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The measurement and control of service from a Physical Distribution system.

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Abstract

This thesis explores various approaches for measuring and controlling service from a Physical Distribution system. The investigation concentrates on the case of internal service customers and comparisons are made with the external service customers situation.

The research is carried out by using Checkland's soft system methodology to generate a framework of activities considered to be required in order to measure and control Physical Distribution's service to internal customers. Three main activities are defined as being required:

1) Understanding the participating company's Physical Distribution operations.

2) Determining the service measures for the company- this involved defining what constitutes service from a Physical Distribution's system.

3) Defining and achieving the best service policy- this involved investigating how service affects the company's profit and from this a way of increasing a company's profits is deduced.

Each of these activities are explored in detail with various alternative approaches being defined for carrying them out. These approaches are used with a participating company and an indication is given- using Checkland's 3 E test (efficacy, effectiveness and efficiency)- of the most productive approach for carrying out a particular activity.

The generated framework for controlling service to internal customers is then compared with that of external customers. When combined a framework is produced which controls service to both external and internal customers. This generates a means of controlling the performance of a whole company.

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CHAPTER 1

INTRODUCTION.

1.1 Introduction.

Physical Distribution (PD) management can be thought of as being concerned with the supply of goods and service from a supply point to a demand point (Eilon et al (1971)). When the points of demand and supply are near each other the importance of PD management is limited. However throughout history there has been a tendency for customers and suppliers to become further apart. Several factors are responsible for this, including: The trend towards economy of size and centralisation of industrial production; the increase in demand from customers for merchandise lines from different parts of the world.Thus it can be seen that the importance of PD is continuously increasing.With events such as the introduction of a single european market in 1992 happening in the near future there is no reason to see why this growth in the importance of PD should not continue.

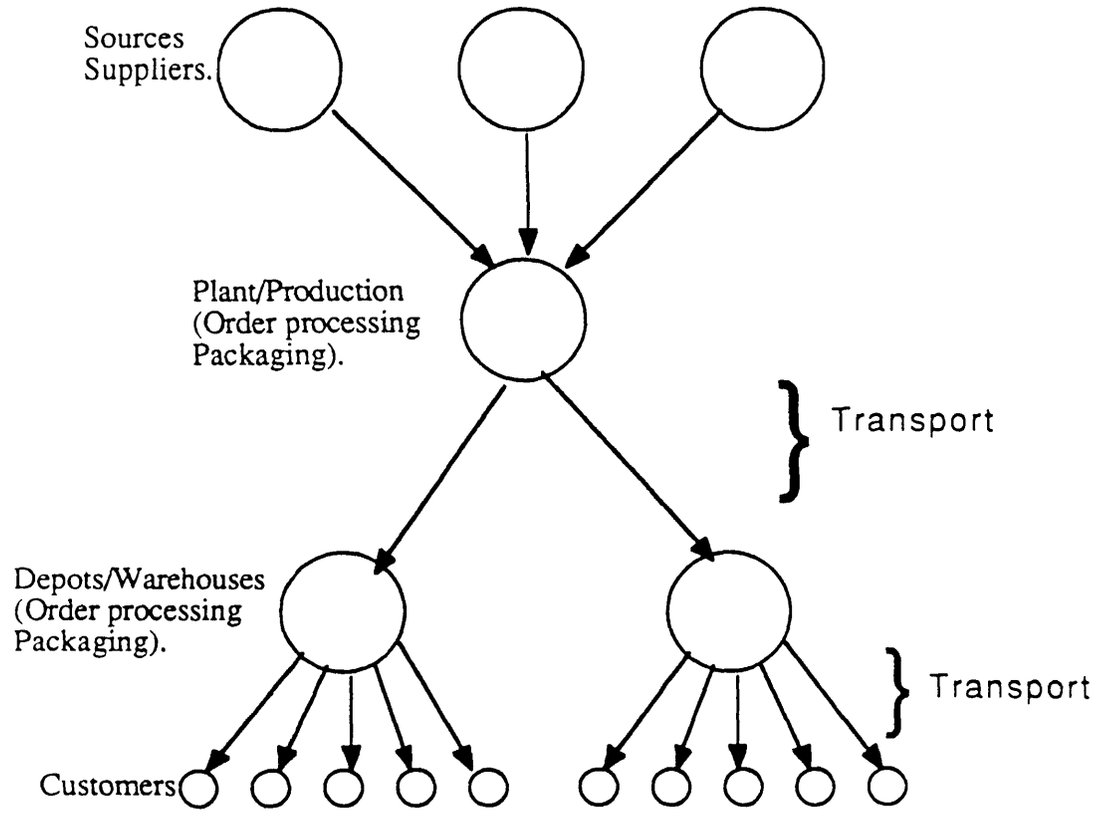
In the early 1970's Christopher estimated that Physical Distribution (PD) costs as a percentage of the total corporate costs in U.K. manufacturing can be between 4 and 42 percent- Christopher (1971). Consequently Physical Distribution Management should be a significant part of management due to the high impact it can have on an organisation's performance.

Unfortunately in the past there has often been a failure to recognise the effect PD has on the organisation's performance. However, in the last twenty or thirty years there has been a growing recognition of the importance of PD. The traditional approach to managing PD has been to consider only a part of it, namely the transport element. However studies performed by consultants A.T.Keaney and Co (Wendell(1964)) indicate that this often only accounts

for a third of the total cost of PD.

As can be seen from Fig 1.1, which shows a simplified PD system there are many other elements involved in PD management. (For example there is warehousing, the control of inventory and packaging). Consequently there has been a move towards involving all these activities in PD management. This is often referred to as adopting a total distribution cost approach to PD Management Christopher(1971).

Fig 1.1: A diagram showing a very simplified version of a typical Physical Distribution system.



Source: Eilon, S; Watson-Gandy C.D.T.and Christofides, N (1971): 'Distribution Management: Mathematical Modelling and Practical Analysis.'Griffin, London.

Unfortunately until relatively recently, and still the case in many organisations, PD has been purely regarded as a cost centre whose costs should be reduced as far as possible. However, the more enlightened organisations have seen that there are also benefits

associated with PD. These benefits are the services that PD provide to their customers. This thesis aims to look at how this service can be measured and controlled to increase an organisation's performance.

1.2 Outline of thesis.

Initially **Chapter 2** examines the previous studies that have been carried out on controlling customer service from a PD system. From this analysis an indication is given of the shortfalls that exist in these previous studies. The main shortfall is suggested to be the general basic assumption that customers are not in the same organisation as the PD operation. Consequently the main emphasis of this thesis is to look at how to control service to these internal customers and how this differs to when the customers are external. The research objectives of the thesis are then outlined. Descriptions of the main problem solving methodologies that are used in the research are also included in this chapter.

In **Chapter 3** an approach is outlined to meet the research objectives. The first part of this methodology is then used to determine 3 principle activities felt to be required in controlling service. These are identified as being:

1) Understanding the Company's PD system.
2) Defining what constitutes service (defining the service measures).
3) Defining and ensuring that the optimum service policy is achieved.

Each of the systems that carry out these activities has to be both feasible and financially viable. An approach to identify whether this is true is highlighted.

Chapter 4 looks at understanding the company's PD operations. This is done by carrying out a material and information flow audit of a participating company's PD operations.

How to define the service measures is examined in **Chapter 5.** What actually constitutes a service measure is explored and whether this is dependent on the service customer being external or internal. Various approaches are then proposed for defining the service measures. The merits of these approaches are tested by using them with a participating company to generate a set of service measures.

Chapter 6 investigates how to increase the profits associated with service. Various factors affecting this are identified and explored. This enables the activities required to be present to be identified. These activities are classified into two sets those that are more cost effective when used infrequently and those that are more cost effective when used frequently.

Chapter 7 looks at carrying out the activities that should be used infrequently when increasing the profits associated with service. Various approaches are proposed for carrying out these activities. The merits of these different approaches are investigated by using them with the participating company. The general results produced by carrying out the activities are also included.

Chapter 8 deals with carrying out the activities associated with increasing the profits but are more cost effective when used infrequently. These activities concentrate on the information reporting systems and the running of the day to day decision making systems. This chapter concludes by bringing together all the derived research information to generate a framework for controlling PD service to both internal and external customers.

CHAPTER 2

THE LITERATURE SURVEY AND THE RESEARCH OBJECTIVES.

2.1 Introduction.

Initially this chapter will look at the previous work that has been carried out in the area of Physical Distribution (PD) customer service. Then an attempt will be made to identify any shortfalls that may exist in these previous studies.

The research objectives will be identified and following this an indication will be given of how it is proposed to carry out the research to meet these objectives.

The chapter will conclude by looking at the requirements of any methodology being used to carry out the research and finally an indication will be given of appropriate methodologies.

2.2 Literature survey on customer service.

2.2.1 What is customer service ?

Most companies view their PD system as a cost which should be reduced to a minimum. However this perspective only considers the input into PD and fails to perceive any benefit which may be associated with the output. This output is the service that is being given to the customers through the PD system.

There have been numerous investigations into the general area of customer service reported

in the literature (For Example Ballou(1971), Bender(1976), Christofides and Watson-Gandy(1973), Christopher(1983), Cunningham and Roberts (1976), Davis(1974), Davis(1979), Ernst and Whinney(1988), Hutchinson and Stolle(1968), Lalonde and Levy(1977), Lalonde and Zinzer(1976), Levy(1978), Marr(1982), Perreault(1973), Perreault and Russ(1974), Schary(1979), Tucker(1980), Wagner(1978), Wagner and Lagrace(1981)). These investigations have concentrated their work on the case of external service customers. That is the situation of the customer belonging to a different organisation than the PD operation.

Due to its fuzzy nature it is very difficult to generate a precise definition of customer service with which everybody would actually agree. Customer service can take many different forms and various opinions exist on what actually constitutes a part of service. Various definitions can be found in the literature, for example:

> "Service as a measure in the logistics strategy which involves a transfer- a shifting of functions from one firm to another, the avoidance of cost on one side to be incurred on the other." Schary(1970).
>
> "Customer service is a system organised to provide a continuing link between the time that the order is placed and the goods are received with the objective of satisfying customer needs on a long term basis." Christopher et al (1979).
>
> "To most customers good service comes down to availability, convenience and information. It means that the buyer is confident he will:
> - o Get the right product at the right place, at the right time, in good condition.
> - o Have to expend a minimum amount of administrative effort to get the goods and pay for them.
> - o Be advised promptly if the supplier is unable, or expects to be unable, to deliver the complete order on time." Distribution Management Handbook (ed by Wentworth(1976)).

Customer service can be broadly defined as the attributes of PD's performance which have an effect on the customer's operations. Thus, any activities, in PD, whose influence cuts across the supplier's and customer's system boundaries, can be considered as being part of customer service.

The relationship between the supplier's system and the customer service measures and the

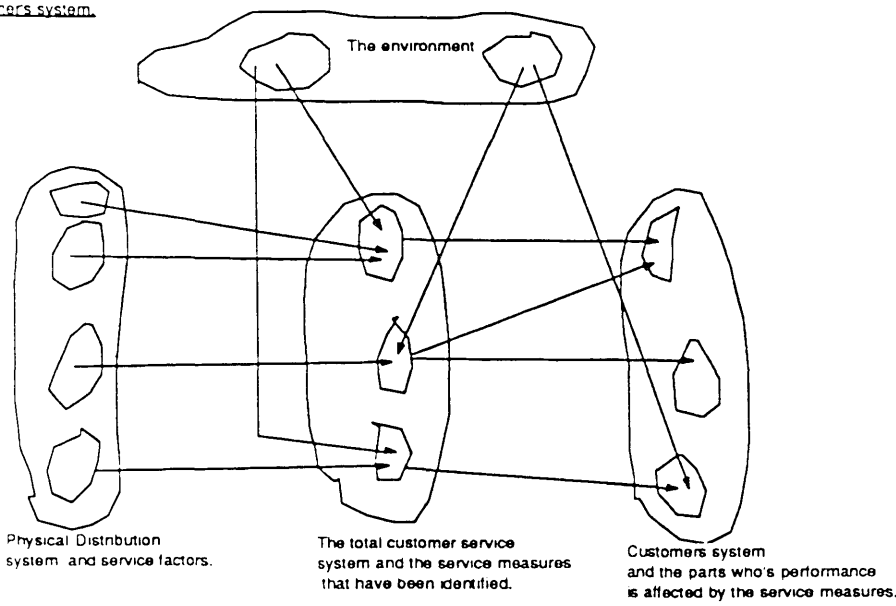
relationship of these to the customer's system is shown in Fig 2.1. Specific areas of the supplier's system influence specific customer service measures who in turn affect the customer's system. The reverse is also true, that is parts of the customer's system influence specific service measures (service to the suppliers) which in turn affect the supplier's system. Thus, the customer service measures can be considered as not being either in the supplier's system or in the customer's system but rather being in an abstract system which links, or couples, these two systems together. Customer service as shown in Fig 2.1 is a coupling system (Ashby (1956)) which couples the PD system to the customer's system. When the customer's system is also coupled to the PD system there is said to be feedback occurring between the two systems.

Customer service often has a high importance attached to it, by the customer, due to its strong influence on his own system's performance. Perrault and Russ(1976) found that customer service is the second most important part of a product, next to the product quality, for a customer. Similar results have been found by Cunningham and Roberts(1974), Lalonde and Zinzer(1976).

