORMAT(1X,2A6,I3,5X,3A6,8X,F7.2,14X,F7.2,4X,F7.2,4X )
    2 CONTINUE
      RETURN
      END
C
C
      SUBROUTINE OUT2(NAME,MFLAG)
      REAL SORTED(50),TWRDEV(50,2),MODXS(50,2),XSDEV(50,2),MODTWR(3),
     1 TWRDEV(3,2),TWRAV(2),AVXS(2)
      INTEGER CLASS,TITLE(2,4),NUM(2),I,POINT(50),MODTYP(50,2),
     1 MANE(50,7),CL,RANK(50),MGRWHO(50,2),LINES,MODNAM(2),MOTITL(3,3)
     2 ,NMOD,M,PAGE,J,W,II,MPOINT(3),NMOD,FLAG,MFLAG
      COMMON /G1/ TWRAV,NMOD,MODTWR
      COMMON /G4/ MGRWHO
      COMMON /G5/ CLASS
      COMMON /G9/ NUM,MODNAM,MOTITL
      COMMON /G10/ W,TITLE
      COMMON /G17/ PAGE
      COMMON /G19/ SORTED
      COMMON /G20/ MPOINT,RANK2
      COMMON /G21/ TWRDEV,XSDEV,MODDEV
      COMMON /G26/ MODTYP,MODXS
```

```
      COMMON /G29/ POINT
      COMMON /G30/ AVXS
      LINES = 11
      FLAG = MFLAG
      CL=CLASS
      WRITE(W,1000) ( TITLE(CL,J),J=1,4 )
 1000 FORMAT(////,20X,5H2.    ,4A6,
     163H  FUNDS -  TIME  WEIGHTED  RATE  OF  RETURN  THIS  PERIOD  AND
     2 ,/,20X,82(1H-),/,42X,
     3 41HEXCESS RETURN OVER MODEL FUND THIS PERIOD,/,42X,41(1H-),// )
      WRITE(W,1010)
 1010 FORMAT(54X,21HTIME WEIGHTED RATE OF,12X,
     1 24HEXCESS MONEY WEIGHTED RETURN,/,56X,18HRETURN THIS PERIOD,13X,
     2 27HOVER MODEL FUND THIS PERIOD,/,13X,17HF U N D   N A M E,13X,
     3 29(1H-),4X,35(1H-),4X,7HMANAGER,/,52X,5HVALUE,9X,11HEXCESS OVER,
     4 6X,5HRANK,2X,5HVALUE,9X,11HEXCESS OVER,/,54X,1H/,4X,4HRANK,1X,
     5 15HOFFICE A/. (/)*,4X,5HMODEL,4X,1H/,4X,4HRANK,1X,
     6 10HOFFICE A/. (/)*,/,3X,42(1H-),6X,7(1H-),1X,4(1H-),1X,15(1H-),
     7 4X,5(1H-),2X,5(1H-),2X,4(1H-),1X,16(1H-),4X,7(1H-),/ )
C  FOR EACH FUND IN THIS CLASS, PRINT ONE LINE.  CHECK FOR END OF ONE PAGE
C      (WHENCE REPORT HEADINGS) AND OCCURRENCE OF MODEL FUND (WHENCE HIGHLIGH
C      WITH ASTERISKS).
      MOD = 1
      DO 1 I=1,NUM(CLASS)
      II = POINT(I)
      IF( I.GT.LINES ) GOTO 101
  501 IF( FLAG.NE.0 ) GOTO 701
      IF( SORTED(I).LT.MODTWR( MOD ) ) GOTO 201
  701 WRITE(W,1020) ( NAME(II,J),J=1,7 ),SORTED(I),I,CHRDEV(II,CL),
     1 MODTYR(II,CL),MODXS(II,CL),RANK2(II),XSDEV(II,CL),MGRWHO(II,CL)
 1020 FORMAT(3X,7A6,5X,F7.2,I5,4X,F7.2,9X,I4,1X,F7.2,2X,I4,5X,F7.2,12X,
     1 I2,/ )
      GOTO 1
  101 CALL HEAD
      WRITE(W,1010)
      LINES = LINES + 11
      GOTO 501
C  MODEL FUND HAS TWR WHICH IS NEXT HIGHEST BEFORE TWR OF FUND CURRENTLY
C      POINTED TO.