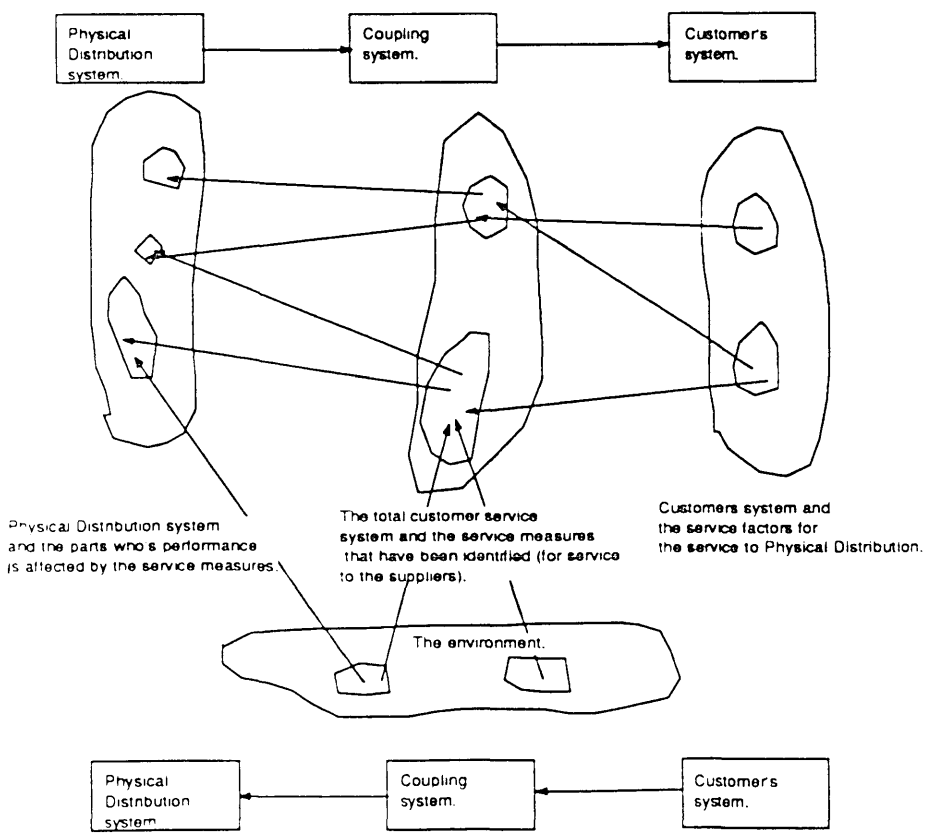
Due to the importance placed on service by customers, a high service level policy can give a supplier a competitive edge over his competitors. A higher level of service results in an increase in sales, but there is also an associated increase in costs. There thus exists a trade-off between the costs of providing a service level and the benefits associated with this service level. There is, in theory, an optimum service level where the profits, benefits-costs, is maximised. This is demonstrated in Fig 2.2. Due to market changes, such as increased competition, the curve will often shift resulting in a new optimum service level. Thus, the optimum service level is not a static figure. As a result of its effect on sales, customer service is often considered as being part of the marketing of a product. Due to its high impact on the level of sales, and hence the profitability of the company, there is a need for companies to develop a customer service policy.

Fig 2.1: A diagram showing how the two systems, Physical Distribution and the service customers, are coupled together by the service measures.

Physical Distribution coupled to the customers system.



Customers system coupled to the Physical Distribution system.



Feedback between the two systems.

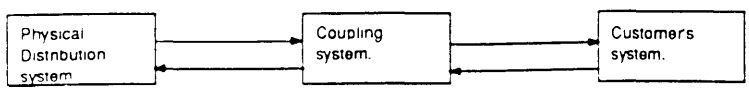
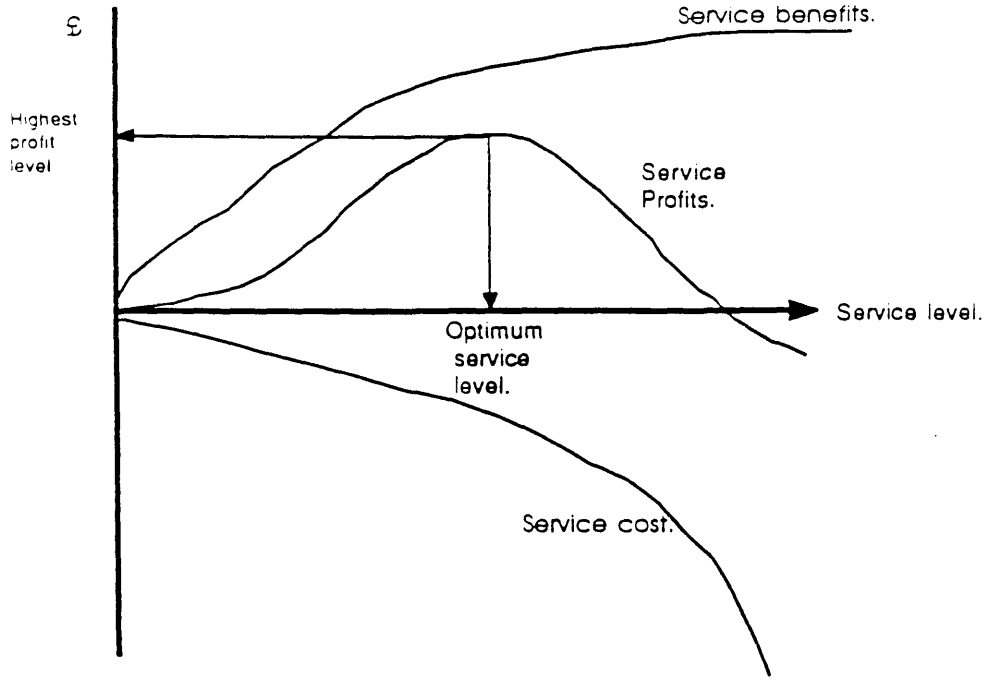


Fig 2.2 : Diagram illustrating the concept of an optimum service level.



Christopher(1983), Heskett(1971) and Hutchinson and Stolle(1968) have all developed frameworks for developing such a customer service policy. When these 3 frameworks are amalgamated the following eight stages are present:

1) Identify the key measures of service.

2) Establish the relative importance of each service component to the customers.

3) Identify company position on key service components relative to competition.

4) Segment the market by their service requirements.

5) Design a competitive customer service package.

6) Develop a program to sell the service package.

7) Test market the program.

8) Establish customer service management and control procedures.

The literature concerned with the carrying out of each of these stages will now be examined.

2.2.2 Framework for a customer service policy.

Step 1 Identify the key measures of service: Defining the service measures requires identifying the measures that actually make up customer service. There exist many views on what actually constitute a service measure. Numerous service measures have been identified (Levy (1981(a) and (b)) alone produced 71 measures). The most popularly used service measures are:

- o Order cycle time.
- o Lead time consistency.
- o Inventory availability.
- o Order-size constraints.
- o Ordering convenience.
- o Delivery times and flexibility.
- o Invoicing procedures accuracy.
- o Claims procedures.
- o Salesman visits.
- o Order status information.
- o Special orders.

For each service situation there will be different service measures that are appropriate to that particular situation which may not be appropriate to other situations. It should be noted that the above service measures have concentrated on the ordering and the supply of stock. An exception to this is the salesman visits which indicates that there may be other components to service.

There are a limited number of approaches, described in the literature, for generating service measures. One such approach is Kelly's repertory grid analysis (Kelly (1955)). A number of cards are prepared each with a name of a different supplier on it. After eliminating the cards that have names of suppliers that are unfamiliar to the respondent, the respondent is randomly given three cards. The respondent then identifies the two companies that he considers to be most similar in terms of the service they provide and explains why. This produces a initial list of measures. This list can be increased by repeating the procedure with different triads of cards. This procedure has been used by Christopher(1983) to identify service measures.

Another approach, described in the literature, for identifying service measures, used by Levy (1981(a)), is the nominal group technique. This process consists of four stages. First, the group is asked to generate ideas silently. Second, ideas are recorded in a round-robin fashion. Third, each of the ideas are discussed. Finally, the group votes on each item's importance.

Step 2 Establish the relative importance of service components to the customers: The effect of customer service, on the level of sales, is determined by customer's perception of the level of service. Marr(1980) has shown that this perception of service is often different from that held by the supplier. Thus there is a need to find out, how the customers perceive each customer service measure and what the relative importance of each service measure are to them- Sabath(1978).

Several examples of proposed techniques for doing this are described in the literature, probably the most popular being conjoint analysis (see Green and Wind(1975)). This is a technique based on the principle of trade-off between two or more measures. The technique works by presenting a respondent with feasible combinations of customer service measures. The respondents then ranks these options in order of preference. An

example of a completed table, for order lead time and order fill rate, is shown in Fig 2.3. These rankings are then transformed, by a computer program, into importance weightings. Conjoint analysis has been used in several exercises looking at customer service including: Christopher et al(1979), Marr(1982) and Perrault and Ross(1977).

Fig 2.3: A diagram showing an example of a completed trade-off matrix for the two service measures lead time and the order fill rate.

ORDER FILL RATE

LEAD TIME (IN DAYS)	90%	95%	98%
3	4	2	1
4	7	6	3
6	9	8	5

As well as using conjoint analysis, straight forward questionnaires with respondents giving their relative importance rating for a particular customer measure can be used. Christopher(1983) points out that although this approach has a distinct advantage due its ease of use there are disadvantages associated with the customer rating every part of service as being important. A partial solution to this problem is to ask the respondents to allocate a total of 100 points amongst all the measures listed, according to their perceived importance. In practice, however, this is a fairly daunting for the respondent and can often result in an arbitrary allocation.

Step 3: Identify company position on key service components relative to competition: As the supplier is competing against other suppliers the relative perception of the different supplier's service, in the customer's eyes, is an important factor in the level of sales being generated. Christopher and Morcom(1988) have pointed out that unless

the product or service offered can be distinguished(i.e. differentiated) in some way from its competitors, it is more likely that it will be simply be regarded as a commodity and the sale will go to the cheapest supplier. Christopher(1983) shows how questionnaires can be used to work out the relative competitiveness of any one supplier. These questionnaires are completed by each respondent giving each of its suppliers a value rating, such as from 1 to 10, for how good a service they give for the different service measures.

Step 4 Segment the market by service requirements: Christopher(1983) suggests that there are often advantages associated with not treating markets as if they were homogeneous with customers sharing common characteristics. These advantages are associated with seeing that different customers have different optimal service levels. Thus, by giving different service levels to these different customers the overall gross profit level is increased.

To reap these advantages the following questions have to be addressed:

a) Do all the customers require the same level of service?

b) Are all the customers equally sensitive to service?

c) What are the different requirements of different market segments, or trade sectors for customer service?

A limited number of investigations into service segmentation can be found in the literature. Two such studies by Nielson(1968) in the US and by Schary and Christopher (1979) in the UK showed that when shoppers were faced with a stock-out of the preferred brand there were noticeable differences in subsequent behaviour between when the store's own label and when the manufacturer's brand item were the preferred brand.

Work done on the scientific instrument industry, by Gilmour(1977), indicated that there were several different market segments present.

Cluster analysis, on questionnaire results, has been used by Christopher(1969) to identify distinct market segments.

Step 5 Designing the customer service package: This step entails looking at the costs and benefits associated with a service level, so as to define the service level which maximises the profits. Christopher(1983) states that as customer service is only one of many ways by which the supplier can achieve a competitive edge over his rivals, there is a need to look at customer service in the context of other marketing techniques- such as the product selling price and the level of advertising.

Various studies into the cost of providing a service level can be found in the literature. Some of the more important studies are described below.

Hutchinson and Stolle (1968) looked at the effect that the number of warehouses has on the cost of distribution and the percentage of customers which as a result are within 1 or 2 days delivery time of the warehouse.

In a similar study carried out by Christofides and Watson-Gandy(1983), the cost of providing different frequency of deliveries was investigated. This was done by looking at the number of and size of delivery vans required to generate a specified service level.

Numerous investigations have looked at the cost of achieving a specific order-fill rate (examples of these include: Heskett et al(1973), Christopher et al(1979) and Johnston et al (1988))

The investigations contained in the literature have concentrated on the cost of an order fill rate or of a lead time. This is probably due to the relative ease of generating a cost model for these measures. Christopher(1983) points out that practically determining the

costs of achieving a service level is not always very easy; because the costs associated with service are not easily identified using normal accounting procedures.

In contrast, to the high number of studies in the literature looking at the costs, there are comparatively few actual studies concerning the benefits associated with a service level. One such study carried out by Shycon and Sprague(1975) looks at the penalties associated with providing a poor lead time to a retailer. These penalties are divided into 4 components:

1) The penalty of lost sales.
2) The penalty associated with a present line being delisted.
3) The penalty associated with a new line not being stocked.
4) The penalty associated with promotions not being accepted.

Other studies into service benefits have been carried out by Stephenson and Willet(1968), Ballou(1971), Mossmain and Morton (1965). Christopher and Willis(1974) criticise these three studies for considering only the effect of only one service measure, when the actual effect is determined by many measures.

Schary and Becker (1973) tried to get around this problem by considering the benefits associated with the total expenditure on service. (Other investigations into service benefits include Schary and Becker(1972), Walter and Grabner(1975), Walters(1974), Walters and Lalonde(1975), Vinson(1972)).

The main difficulty with defining the service benefits stems from being unable to generate an accurate quantitative model of the relationship between service and the benefits, sales. This is often due to the difficulty of discerning the effect of service from the effect other factors are having on the level of sales. Also as some effects are long term in nature there is a need to run an experiment on a system for some time before the full effects are actually felt.

The requirements for carrying out the first five steps of the above described framework, for effectively controlling service to external customers, are summarised in Fig 2.4.

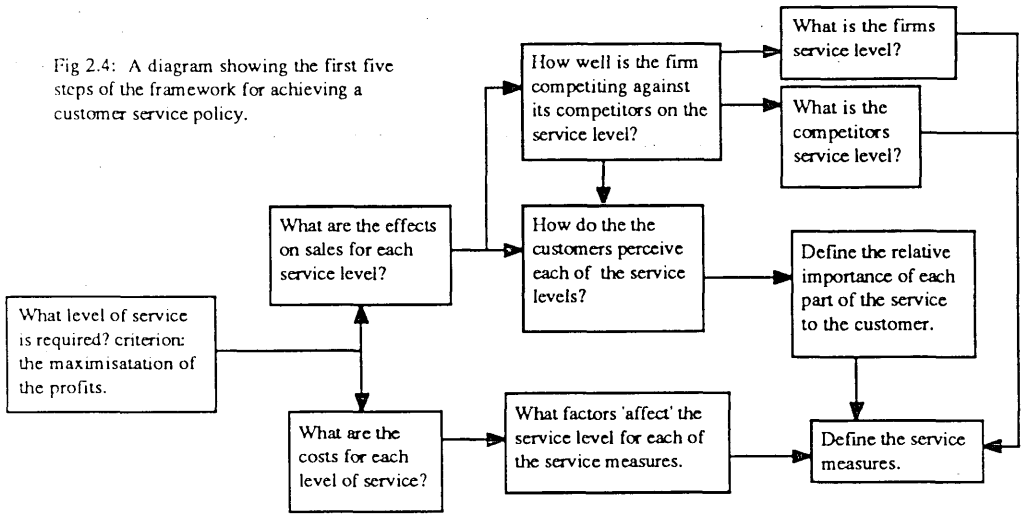


Fig 2.4: A diagram showing the first five steps of the framework for achieving a customer service policy.

Step 6 Develop a program to sell the service package: Hutchinson and Stolle (1968) state that as customer service is part of the marketing mix of a product the supplier should promote his service package to his customers, pointing out the advantages of his service package.

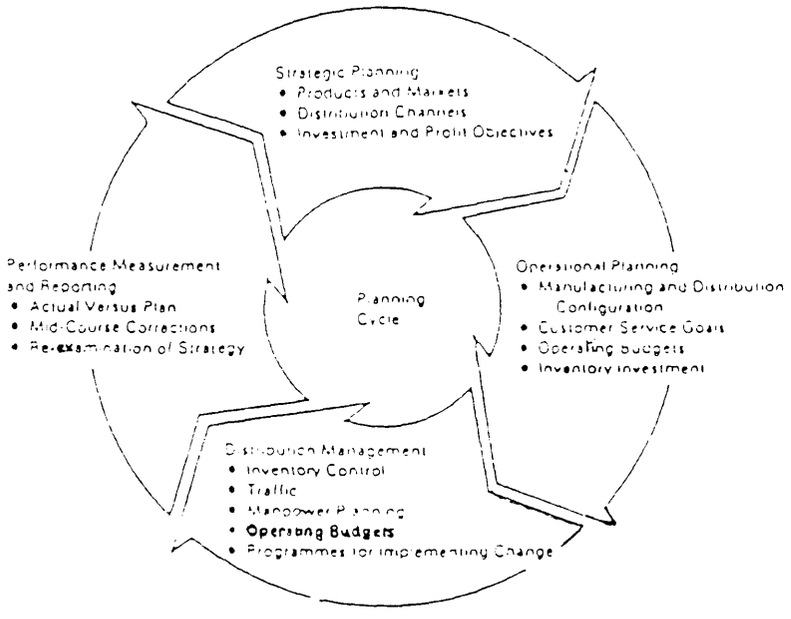
Step 7 Test market the program: Hutchinson and Stolle(1968) argue that before a customer service package is implemented through out a company's entire operations it is sensible to test market it. This is because of the uncertainty that surrounds both the actual costs of providing and the benefits from a service package.

Step 8 Establish customer service management and control procedures: The last step, in the development of a service policy, is to establish performance controls to ensure that the service that is being offered, is actually being achieved. Also it is important to monitor the cost of providing the service and the effect it is having on the sales.

Christopher(1983) sees that customer service objectives should mirror the typical planning cycle of the firm. This is shown in Fig 2.5. From this Christopher(1983) sees that

customer service goals are based on the strategic objectives and that a policy for customer service can only be defined as part of a global review of the whole marketing strategy.

Figure 2.5The Distribution Planning Cycle

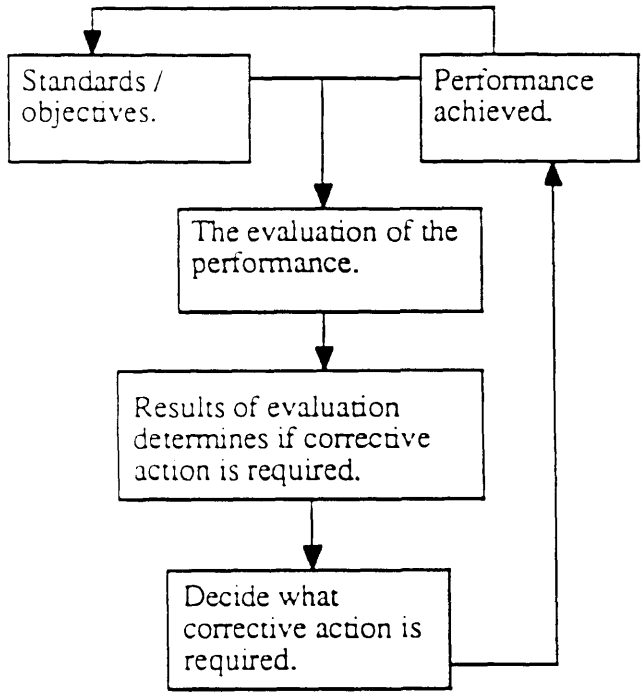


Source: Moore, J., "Strategic Considerations in Measuring and Reporting Performance for Physical Distribution Management", *NCPDM Annual Meeting Proceedings*, 1977.

One of the problems in trying to manage service is its inter- departmental nature and the lack of acceptance of its importance by different departments. According to Christopher(1983), this means that to manage customer service successfully there must be both an established organisational recognition of the customer service function and a reporting and control system necessary to carry out the effective management of this function. The only way to do this is by having all the activities involved in a service measure being managed as a intergrated function.

The stages involved in controlling customer service are the same as in the controlling of any other activity. The simple basis of any management control system is shown in Fig2.6.

Fig 2.6: A diagram showing the basis of a simple management control system.



Both Heskett et al (1973) and Hutchinson and Stolle (1968) have proposed service control system complying with this simple format. Heskett et al(1973) suggest a procedure which, slightly modified, would be:

1) Identify all important logistics cost categories along with other inputs of effort which the organisation incurs.

2) Institute systems and procedures for the collection of this data.

3) Identify and collect the output data.

4) Prepare a set of desired measures by which the logistics activities within the organisation might be evaluated.

5) Set up a mechanism for the regular presentation of status reports.

Unfortunately, normal accounting systems are often incapable of providing the relevant cost data. The designing of systems for the collection of this data is therefore, no easy task.

Identifying and collecting output data may also be problematic. Output data is considered with revenue, thus, the problem becomes one of pinpointing the extent to which the service has resulted in the generation of revenue. Instead of doing this the service measure is usually used as a surrogate measure.

Hutchinson and Stolle(1968) propose that the following stages are required in a service control system:

1) Establish quantitative standards of performance.

2) Measure actual performance for each service measure.

3) Analyse variance- viz- actual service versus the standard.

4) Take corrective action as needed to bring the actual performance into line.

It should be stressed that with this approach there are still the same problems of defining the service costs and benefits, as this is required when determining the required standard of performance.

2.3 The previous research shortfalls.

It is felt that previous studies dealing with controlling PD customer service have some shortfalls, these include:

1) The previous studies have only considered the case where the service customer is external, that is not in the same company as the PD operation. However often a PD system supplies service to an internal customer. A very common example of this is retail companies who run their own PD operations.

2) They have a tendency to concentrate on providing one off solutions which do not adapt themselves to possible situation changes.

3) Few investigations have been held into the relative merits of possible approaches for carrying out a particular activity required in a service control system.

4) They have generally concentrated on service measures that are concerned with the ordering and actual supply of stock and usually have not dealt with the possibility of other types of service, such as the accuracy of stock information.

5) Previous studies have considered mainly what controlling service in theory requires and have isolated this from what is actually felt to be required in reality, by the service controllers.

6) Different people hold different views on what is involved in controlling service or even why there is a need to control PD service. Previous studies have generally failed to take this into consideration because they usually adopt one particular viewpoint of what is involved in controlling PD service.

2.4 The research objectives.

The objectives of this research are to address the gaps that have been identified (above) in the previous studies. Thus they are:-

1) To look at the similarities and differences in the two situations of:- controlling service to internal customers, and controlling service to external customers.

2) To investigate how customer service can be controlled so that a system is created that will continually change and be updated to fit the actual changes in the situation.

3) To determine a way of discerning the relative merits of a particular approach

and then use this to define the best way of doing an activity. This means that the defined system will be a learning system.

4) To take a broad view of the definition of service and to question whether it is merely concerned with the ordering and the delivery of stock.

5) To define what is considered to be actually required in controlling service in reality and not just in theory.

6) To take into consideration the many different viewpoints that exist when determining what is involved in controlling PD service.

2.5 What needs to be done ?

The basic outline of what needs to be done to meet the above objective are as follows:

1) Determining the activities which are felt to be required in controlling PD's service to internal customers, by considering the various views of people that are concerned with controlling service from a PD operation to internal customers.

2) Comparing the activities identified above with those required to control the service to an external customer, as defined in the literature.

3) For each of the defined activities determine possible designs of systems which will carry out the activities continuously.

4) Defining a framework which can be used to test the relative merits of these different system approaches.

5) Testing the relative merits of each possible system by trying them out in an actual situation wherever possible.

6) Carrying out all the above without, hopefully, adopting any preconceived ideas of what is and is not a part of service.

2.6 The methodology being used.

2.6.1 The requirements of the methodology.

From the above discussions it is possible to identify some of the characteristics which are needed by any methodology used to carry out the research will need. These are:-

1) To be able to take into consideration different views of a particular situation.
2) To generate a continuous solution (i.e. one that is continuously updated) to the problem rather than a one off solution to the problem.

2.6.2 The choice of the methodology.

The nature of the problem being looked at in this thesis is ill-defined because of the many different views about it. Therefore it is proposed that soft system methodologies may be of use in understanding the problem. There are 2 in particular methodologies that are felt to be appropriate here: Checkland's soft system methodology (Checkland (1981)) and Eden's cognitive (Eden et al(1983)) mappings.

These were chosen because of their ability to be able to deal with many differing views of a problem.

2.6.3 Description of methodologies.

A description of the 2 methodologies that will be used in this thesis are included below.

I) Checkland's methodology: Only a brief description of the methodology is included here. A more detailed description can be found in Checkland's book (Checkland(1981)). Checkland's methodology is a process designed to deal with fuzzy situations where there are many different perspectives on a problem. The whole approach of this methodology is based on being able to use and discuss different views of the problem situation. The methodology determines what human activity systems (that is a set of activities) are felt, by the various problem owners, to be required in a situation to solve a problem. These human activity systems (HASs) arecarried out continuously. Hence allowing the problem solution to react to changes in the problem. Consequently it is felt that Checkland's methodology has the characteristics necessary for the required methodology.

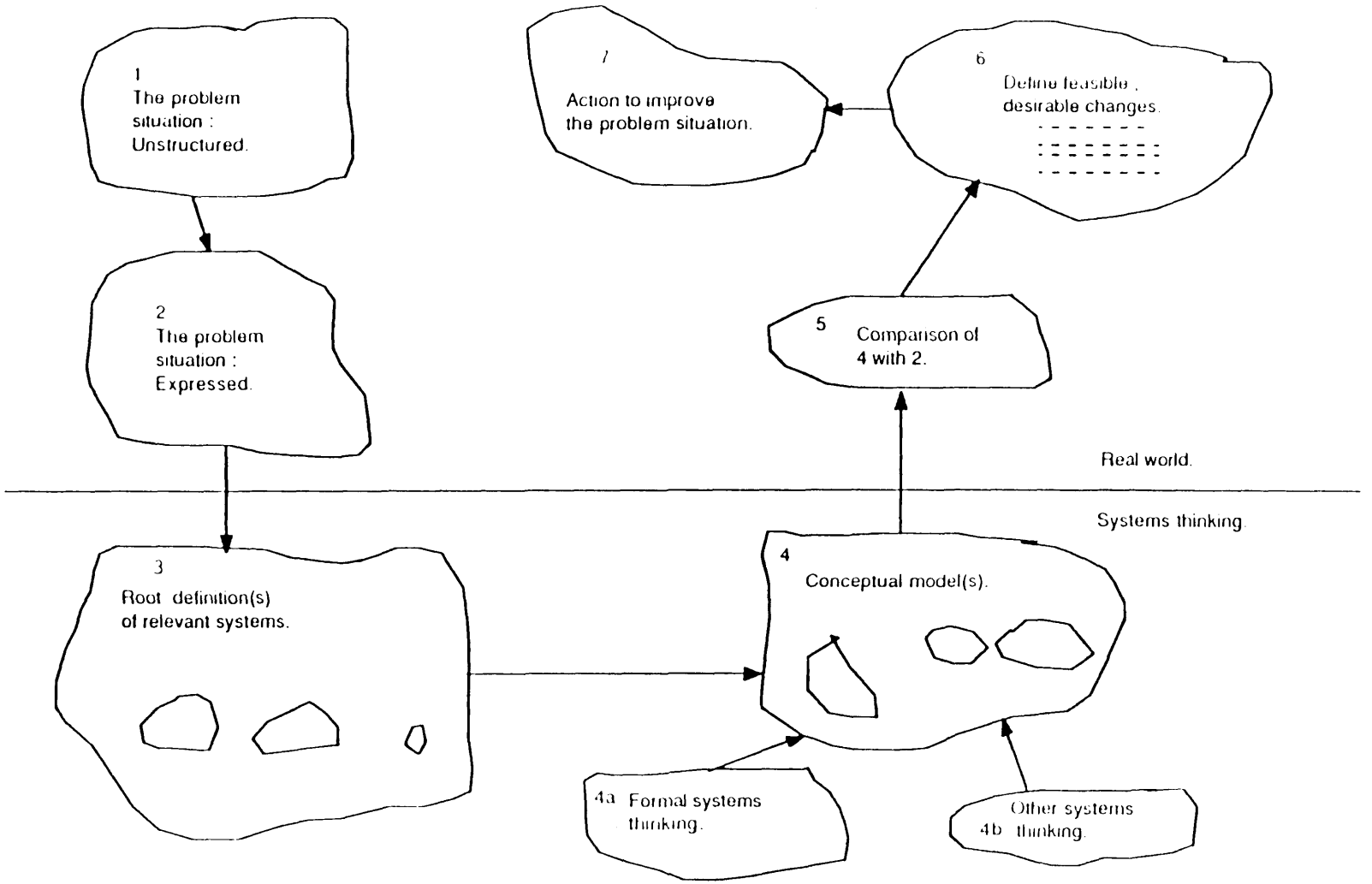
The general outline of Checkland's methodology is shown in Fig 2.7 (Checkland 1981). The first part of the methodology is concerned with finding out as much as possible about the problem situation (stages 1 and 2). Checkland(1981) has prescribed several approaches for use in this finding out stage. These include:

1) Not having any preconceived ideas about what the problem is.