  201 WRITE(W,1030)
 1030 FORMAT(/,1X,131(1H*))
      M = MPOINT(MOD)
      WRITE(W,1040)MODNAM,M,(MOTITL(M,J),J=1,3),MODTWR(MOD),MODDEV(M,CL)
 1040 FORMAT(5X,2A6,I3,2X,3A6,10X,F7.2,9X,F7.2 )
      WRITE(W,1030)
      WRITE(W,1060)
 1060 FORMAT(/)
      IF( MOD.EQ.NMOD ) FLAG=1
      IF( MOD.LT.NMOD ) MOD = MOD + 1
C  RETURN TO PRINT LINE FOR FUND CURRENTLY POINTED TO.
      GOTO 501
    1 CONTINUE
C PRINT REST OF MODEL FUNDS IF ANY
      IF( FLAG.NE.0 ) GOTO 601
      DO 2 I=MOD,NMOD
      WRITE(W,1030)
      M = MPOINT(I)
      WRITE(W,1040)MODNAM,M,(MOTITL(M,J),J=1,3),MODTWR(I),MODDEV(M,CL)
      WRITE(W,1030)
      WRITE(W,1060)
    2 CONTINUE
C  PRINT FOOTNOTES
  601 WRITE(W,1050)
 1050 FORMAT(////,5X,7HNOTES :,/,5X,5(1H-))
      CALL NOTE(CLASS,TWRAV,1)
      CALL NOTE(CLASS,AVXS,2)
      RETURN
      END
C
C
      SUBROUTINE OUT3(NAME,DATBGN,MFLAG)
      REAL SORTED(50),CTWDEV(50,2),MAD(50,2),CMDTWR(3),MODCOV(3,2),
     1 MODMAD(3),MADDEV(50,2),MOMADV(3,2),AVMAD(2),TWRAV(2),
     2 MODTWR(3)
      INTEGER CL,CLASS,TITLE(2,4),NPAST,LINES,MOD,DATBGN(50,3),I,II,
     1 MPOINT(3),RANK2(50),MGRWHO(50,2),M,NAML(50,7),J,FLAG,MFLAG,
     2 MODBGN(3,3),MODOBS(3),MOTITL(3,3),NMOD,NUM(2),MODNAM(2),W,
     3 MADOBS(50,2),POINT(50)
      COMMON /G1/ TWRAV,NMOD,MODTWR
      COMMON /G3/ NPAST
      COMMON /G6/ MGRWHO
      COMMON /G5/ CLASS
      COMMON /G9/ NUM,MODNAM,MOTITL
      COMMON /G13/ W,TITLE
      COMMON /G14/ CTWRAV
      COMMON /G16/ AVMAD,CMDTWR,MODMAD
      COMMON /G19/ SORTED
      COMMON /G20/ MPOINT,NMPT
      COMMON /G22/ CTWDEV,MADDEV,MODBGN,MODCOV,MOMADV,MODOBS
      COMMON /G28/ MAD,MADOBS
      COMMON /G29/ POINT
      LINES = 11
      FLAG = MFLAG
      CL=CLASS
      WRITE(W,1000) ( TITLE(CL,J),J=1,4 ),NPAST
 1000 FORMAT(////,20X,5H3.    ,4A6,
     1 5H  FUNDS -  RISK / RETURN  PERFORMANCE  OVER  PAST ,I3,
     2 9X,8HREVIEWS,/,20X,82(1H-),// )
      WRITE(W,1010) NPAST
 1010 FORMAT(54X,28HAVERAGE ANNUAL TIME WEIGHTED,12X,
     1 23HR I S K   M E A S U R E,4X,1H*,/,54X,
     2 16HRETURN OVER PAST,I3,8H REVIEWS,9X,
     3 33HAVERAGE FLUCTUATION OF RETURN),/,14X,17HF U N D   N A M E,
     4 12X,36(1H-),4X,35(1H-),4X,7HMANAGER,/,51X,3HDATE FROM,16X,
     5 10HEXCESS OV-,17X,10HEXCESS OV-,1X,6HMOD. OF,/,50X,
     6 12HWHICH RETURN,2X,5HVALUE,2X,4HRANK,1X,9HER OFFICE,6X,5HVALUE,
     7 2X,4HRANK,1X,9HER OFFICE,3X,4HPAST,/,52X,8HAVERAGED,3X,7H(P.A.),
     7 7X,5HAV. (/)*,5X,
     8 7H(P.A.),7X,5HAV. (/)*,1X,7HRETURNS,/,2X,42(1H-),6X,12(1H-),1X
     9 ,7(1H-), 1X,4(1H-),1X-10(1H-),4X,7(1H-),1X,4(1H-),1X,10(1H-),1X,
     9 7(1H-),4X,7(1H-),// )
C  PRINT  LINE FOR EACH FUND, WATCHING OUT FOR A FULL PAGE (WHEN RE-PRINT
C  HEADINGS) AND MODEL FUND.