2) Getting as many perceptions as possible of the problem.

3) Identifying the various opinions of those interested in solving the problem. (These various defined opinions forms the basis of defining the various Weltanschauung (world views), of the problem situation that are present).

Fig 2.7 Diagram showing Checkland's methodology
(Source: Checkland P. "Systems thinking, systems practice, John Wiley and sons)



Various other techniques have been proposed in the soft system literature for helping to define the problem. Some of these are included here:

1) Koberg and Bagnell (1981) suggested that the following questions are useful for a problem solver to ask when defining a problem and its context:

a) What are my resources and what is required?

b) Where can information be found about the problem?

c) What is the total scope of the world in this problem?

d) Which points are controllable and which are fixed?

e) What is allowed and what is ruled out in a solution to the problem.

2) Koberg and Bagnell (1981) also suggest that problem solvers should try to get involved in the problem situation and put themselves in the problem owners shoes. This can be done by gaining first hand experience of working in the problem situation.

3) Eden et al (1983) propose various approaches that can be used by a problem solver, these include:

a) Letting the problem owner ramble on about his problem and it's context. By identifying the concepts mentioned frequently, by the problem owner it is possible to determine what he considers to be the main parts of the problem.

b) The use of empathy when holding discussions with the problem owner. This involves using feedback with the problem owners. This is done by asking them to say more about and clarify about certain areas being discussed. This helps the problem owners feel that they are being listened

to. Consequently they are more likely to express their real feelings about the problem.

c) The use of interviews. This involves the use of formatted questions prepared before hand.

d) The use of cards to determine the intersubjectivity of ideas. The ideas that are felt to be most salient to the problem, identified by using other techniques, are written on cards. The client is then invited to organise the cards in a way that describes the interaction of the ideas which are most appropriate to him.

e) Use of repertory grid techniques. A description of this technique has been included earlier in this chapter (section 2.2.2 on how to define service measures). Where a client expresses differences and similarities between 3 different suppliers of stock. Here a client expresses similarities and differences between 3 different measures of the problems.

f) Interactive modelling using cognitive maps. This is discussed later on in this section.

It is proposed that the following approaches are also useful for carrying out this stage of Checkland's methodology:

1) Consulting work carried out on similar problems in the past. This enables the problem solver to learn from other people's experience and using their insight into the particular problem. However, there is a need to identify the differences in the problems being investigated and still have an open mind about the situation.

2) Define the constraints operating on possible system designs. There are principally two classes of constraints operating on a problem situation:

a) Universal constraints, which operate wherever the problem is, these can usually be identified by looking at the literature. An example of a universal constraint is Ashby's law of requisite variety (Ashby(1956)).

b) The domain constraints, which are due to the problem situation. These are highlighted by consulting the problem owners over what is and is not allowed.

The culmination of stages 1 and 2 of Checkland's methodology is the defining of a set of root definitions of systems (stage 3 of the methodology) which are felt would reduce the problem symptoms. The root definition of a required system is basically a verbal statement of a particular objective and a point of view which together with a set of activities, makes the statement a meaningful system. Each root definition reflects one particular viewpoint on what problem needs to be solved.

Smyth and Checkland (1976) propose a framework that can be used to test whether a root definition is well formulated. This involves checking that the following measures are contained in the root definition: The Customers; the Actors; the Transformation (this is the central essence of the system); the Weltanschauung (the world view being adopted); the Owner of the problem and the Environmental constraints of the problem situation. Collectively these measures are referred to as being the CATWOE of the root definition. This framework can then be used to determine if all the measures are present in a root definition. From this a particular root definition can be reformulated if required. It should be stressed that it is not necessary for all the CATWOE measures to be present in a root definition. However each root definition needs to have a transformation and a Weltanschuuang specified in it.

Wilson(1984) suggests that the CATWOE system is also a useful device for helping in the construction of root definitions. By using this consideration can be given to the various measures of a root definition prior to its definition. However once formulated, the root definition should still be tested against the CATWOE to ensure that the definition represents what was intended. Wilson(1984) points out some pitfalls, listed below, which should be avoided when defining a root definition.

1) The root definition should describe a system and not what physically exists.

2) Customers represented in the CATWOE should be the direct benefactors of the systems transformation, not the final indirect benefactors of the system.

3) A root definition should, where grammatically possible, contain only one world view and transformation.

In stage 4 of the methodology each of the derived root definitions are then translated into a conceptual model of the human activity systems (HASs) which have to be present to be the system defined in the root definition. (A human activity system is a notionally purposeful system which expresses some particular human activity). The root definition describes what the system is, whereas the conceptual model describes what the system does. These conceptual models can then be validated against other system thinking, such as cybernetics, to ensure that it is complete as an adaptive system. The conceptual model is then compared against the root definition to ensure that the HASs contained in the conceptual model are actually represented in the root definition and all the root definition is encapsulated within the conceptual model. If either of these cases is not true then either the root definition or the conceptual model have to be reformulated.

The next stage in Checkland's methodology is to compare the set of conceptual models that are produced against the problem situation by discussing them with the problem owners. These discussions are used to redefine the problem situation and hence the root definitions. From these a further set of conceptual models are produced. This cyclic learning process is repeated until an agreement on a particular conceptual model is achieved.

This final conceptual model is used for stating what activities are felt to be required in the situation to alleviate the perceived problem situation. Stage 6 of the methodology defines how each of these human activity systems derived in the final conceptual model, derived at stage 4, are going to be carried out. Stage 7 is then concerned with how the changes required are going to be implemented.

Checkland's methodology is used in this thesis to help determine what activities are felt by a set of problem owners to be required in controlling PD service to internal customers.

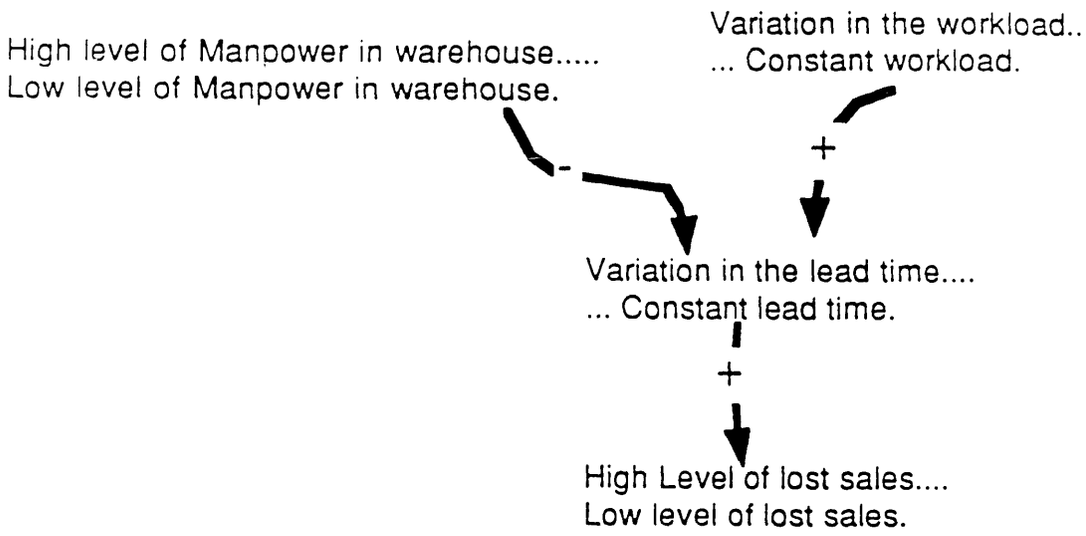
II) Cognitive mapping: Cognitive mapping is a method, developed by Eden et al(1983), for modelling ideas, beliefs and values about a problem. This technique enables the problem helper and clients to have an explicit basis for negotiating about a particular problem's context and structure. The technique can also be used by individuals to help formulate their thinking about a problem situation.

The first stage in carrying out the technique is for the helper to find out as much about the problem situation as possible. Similar methods to those used in stages 1 and 2 of Checkland's methodology, see above, are used to do this. The next step in the methodology is for each of the problem owners to define a label for the problem. Then they are asked to define what would be a satisfactory alternative to this circumstance in their eyes. This generates the two opposite poles of the problem: problem present and the problem not being present. Repository grid technique are often used as an aid in doing this.

The next step is to develop ideas through the problem owners addressing the questions: "Why does this problem matter to you?", or "Why are you worried about the problem?" Again, where possible, alternatives (opposites) to these situations should be formulated. Next the problem owner is asked the question: "What reasons come to mind as explanations for the problem?".

It should be noted that the above analysis identifies and represents a particular person's views on what the effects and causes of a particular problem are. An example of such a mapping for the problem of lead time consistency is shown in Fig 2.8.

Fig 2.8: A diagram showing a possible cognitive map showing the causes and the effects of the problem of variations in the lead times.



By defining the causes and effects of a problem situation with two opposite poles it is also possible to indicate the direction of any causal relationship between two variables. When the first pole leads to the second pole there is said to be a negative relationship. Whereas when the first pole leads to the first there is said to be a positive relationship. These directional relationships are shown in Fig 2.8 for the example of lead time consistency. This mapping process can be carried on to consider what a particular person considers to be the causes of the causes and what the effects of the effects.

The cognitive maps that are produced by carrying out the above procedure are used with the problem owners to reformulate thinking about the problem and from these discussions a further set of cognitive maps are produced. This process is carried on until a cognitive map are produced which is felt encapsulates the problem owners understanding of the problem.

When this technique is used with many different people (who each have differing views on the problem) the different problem views are visually represented by using this technique. The resultant maps representing the differing views about a problem help in allowing a group discussion about the problem to take place.

Due to the methodology being ideally suited in analysing the causes and effects of events it will be mainly used in this research to look at the effects of and causes of a service level for each of the service measures that are derived.

2.7 Summary.

Initially this chapter looked at the previous studies that had been carried out on controlling customer service. This showed that customer service is an important part of physical distribution's performance. Also it was shown that customer service is a very fuzzy concept and hard to define precisely, resulting in there being many different opinions about what it involves. A framework of eight activities which the literature defined as being required to control the service were identified. These activities are as below:

1) Identify the key measures of service.

2) Establish the relative importance of each service component to the customers.

3) Identify company position on key service components relative to competition.

4) Segment the market by their service requirements.

5) Design a competitive customer service package.

6) Develop a program to sell the service package.

7) Test market the program.

8) Establish customer service management and control procedures.

The methods the literature described for carrying out each of these activities have also been included.

Following the literature survey an indication was given of some shortfalls in these previous

studies, these include:

1) They have not considered the case of an internal customer.

2) They have a tendency to concentrate on providing one off solutions rather than continuous solutions.

3) They have not determined the relative merits of the different possible approaches for carrying out a particular activity.

4) They have generally concentrated on service measures that are concerned with the actual supply of stock.

5) They have failed to take into consideration different peoples views on what is involved in controlling PD service.

6) They have considered mainly what controlling service in theory requires and have isolated this from what is actually felt to be required in reality, by the service controllers.

From these shortfalls the following research objectives were defined:

1) To look at the similarities and differences in controlling service to internal customers and to external customers.

2) To investigate how to control customer service in a way which updates itself to reflect actual changes in the situation.

3) To determine a way of discerning what the relative merits of a particular approach are. Then use this to define the best ways of doing a activity.

4) To take a broad view of what service is.

5) To take into consideration the many different viewpoints when determining what is involved in controlling PD service.

6) To determine what is considered to be required in controlling service in reality.

From the objectives the actual proposed outline of what is required to be done in the research was generated. This outline is shown here:

1) Determine the activities that are felt to be required in controlling PD's service to internal customers by considering the various views of people concerned with controlling service from a PD operation to internal customers.

2) Compare these activities with those required to control the service to an external customer, as defined in the literature.

3) For each of the defined activities determine various possible designs of systems to carry out the activities continuously.

4) Define a framework to test the relative merits of these different system approaches.

5) Test the relative merits of each possible system, where possible, by trying them out in an actual situation.

6) Carry out the above without, hopefully, adopting any preconceived ideas of what is and is not part of service.

Two methodologies, Checkland's soft system methodology and Eden's cognitive mapping were identified as being useful in carrying out the research. The next chapter deals with how the above research can be performed and what the similarities and differences in the activities required for controlling service to internal customers from those required in controlling service to external customers.

CHAPTER 3

RESEARCH METHODOLOGY AND DEFINING THE BASIC ACTIVITIES REQUIRED.

3.1 Introduction:

This chapter looks at how each step in the research outline, contained in chapter 2, can actually be carried out. This results in a procedure being generated which enables the research objectives to be met.

The initial part of this research procedure will be used to indicate what basic human activity systems (HASs) are felt to be required to control service to internal customers. These HASs will then be compared against those needed for external customers.

3.2 How the research can actually be carried out.

In chapter 2 various steps were identified for carrying out the research in this thesis, these were:

1) Determining the activities that are felt to be required in controlling PD's service to internal customers, by considering the various views of people that are concerned with controlling service from a PD operation to internal customers.

2) Comparing these activities defined in step 1 with those required to control the service to an external customer- as defined in the literature.

3) For each of the defined activities for controlling service to internal customers, determine various possible approaches which will perform the required activities .

4) Defining a framework which can be used to test the relative merits of the different approaches for carrying out the activities.

5) Testing the relative merits of each feasible system by trying them out in a actual situation, where possible.

6) Carrying out the above without- hopefully- adopting any preconceived ideas of what is and is not part of service.

How each of these steps can be accomplished will now be investigated.

3.2.1 Carrying out Step 1:

It is proposed that Checkland's methodology (Checkland (1981)) as described in chapter 2 can be used to carry out step 1 above.

Due to the amount of time and effort it would have involved if used with many different companies, Checkland's methodology will only be used with one participating company in this research. This strictly means that the HASs defined are only valid for the problem facing this one company. However, it is considered that the problem that is investigated, for this one company, is a universal one which faces any company which has its own PD system. Also it is felt that this company's PD system is similar to other companies systems, consequently solutions to this problem are likely to be transferable to other situations.

It is suggested that Checkland's methodology can be enhanced by looking at previous

studies of similar problems. This shows what activities (HASs) were felt to be required to solve these problems. When these HASs are compared against those derived by using Checkland's methodology there will often be mismatches. These mismatches can then be used to discuss, with the participating company, whether they are actually required or not. This whole process is shown in the flow chart in Fig 3.1. This process enables knowledge gained from other studies to be introduced into Checkland's methodology. Basically the worldviews expressed in previous studies are being used to define an additional set of conceptual models. This enhances the discussion about the problem in stage 5 of Checkland's methodology.

3.2.2 Carrying out step 2:

Previous customer service studies have looked at service to external customers. By looking at the activities described in these studies it is possible to determine the HASs felt to be required for controlling service to external customers. The activities that are felt to be required for controlling service to internal customers have already been defined by step 1.

3.2.3 Carrying out step 3:

Checkland's methodology will be used as a front-end procedure in this research. That is the methodology will be used to transform the original problem into one of how to carry out a set of HASs (It should be noted that the HASs define what activities are needed to be carried out). This transformation process is shown in Fig 3.2. Any management technique or tool felt to be appropriate, will then be used to define how to perform these HASs.

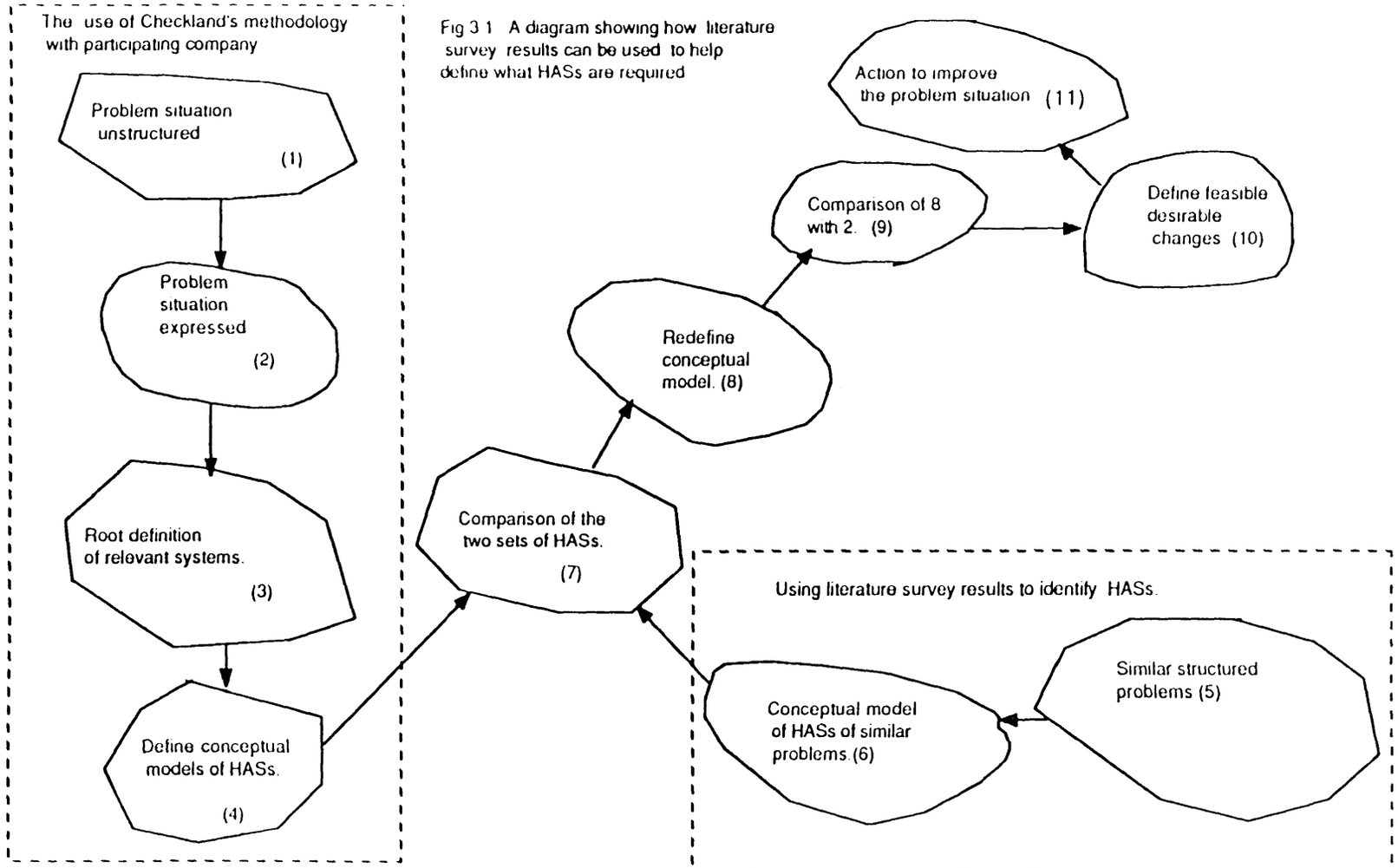
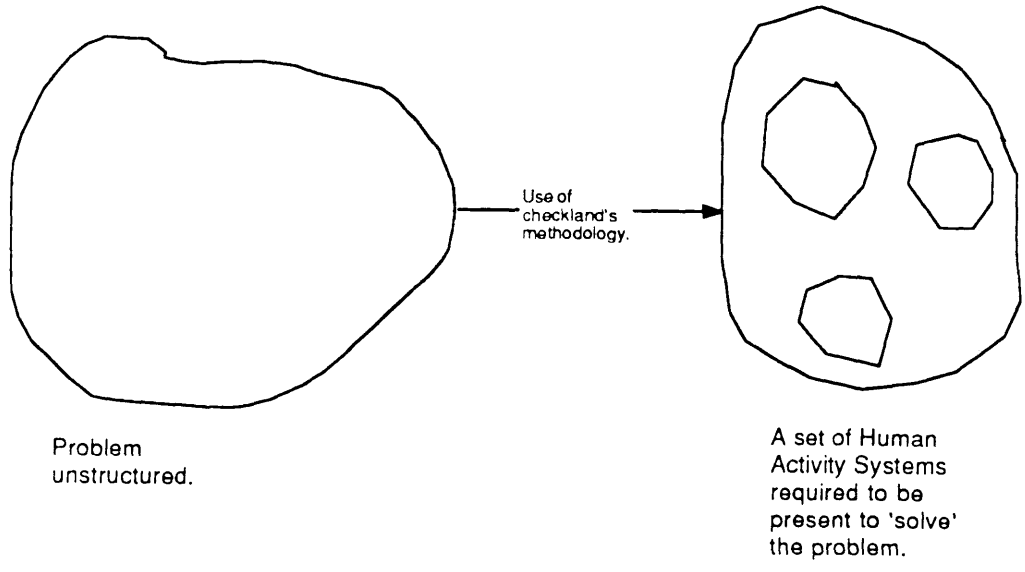


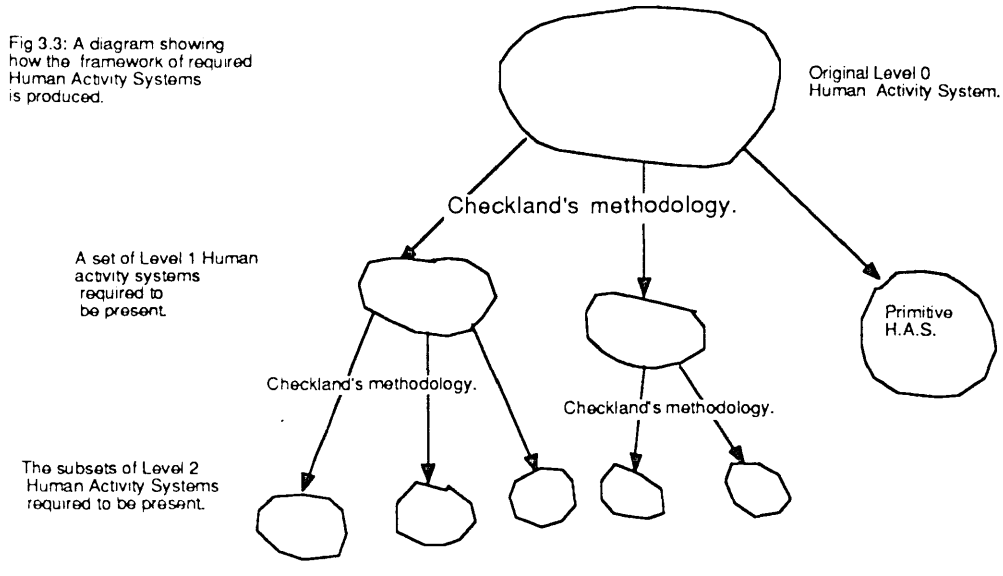
Fig 3 1 A diagram showing how literature survey results can be used to help define what HASs are required

Fig 3.2: A diagram showing the transformation of the original problem by using Checkland's soft system methodology into defining how certain Human Activities Systems should be carried out.



However, if it proves difficult to define how a particular HAS can be carried out, then Checkland's methodology will be used again, with the participating company, to redefine this HAS in terms of a further subset of HASs that are felt to be required. This once again gives the opportunity for any technique to be used to carry out these HASs. This procedure is repeated until the methodology defines a HAS where it is known how to carry it out.

Consequently, Checkland's methodology is used to define a framework of HASs which are felt to be required to solve the problem. This process is illustrated in Fig 3.3. It can be seen from Fig 3.3 that this framework has various levels of HASs with the initial problem being at level 0. This problem is 'solved' by transforming it into the problem of defining how the HASs at level 1 can be performed. In turn these level 1 HASs if required can be defined in terms of the level 2 HASs and so on.



3.2.4 Carrying out step 4:

Often a choice of possible approaches exists to carry out a particular HAS. Consequently there is a need to define criteria for the relative merits of the different options in order to determine which approach is best. It is proposed to use the criteria suggested by Checkland(1987). These criteria look at how well a particular option carries out the described transformation in the HAS's root definition. There are three dimensions to this criteria:

1) The effectiveness of an approach. How much output is produced?

2) The efficacy of an approach: Is the approach capable of producing the desired result.

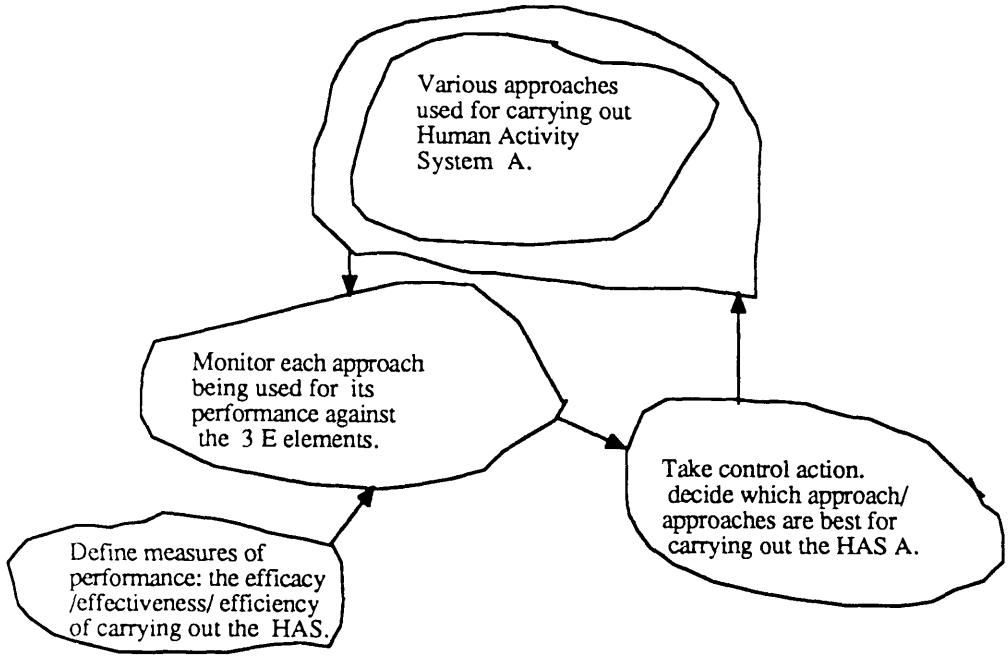
3) The efficiency of an approach: Does the proposed approach use up valuable resources?