      MOD = 1
      DO 1 I=1,NUM(CLASS)
      II=POINT(I)
      IF( I.GT.LINES ) GOTO 101
  301 IF( FLAG.NE.0 ) GOTO 701
      IF( SORTED(I).LT.CMDTWR( MOD ) ) GOTO 201
  701 WRITE(W,1020) ( NAME(II,J),J=1,7 ),( DATBGN(II,J),J=1,3 ),
     1 SORTED(I),I,CTWDEV(II,CL),MAD(II,CL),RANK2(II),MADDEV(II,CL),
     2 MADOBS(II,CL),MGRWHO(II,CL)
 1020 FORMAT(2X,7A6,6X,2I3,1X,1X,F7.2,2X,I3,3X,F7.2,5X,F7.2,2X,I3,2X,
     1 F7.2,6X,I3, 9X,I2 ,/ )
      GOTO 1
  101 CALL HEAD
      WRITE(W,1010) NPAST
      LINES = LINES + 11
      GOTO 301
C  MODEL FUND HAS AVERAGE TWR WHICH IS  NEXT HIGHEST BEFORE FUND CURRENTLY
C  FUND CURRENTLY POINTED AT.
  201 WRITE(W,1030)
 1030 FORMAT(/,1X,131(1H*))
      M=MPOINT( MOD )
      WRITE(W,1040) MODNAM,M,( MOTITL(M,J),J=1,3 ),( MODBGN(M,J),J=1,3)
     1 ,CMDTWR(MOD),MODCOV(M,CL),MODMAD(M),MOMADV(M,CL),MODOBS(M)
 1040 FORMAT(5X,2A6,I3,5X,3A6,1X,2I3,I5,1X,F7.2,3X,F7.2,5X,F7.2,2X,
     1 F7.2,6X,I3 )
      WRITE(W,1030)
      WRITE(W,1070)
 1070 FORMAT(/)
      IF( MOD.EQ.NMOD ) FLAG = 1
      IF( MOD.LT.NMOD ) MOD = MOD + 1
C  RTURN TO PRINT LINE FOR CURRENTLY POINTED TO FUND
      GOTO 301
    1 CONTINUE
C PRINT REST OF MODEL FUNDS IF ANY
      IF( FLAG.NE.0 ) GOTO 601
      DO 2 I=MOD,NMOD
      WRITE(W,1030)
      M=MPOINT( I )
      WRITE(W,1040) MODNAM,M,( MOTITL(M,J),J=1,3 ),( MODBGN(M,J),J=1,3)
     1 ,CMDTWR(I),MODCOV(M,CL),MODMAD(M),MOMADV(M,CL),MODOBS(M)
      WRITE(W,1030)
      WRITE(W,1070)
    2 CONTINUE
C  PRINT FOOTNOTES
  601 WRITE(W,1050)
 1050 FORMAT(///,5X,7HNOTES :,/,5X,5(1H-),/)
      CALL NOTE(CLASS,CTWRAV,1)
      CALL NOTE(CLASS,AVMAD,2)
      WRITE(W,1060)
 1060 FORMAT(/,5X,1H*,2X,
     1 122HTHIS RISK MEASURE, TECHNICALLY KNOWN AS MEAN ABSOLUT
     1E DEVIATION, MEASURES THE AVERAGE EXTENT TO WHICH THE FUND'S PER A
     2NNUM,/,9X,120HTIME-WEIGHTED RATE OF RETURN HAS VARIED FROM ITS AVE
     3RAGE OVER THE PAST.  THE HIGHER THE MEASURE, THE MORE 'RISKY' IS T
     4HE,/,9X,119HFUND. IN THE SENSE THAT ITS RETURN IS LESS RELIABLE.
     5 (N.B.:  LITTLE EMPHASIS SHOULD BE PLACED ON A RISK MEASURE BASED,
     6/,9X,33HON LESS THAN SAY 8 PAST RETURNS.) )
      RETURN
      END
```

```
C
C
      SUBROUTINE OUT4
      REAL SORTED(50),MGRDEV(8,2),MGRXS(8,2),MXSDEV(8,2),MGWCAV(8,2),
     1 MGWCOV(8,2),MAVXS(8,2),MAVXSD(8,2),MGMFSZ(8,2),MGAMAD(8,2),
     2 THRWAV(2),AVWXS(2),AMAVXS(2),CTWWAV(2),AVWMAD(2)
      INTEGER W,CLASS,CL,TITLE(2,4),MPAST,SYMBOL(4),NMGES,POINT(50),II,
     1 RANK2(50),RANK3(50),RANK4(50),MGRNUM(8,2),I,J,MPOINT(3),RANK1(8)
      COMMON /G3/ MPAST
      COMMON /G5/ CLASS
      COMMON /G7/ MGRNUM,MGMFSZ
      COMMON /G10/ W,TITLE
      COMMON /G18/ THRWAV,AVWXS,CTWWAV,AVWMAD
      COMMON /G19/ SORTED
      COMMON /G20/ MPOINT,RANK2
      COMMON /G24/ NMGES,MGRDEV,MGRXS,MXSDEV,MGWCAV,RANK3,MGWCOV,
     1 MAVXS, RANK4,MAVXSD,MGAMAD,RANK1,AMAVXS
      COMMON /G29/ POINT
      DATA SYMBOL /2H* ,2H**,2H+ ,2H++/
      CL=CLASS
      WRITE(W,1000) ( TITLE(CL,J),J=1,4 )
 1000 FORMAT(////,23X,5H4,    ,4A6,
     1 57H  FUNDS  -  AVERAGE  PERFORMANCE  FIGURES  FOR  PERSONNEL,/,
     2 23X,86(1H-),/,27X,
     3 42H( FIGURES ARE AVERAGES OF RESULTS FOR ALL ,
     4 35H FUNDS UNDER THE MANAGER'S CONTROL.,
     5 /,33X,64HTHE RESULTS ARE WEIGHTED BY THE SIZE OF THE FUND IN EAC
     6 CASE. ),// )
      WRITE(W,1010) MPAST,SYMBOL
 1010 FORMAT(26X,29HC O M P A R E  W I T H  P A S T  R E S U L T S,11X,1H*,7X,
     119HO V E R   P A S T   ,I2,16H   Y E A R S,7X,1H*,/,3X,7HMANAGE
     2 ,6X,49(1H-),3H * ,49(1H-),3H * ,12HRISK MEASU-E,/,5X,3HAND,9X,
     2 21HAVERAGE TIME-WEIGHTED,6X,22HAVERAGE EXCESS RETURNS,3H * ,
     3 1X,21HAVERAGE OF 3/. ANNUAL,4X,23HAVERAGE OF AV. PAST EX-
     4 3H * ,/,4X,5HFUNDS,11X,
     5 14HRATE OF RETURN,12X,19HOVER MODEL FUND,5X,1H*,2X,
     6 21HTIME-WEIGHTED RETURNS,4X,23HCESS RETURNS OVER MODEL,3H * ,/,
     6 3X,7HMANAGED,3X,2(3X,23(1H-),3H * ,23(1H-),3X,23(1H-),3H * ,
     7 12(1H-),/,13X,2( 19X,19HEXCESS OV-),
     8 3H * ,13X,21HEXCESS OV-,16X,19HEXCESS OV-,3H * ,/,
     8 12X,2( 5X,5HVALUE,2X,4HRANK,1X,3HER OFFICE ),1X,3H * ,1X,
     8  5HVALUE,2X,4HRANK,1X,9HER OFFICE,5X,5HVALUE,2X,4HRANK,1X,
     9 9HER OFFICE,2X,1H*,2X,5HVALUE,2X,4HRANK,/,
     8 1X,12H(NO. ,  EMIL),2( 5X,3H(/),3X,7HAV. (/),
     3 A2,1X ),3H * ,7H(/P.A.),6X,3HAV (/PA),A2,2X,7X,7H(/P.A.),
     9 6X,3HAV (/PA),A2,3H * ,7H(/P.A.),/,1X,12(1H-),
     9 2( 3X,7(1H-),1X,4(1H-),1X,10(1H-) ),3H * ,
     9 7(1H-),1X,4(1H-),1X,10(1H-),3X,7(1H-),1X,4(1H-),1X,10(1H-),
     9 3H * ,7(1H-),1X,4(1H-),// )
CFOR EACH MANAGER.....