These criteria will from now on be referred to as the 3 E test. It should be noted that the more effective and efficient a particular efficacious technique is, generally the better the technique is.

3.2.5 Carrying out step 5:

Each of the approaches proposed in stage 3 for carrying out a HAS will be tested in the participating company's situation and their performance measured against the 3 E criteria proposed for that particular HAS in step 4. This enables a decision to be made concerning which approach is considered to be the most beneficial to use. This means that the system evolves and increases its performance by selecting the best techniques. This procedure is shown in Fig 3.4.

Fig 3.4: A diagram showing how using the 3 E test creates a learning system by choosing the best way/ways of performing a H.A.S.



3.2.6 Carrying out step 6:

As Checkland's methodology starts from the premise that no preconceived ideas about a problem should be adopted step 6 is automatically carried out when using this methodology.

3.2.7. Summary of research outline:

A summary of the above proposed research outline of how the research will be carried out is shown below:

1) The HASs that are required for controlling service to external customers are defined by investigating previous studies on similar problems.

2) The HASs that are felt to be required for controlling service to internal customers are defined by using Checkland's methodology with the participating company.

3) Results of 1 and 2 are compared, where HASs are present in 1 but not in 2 then discussions are held with the participating company to decide if they should be left out or not.

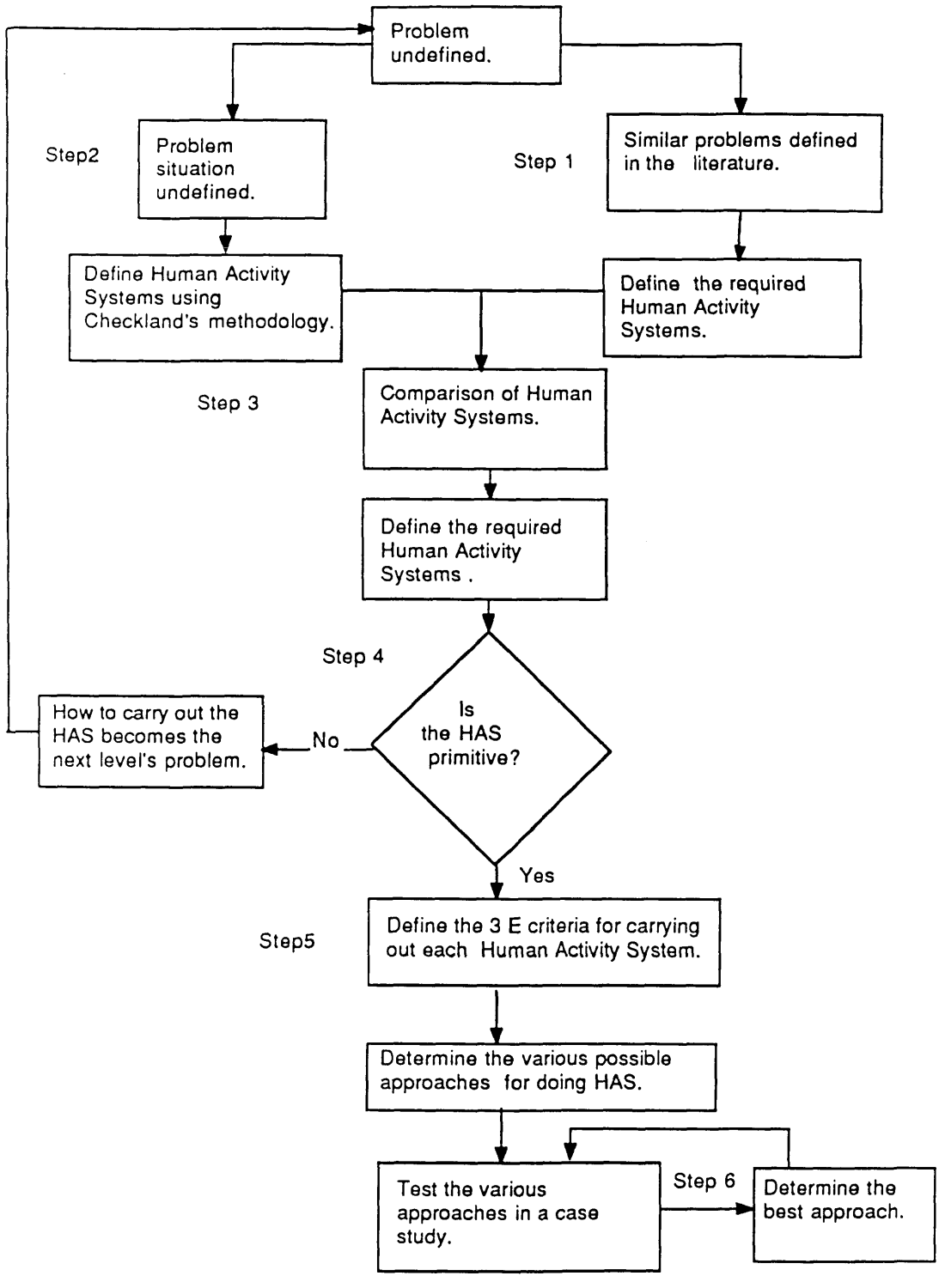
4) Determine if the HASs defined in step 3 are primitive (i.e. it is known how to carry the HAS). If they are not, carry out stages 1- 3 for each of the defined HASs until a set of primitive HASs are produced.

5) Use the 3 E test to determine criteria for testing the various approaches for each of the HASs.

6) Use each of the proposed approaches for carrying out a HAS with the participating company and test their performance against the 3 E criteria to determine the best approach.

This procedure is shown in Fig 3.5. This procedure will be used throughout the rest of this thesis.

Fig 3.5: A diagram showing the outline of the research approach being used in the thesis.



3.3 The actual use of procedure:

3.3.1. Carrying out step 1:

It was shown in chapter 2 that according to Christopher et al (1983), Heskett(1973) and Hutchinson and Stolle (1968) there are eight activities required to be performed when controlling service to external customers. These are:

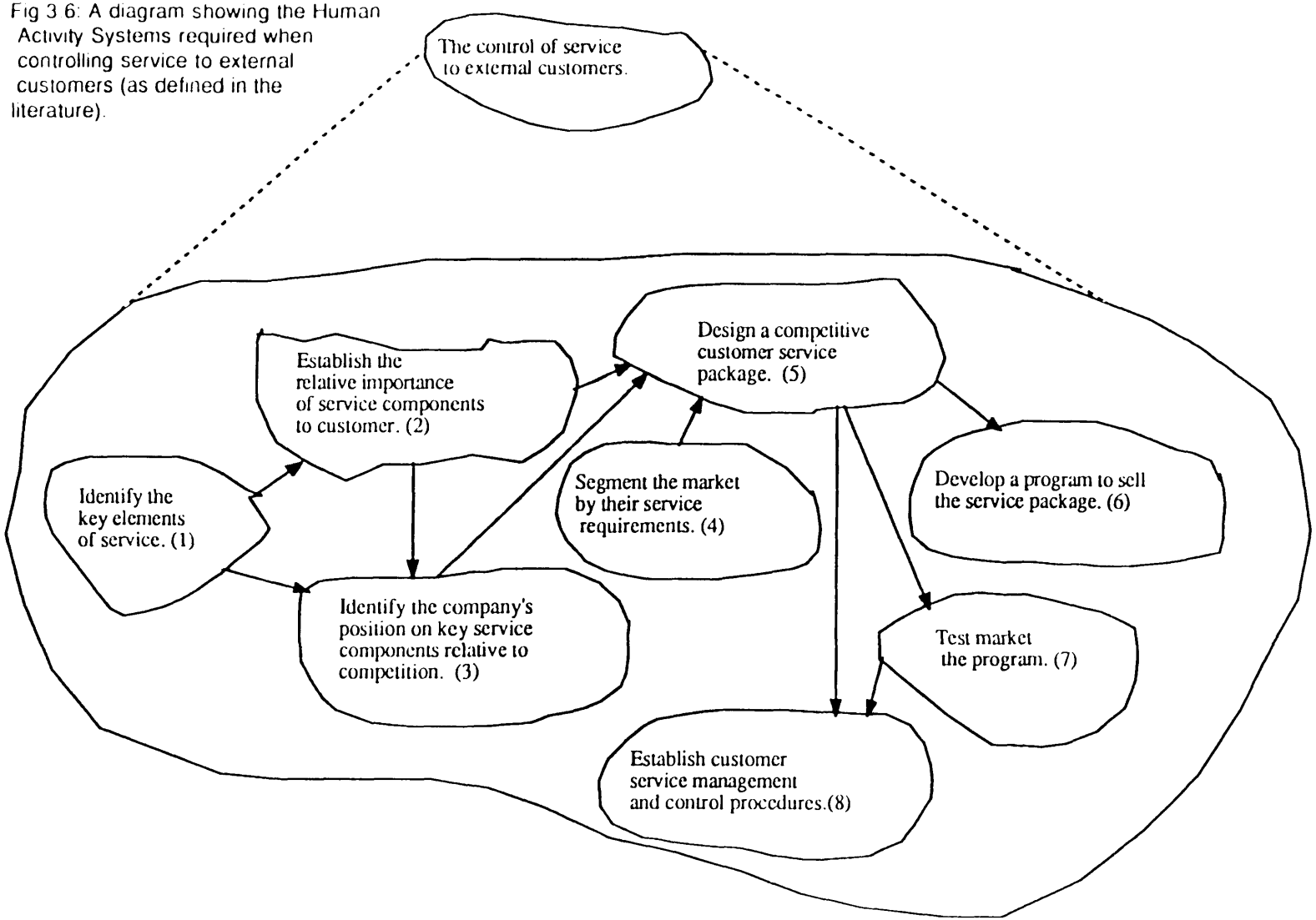
1) Identify the key elements of service.
2) Establish the relative importance of service components to the customers.
3) Identify company position on key service components relative to competition.
4) Segment the market by their service requirements.
5) Design a competitive customer service package.
6) Develop a program to sell the service package.
7) Test market the program.
8) Establish customer service management and control procedures.

Each of these activities represents an activity carried out by a particular HAS. The conceptual model for these HASs is shown in Fig 3.6.

3.3.2 Carrying out step 2 of the procedure:

Stages 1+2: Getting a rich picture of the problem. Consultations were held with company staff, who were felt to have a concern about solving the problem. In these consultations the personnel were allowed to express their opinions on what they considered the actual problem to be. Generally these consultations were of rambling type, (see Eden et al (1983)) giving the personnel the opportunity to talk freely about the problem. After these initial discussions several personnel were reconsulted to clarify ideas

Fig 3 6: A diagram showing the Human Activity Systems required when controlling service to external customers (as defined in the literature).



about the problem. Also during these consultations the personnel were encouraged to express their opinions on what formed part of PD service. They were asked to indicate if they thought there were any possible constraints on possible solutions. First hand experience was also gained in the company's areas that was affected by PD's service so as to get a feeling of the effects of the problem.

The investigation indicated that the following issues were felt to be part of the problem:

1) There were several different views of what customer service actually is.

2) There was no absolute standard of what the level of service should be or what the service policy should have been.

3) Service level was measured by only a limited number of quantifiable factors.

4) The effect on overall efficiency of controlling the service level was imprecisely known.

The constraints operating on the system were identified as being: That any solution being offered had to be both feasible and cost effective.

Stage 3: Defining the root definition: Once a rich picture of the problem situation had been developed, it was possible to attempt a formulation of a set of root definitions. To aid in this the CATWOEs of the required systems were defined, this analysis is shown below:

The **customers** (those who benefit from an improvement in the problem situation) were identified as being: The controllers of PD service.

The **actors** (those who carry out the activities of the system) were identified as being: The PD system.

The **transformation** (the transformation process carried out by the system) was identified as being: From no way of controlling PD service so as to increase the performance of the company to a state where there is a way of controlling PD

service which would increase the performance of the whole company.

The **Weltanschauung** was identified as being: Controlling and evaluating service is worthwhile due to the effect it has on the company's performance (profitability).

The **Ownership** (those who are concerned about the problem) was identified as being: "The PD operation and in a wider sense the whole company."

The **environmental constraints** were identified as being: "The requirement that the systems have to be financially viable and feasible."

It can be seen from above that only one Weltanschauung and transformation were identified. This meant that all the views expressed could be represented in one root definition. The above CATWOE analysis was used in defining the following root definition of the system that was felt to be required to alleviate the perceived problem:

> "A system which controls the service of the Company's Physical Distribution system in a way which increases the profitability of the whole company. Any control systems used have to be both feasible and financially viable."

This root definition was then checked against the CATWOE analysis to ensure it was well formulated.

Stage 4: Defining a conceptual model: The conceptual model of the HAS that was generated is shown in Fig 3.7.