      DO 1 I= 1,NMGES
      IF( MGRNUM(I,CLASS).EQ.0 ) GOTO 1
      II = POINT(I)
      WRITE(W,1020) II,SORTED(I),I,MGRDEV(II,CL),MGRXS(II,CL),
     1 RANK2(II),MXSDEV(II,CL),MGWCAV(II,CL),RANK3(II),MGWCOV(II,CL),
     2 MAVXS(II,CL),RANK4(II),MAVXSD(II,CL),MGAMAD(II,CL),RANK1(II),
     3 MGRNUM(II,CL),MGMFSZ(II,CL)
 1020 FORMAT(3X,I3,6X,2( 3X,F7.2,2X,I3,2X,F7.2,2X ),2X,1H*,
     1 F7.2,2X,I3,2X,F7.2,5X,F7.2,2X,I3,2X,F7.2,4X,1H*,F7.2,2X,I3,/,
     2 1X,1H(,I3,1H,,F6.2,1H),/ )
    1 CONTINUE
      WRITE(W,1030)
 1030 FORMAT(////,5X,7HNOTES :,/,5X,5(1H-) )
      CALL NOTE(CLASS,THRWAV,1)
      CALL NOTE(CLASS,AVWXS,2)
      CALL NOTE(CLASS,CTWWAV,3)
      CALL NOTE(CLASS,AMAVXS,4)
      RETURN
      END
C
C
C
      SUBROUTINE NOTE(CLASS,AV,TYPE)
      REAL AV(2)
      INTEGER CLASS,SYMBOL(4),TYPE,TITLE(2,4),W
      COMMON /G10 / W,TITLE
      DATA SYMBOL /2H* ,2H**,2H+ ,2H++/
      WRITE(W,1000) SYMBOL(TYPE),( TITLE(CLASS,J),J=1,4 ),AV(CLASS)
 1000 FORMAT(/,5X,A2,2X,15HAVERAGE AMONGST,4A6,
     1 12H FUNDS HAS ,F7.2,2H/. )
      RETURN
      END
C
C
C
      REAL FUNCTION ANULIS(ROR,DAYS)
      REAL ROR
      INTEGER DAYS
C
C ANNUALISES 'ROR' GIVEN THAT IT APPLIES TO A PERIOD 'DAYS' AND ALSO
C  CONVERTS TO A PERCENTAGE RETURN.
C
      ANULIS = ( ( 1.0+ROR )  ** ( 365.0/FLOAT(DAYS) ) - 1.0 )  * 100.0
      RETURN
      END
C
C
      SUBROUTINE NXTHST(INDIC)
      REAL TEMP1
      INTEGER RH,INDIC,NOJS,TEMP1
      COMMON /G25/ RH
C
C  READS REMAINDER OF HISTORY INFORMATION FOR A FUND. 'INDIC' TELLS HOW MUCH.
C
C READ DATE OF LAST UPDATE IF NOT ALREADY DONE SO (INDIC)
      IF( INDIC.NE.0 ) GOTO 101
      READ(RH,1000)
 1000 FORMAT(/)
  101 READ(RH,1010)
 1010 FORMAT( 5(/),12( 4(/) ) )
      READ(RH,1020) NOJS
 1020 FORMAT(I10)
      IF( NOJS.EQ.0 ) RETURN
      READ(RH,1030) ( (TEMP1,RTEMP1),J=1,NOJS )
 1030 FORMAT( 4(I10,F10.4) )
      RETURN
      END
C
C
      REAL FUNCTION SUMIT(CUMSTO,ADDON,WEIGHT)
      REAL CUMSTO,WEIGHT,ADDON
C
C ACCUMULATES QUANTITY 'ADDON' INTO 'CUMSTO' AFTER WEIGHTING BY 'WEIGHT'.