The cross examining of this conceptual model against the root definition, to ensure that it is concise and complete, is shown in Fig 3.8. This conceptual model indicated that the following HASs were felt to be required:

1) Understanding the company's PD operation.

2) Defining service.

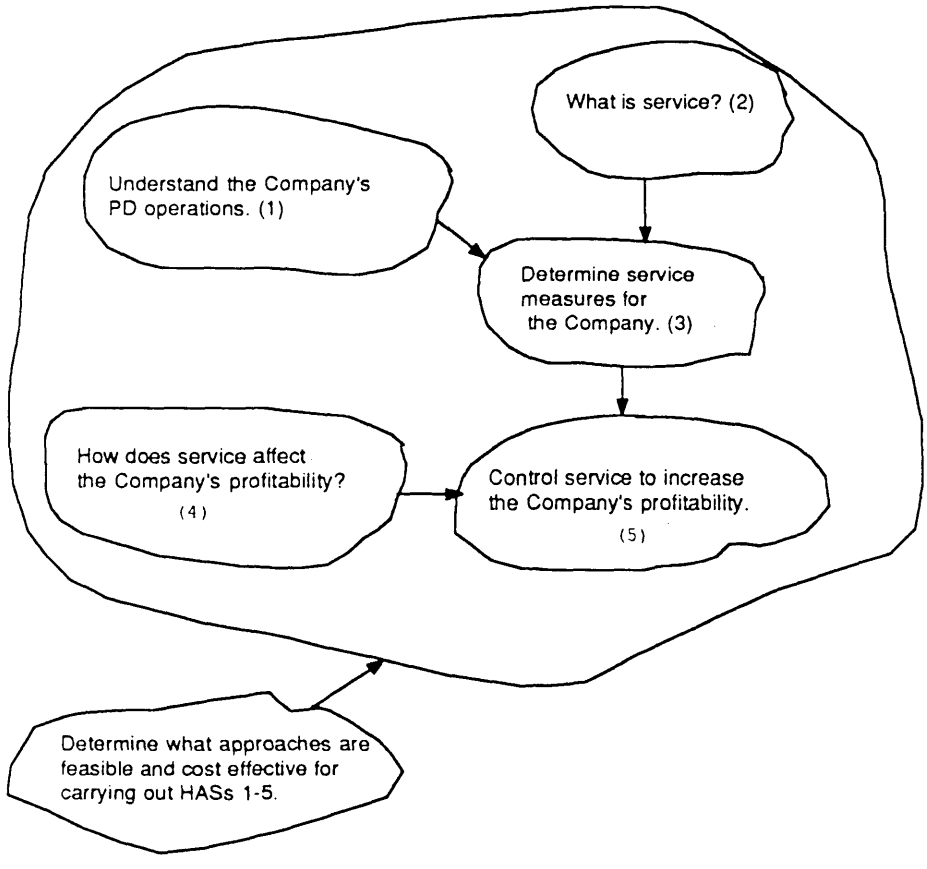
3) Identifying the service being generated.

4) Defining how service affects profitability.

5) Control the service so as to increase the company's profitability.

6) Understand what is possible and financially viable when controlling service.

Fig 3.7: A diagram showing the conceptual model generated for the participating company.



Consultations were then held with the company to ensure that these HASs were the ones felt to be required to solve the apparent problem.

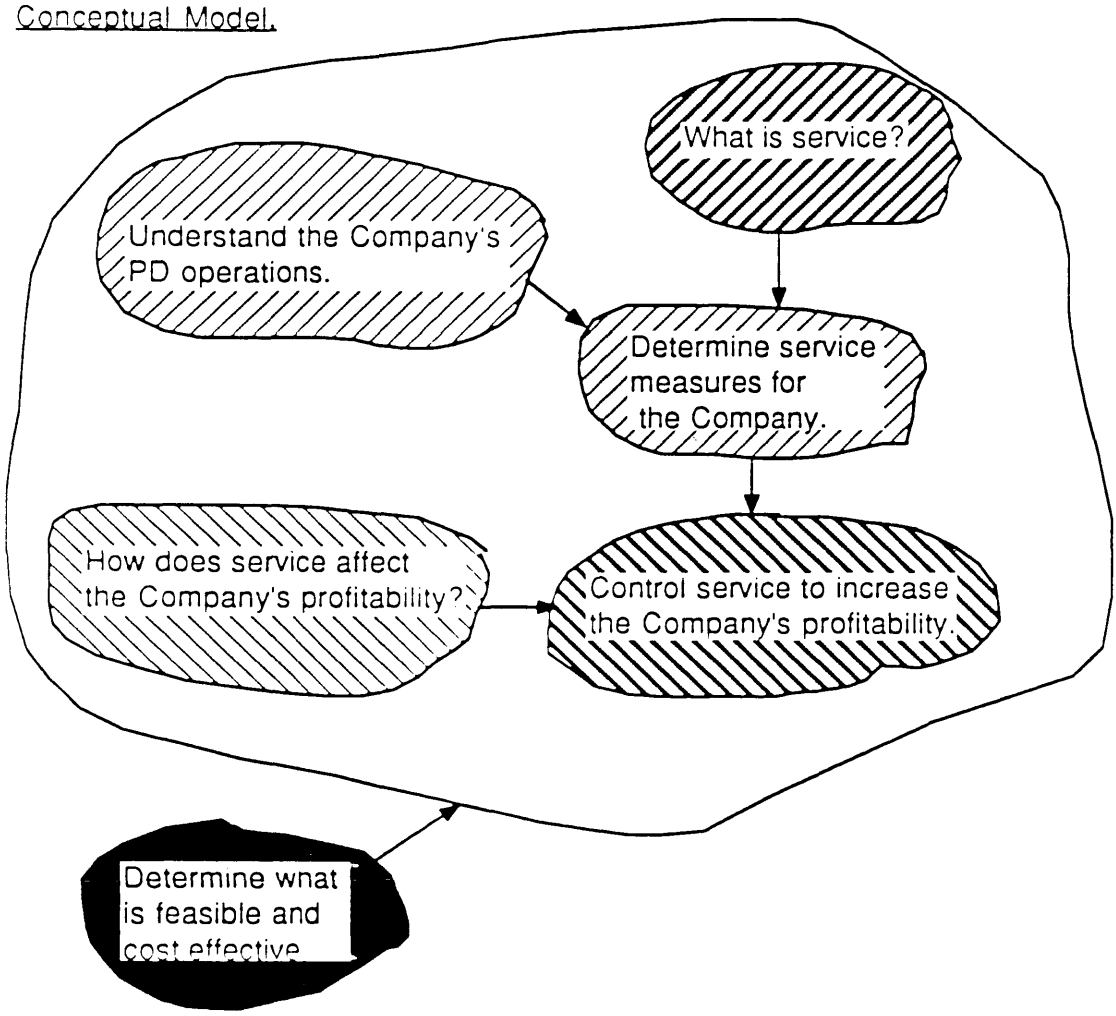
Fig 3.8: A diagram showing the cross referencing between the root definition and the conceptual model generated.

Root definition.

A system which controls the service of the Company's PD system in a way which increases the profitability of the whole system.

Any control systems used have to be both feasible and financially viable.

Conceptual Model.



3.3.3 Checking against the HASs required according to the literature.

The above 6 activities were then checked against the HASs defined, by the literature (as in chapter 2) for controlling service to external customers (see section 3.3.1). Five of these activities were found to be missing namely:

1) Establish the relative importance of service components to the customers.
2) Identify company position on key service components relative to competition.
3) Segment the market by their service requirements.
4) Develop a program to sell the service package.
5) Test market the program.

After consultations with the participating company it was found that the last three extra activities were still considered to be useful and consequently still valid when controlling service to internal customers.

It was indicated, in chapter 2, that there are advantages associated with using different market segment. Thus, this HAS was felt part of the HAS which looks at the policy of increasing the profits associated with service and consequently is not a separate HAS.

The activity of developing a program to sell the service package was still felt to be appropriate. This is because the service benefits achieved by the customer are severely restricted if the customer does not know what the beneficial consequences of a particular service level are. For example, if a customer (such as a store manager) does not know that the stock lead times are now more consistent he may still takes cautionary action against inconsistent lead times by holding higher than necessary stock levels. Thus, there is a need for a system to inform the customers of the service level achieved and the likely effects on his own system. Again this is part of the policy to increase the profits associated with service and consequently is not a separate HAS.

If the implementation of the HASs is done in stages then it will give an opportunity to test the relative merits of the possible different ways of carrying out each HAS. (That can be done by using the 3 E test). This enables the techniques that are most useful to be chosen. Consequently this is not felt to be an actual HAS, but rather a constraint on how to carry out the other HASs.

Therefore, 6 level 1 HASs were felt to be required for controlling PD service to internal customers:

1) Understanding the company's PD operation.

2) Defining service.

3) Identifying the service being generated.

4) Defining how service can affect a company's profitability.

5) Controlling the service so as to increase the company's profitability.

6) Understanding what is possible and financially viable when controlling service.

It was considered that these HAS can be grouped into 3 main sets:

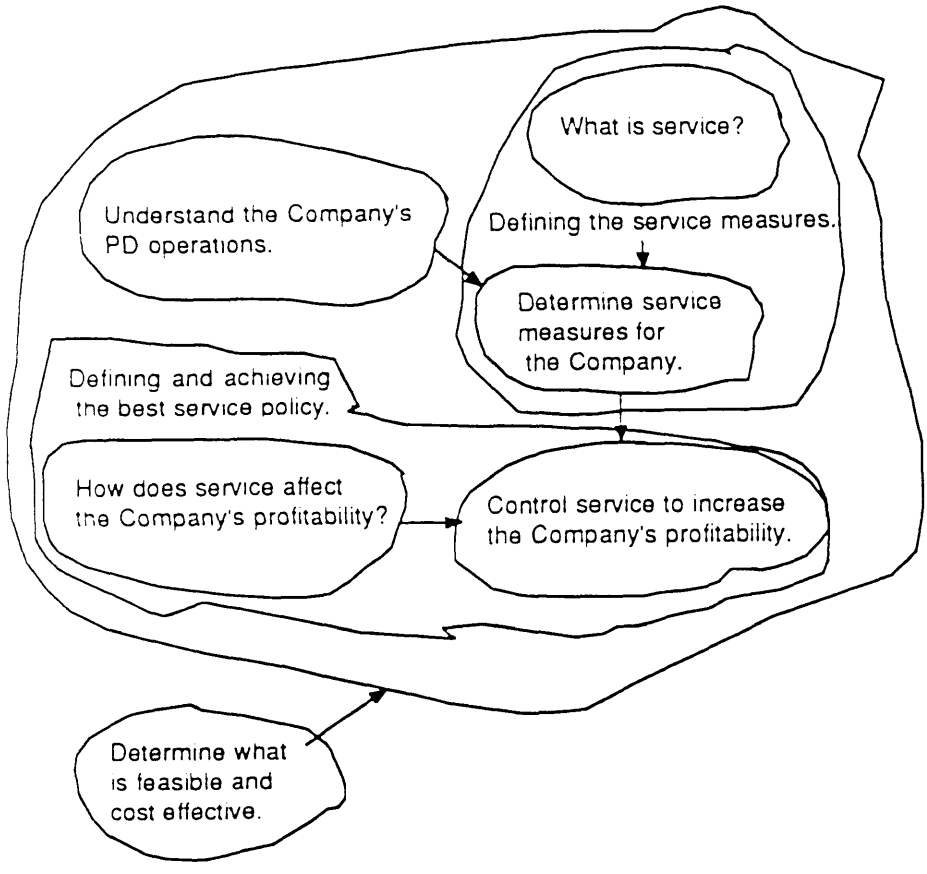
1) The HASs concerned with understanding the company's PD operations (HAS 1 above).

2) The HASs concerned with defining the service elements (HASs 2 and 3 above).

3) The HASs concerned with defining and achieving the optimum service strategy (HASs 4 5 and 6 above).

These general areas and required HASs are shown in Fig 3.9. These 3 sets of HASs are investigated in the remaining chapters of this thesis.

Fig 3.9: A diagram showing the 3 main HASs required.



Although Checkland's methodology was used to investigate these 3 HASs, where it was felt appropriate, a full description of the analysis will not be included in the thesis. Generally only the results (the determined HASs) will be stated.

3.3.4 Comment on HAS 6:

One of the HASs identified above is: "To understand what is possible and financially viable when controlling service." Understanding what is possible can be determined by knowing whether an approach for carrying out a particular HAS is efficacious. Unfortunately it is often very hard to determine the financial feasibility of each HAS. However it is suggested here that an indication of the financial feasibility of a HAS can by given by considering the HAS's effectiveness and efficiency. The cost effectiveness of a HAS will be dependent on the approach being used. The benefits of a HAS are correlated

with its effectiveness and the costs are inversely correlated with its efficiency. Thus if a HAS is highly effective and efficient, it is more cost effective/financially viable. Similarly if a HAS is inefficient and ineffective, it is less cost effective/financially viable.

It is also possible by considering the effectiveness and efficiency characteristics of a HAS to estimate how frequently a particular HAS should be carried out to be most cost effective. The more frequently a HAS is carried out the more effective it becomes (increase in the benefits) however a HAS's efficiency is decreased (increase in the costs) by using it more frequently. Consequently there is a need to strike a balance between the increase in effectiveness and decrease in efficiency associated with using a HAS more frequently. If there is not much increase in the HAS's effectiveness by carrying it out more frequently and there are high costs associated with carrying it out then the HAS is more cost effective when used infrequently. However if there is an increase in a HAS's effectiveness by carrying it out more frequently and there are low costs associated with carrying it out, then the HAS is more cost effective when used frequently.