C
      SUMIT = CUMSTO + WEIGHT*ADDON
      RETURN
      END
C
C
      SUBROUTINE RANKIT(MATRIX,ROWMAX,ROWNUM,RANK)
      REAL MATRIX,VECTOR(50)
      INTEGER RANK(50),CLASS,NUM(2),IWORK(50),IFAIL,W,ROWMAX,ROWNUM,
     1 TITLE(2,4)
      DIMENSION MATRIX(ROWMAX, 2)
      COMMON /G5/ CLASS
      COMMON /G10/ W,TITLE
C
C  RANKS THE 'CLASS'TH COLUMN (OF LENGTH 'ROWNUM') OF 'MATRIX' IN DESCENDING
C   ORDER OF MAGNITUDE.  USES A USER-SUPPLIED SORT ROUTINE WHOSE INPUT IS
C   'VECTOR' (WHICH REMAINS UNCHANGED) AND OUTPUT IS 'RANK', THE RANKS BEING
C   IN DESCENDING ORDER.
C
      CALL COPY(MATRIX,ROWNUM,VECTOR)
C*****************USER-SUPPLIED SORT ROUTINE HERE*****************************
      IFAIL = 0
      CALL M01ABF(VECTOR,1,ROWNUM,RANK,IWORK,IFAIL)
      IF( IFAIL.EQ.0 ) GOTO 101
C*****************************************************************************
C ERROR MESSAGE FOR FAIL OF SORT ROUTINE
      WRITE(W,1000) CLASS,( MATRIX(I,CLASS),I=1,ROWNUM )
 1000 FORMAT(/30HPROGRAM ERROR WITH FUND TYPE,I3,
     1 53H,  FAILED TO SORT INTO DESCENDING ORDER THE FOLLOWING DATA,
     2 /,(5(F10.4) )
  101 RETURN
      END
C
C
      SUBROUTINE REORDR(MATRIX,ROWMAX,ROWNUM,SORTED,POINT)
      REAL MATRIX,SORTED(50),WORK(50)
      DIMENSION MATRIX(ROWMAX,2)
      INTEGER CLASS,POINT(50),IWORK(50),IFAIL,W,ROWMAX,
     1 ROWNUM,TITLE(2,4)
      COMMON /G5/ CLASS
      COMMON /G10/ W,TITLE
C
C RE-ORDERS THE 'CLASS'TH COLUMN (OF LENGTH 'ROWNUM' OF 'MATRIX' INTO DESCENDING
C  DESCENDING ORDER OF MAGNITUDE.  USES USER-SUPPLIED SORT SUBROUTINE WHOSE
C  INPUT IS 'SORTED' (I.E.UNSORTED DATA) AND OUTPUT IS 'SORTED' (I.E.SORTED
C  DATA) AS WELL AS POINTERS 'POINT' TO ORIGINAL ORDER OF DATA.
```

```
      CALL COPY(MATRIX,ROWNUM,SORTED)
C USER-SUPPLIED SORT ROUTINE HERE
C*********************USER-SUPPLIED SORT ROUTINE*****************************
      IFAIL = 0
      CALL M01AKF(SORTED,WORK,POINT,IWORK,ROWNUM,ROWNUM,IFAIL)
      IF( IFAIL.EQ.0 ) GOTO 101
C*********************************************************************
C ERROR MESSAGE IN CSC SORT ROUTINE FAILS.
      WRITE(W,1000) CLASS,( MATRIX(I,CLASS),I=1,ROWNUM )
 1000 FORMAT(28HPROGRAM ERROR WITH FUND TYPE,I3,
     163H.   FAILED TO RE-ORDER INTO DESCENDING ORDER THE FOLLOWING DATA
     2 ,/,5F10.4 )
  101 RETURN
      END
```