3.4 Differences between internal customers and external customers:

The above discussion has shown that it is felt that there are 6 basic HASs required when controlling service to internal customers. The literature shows that there are 8 HASs required when controlling service to external customers.

The analysis seems to indicate that some HASs are common to both situations. However it must be stressed that although HAS's may have common labels attached to them, this does not necessarily mean that they are the same HASs. The similarities and differences in these HASs for the two types of customers, external and internal, is investigated in the greater detail through out the rest of this thesis.

3.5 Summary.

This chapter has derived a methodology for carrying out the research to meet the research objectives and has used this to determine what basic HASs were felt to be required to control service to internal customers. The procedural framework for actually carrying out the research was as follows:

1) Define the HASs required according to previous studies.

2) Define what HAS are required by using Checkland's methodology with the participating company.

3) Compare results of 1 and 2 and discuss mismatches.

4) Carry out stages 1-3 until only primitive HASs are defined.

5) Use 3 E test to determine test criteria.

6) Use criteria in a case study to test approaches.

The first three steps of this above approach were used to determine the HASs required to control the service to internal customers. This showed that there are some slight differences in the HASs required for controlling service to internal customers from controlling service to external customers. It was proposed that there are 3 main sets of HASs required in controlling service to internal customers:

1) The HASs concerned with understanding the company's operation.

2) The HASs concerned with defining the service elements.

3) The HASs concerned with defining and achieving the optimum service strategy.

The following chapters will look at these highlighted HASs in greater detail.

CHAPTER 4

UNDERSTANDING THE COMPANY'S PD OPERATIONS.

4.1 Introduction:

This chapter looks at carrying out the 1st level HAS: "Understanding the company's PD operation." This needs to be done so as to be able to understand the service problems context. The service elements are dependent on the context of the problem studied. How this HAS was carried out will be discussed along with the results of carrying out the HAS.

4.2 The methodology used in carrying out the HAS.

This HAS was carried out by performing a material and information flow audit of the participating company's PD operation.

The first stage of the audit was concerned with looking at how the stock flowed through the system. The investigation then looked at the information flow associated with this stock flow. This was performed by determining what information was required, if any, to carry out each of the steps in the supply chain. The information generated by each step, such as the company's forms, was also looked at and traced around the system. The criteria of how choices in the system were made was also examined.

The boundaries of PD's responsibility were defined by looking at each step in the system and deciding if that particular step was carried out by PD staff or not. For information flows it was assumed responsibility lay with whoever produced the information.

There are high costs associated with carrying out such an audit and a relatively small increase in the effectiveness of the HAS (knowledge gained) by repeating an audit soon after one has been completed. Consequently it is proposed that this HAS is more cost effective when carried out infrequently.

4.3 Output of the HAS:

The output of this HAS was the knowledge concerning the company's PD operation. It should be stressed that the results published here are the researcher's viewpoint of the system and may not be what actually happens in reality. Also, it has been necessary to simplify the system description to include it here.

The description of the company's PD operation is split into two main parts:

1) The context of the PD system.

2) The actual description of the system.

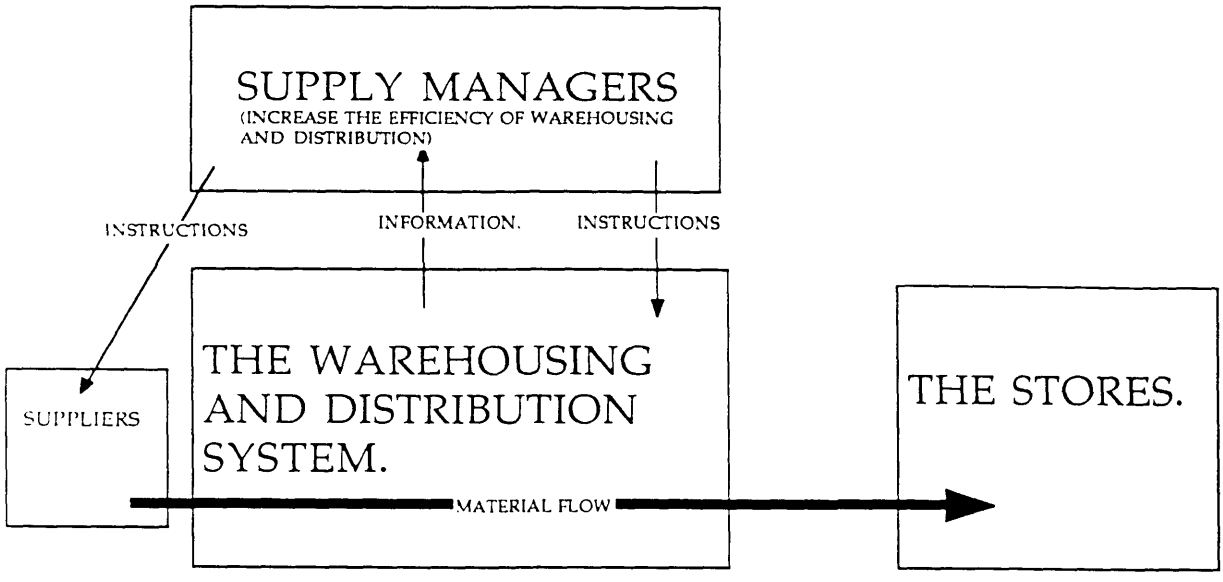
4.3.1 The context of the PD system:

'Boots the Chemists' were principally high street retailers, with around 1000 stores spread across the British Isles. These stores were separated up into various regional districts, each supplied by its own Redistribution Centre (RDC) and Common Stock Room (CSR); which were supplied from the company's central warehouses based mainly at Beeston, Nottingham. Each store was given at least a daily service from its RDC (five times a week) and also a daily delivery service from its Common Stock Rooms (six times a week). However not every merchandise line stocked by a store was delivered everyday.

Boot's inventory was subdivided into various business centres. The stock flow for each business centre was the responsibility of the business centre's Supply Managers.

Consequently, there was a high level of interaction between the Supply Managers and the PD system. The interaction of Supply Managers with the PD and supplier's system is shown in Fig 4.1. The Supply Managers also produced regular stock flow proposals, which were used by PD to estimate the amount of warehousing space required.

Fig 4.1: A diagram showing the basic role of supply managers in the company.



4.3.2 Description of system:

In Boots supply system there were principally three routes, shown in Fig 4.2 and Fig 4.3, through which stock went to stores, these were:

1) Stock was sent through the "normal" warehousing system. This involved warehousing the stock centrally and then sending it to stores through either a CSR or a RDC.

2) Stock was sent directly from suppliers to stores.

3) Stock was sent, from the supplier, semi-directly to stores - via either a RDC or a CSR.

The decision of which route stock took, was broadly based on financial criterion. This decision was made by the logistics department and the Supply Managers. These above

FIG 4 2 A DIAGRAM SHOWING THE TWO DIFFERENT ROUTES USING THE CENTRAL WAREHOUSES VIA
1) THE RDC SYSTEM .
2) THE CSR SYSTEM

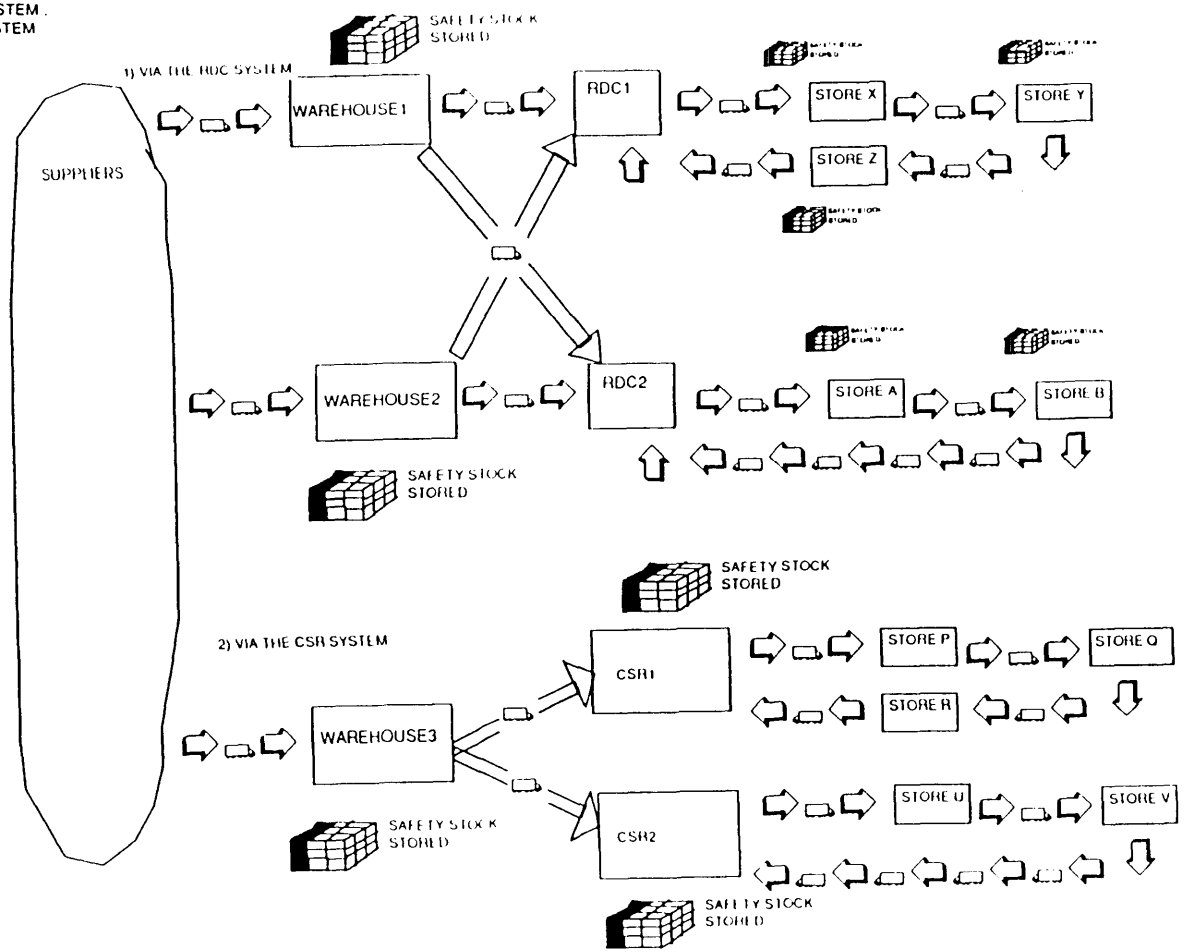
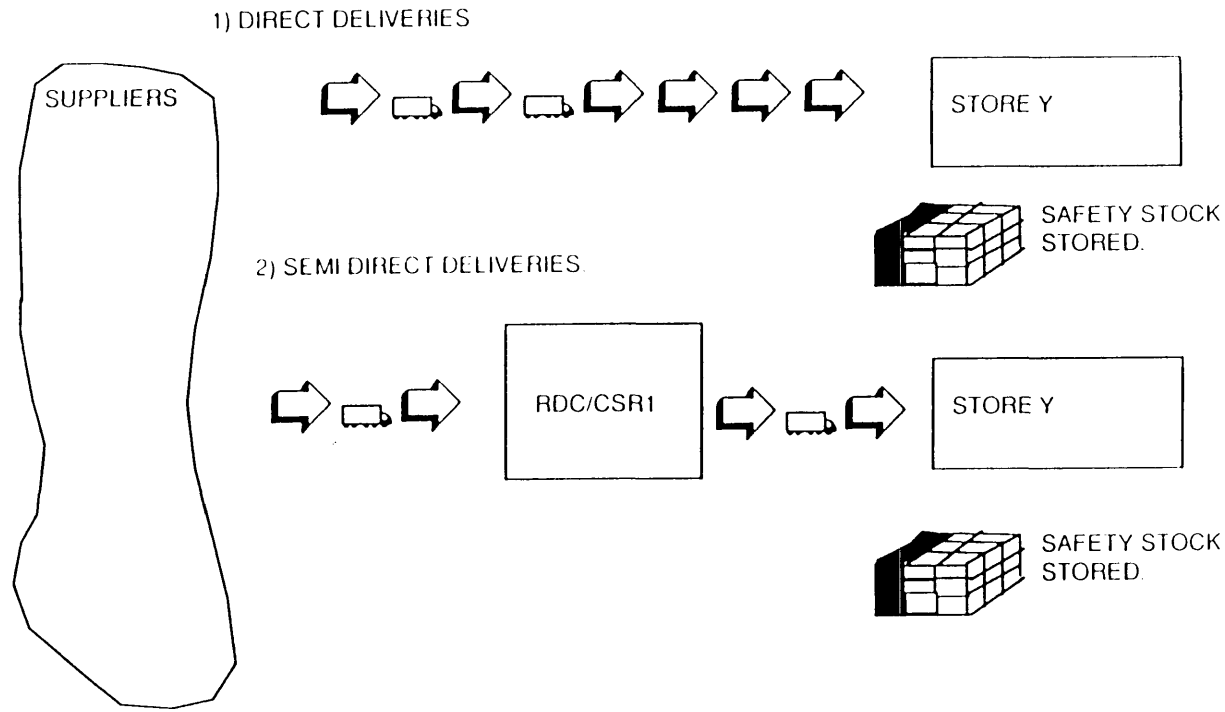


FIG 4.3: A DIAGRAM SHOWING THE TWO DIFFERENT ROUTES NOT USING THE CENTRAL WAREHOUSES
1)DIRECT DELIVERIES;
2) SEMI DIRECT DELIVERIES.



routes are described below. This is followed by a description of the ancillary operations of the PD system.

The different routes taken by the stock.

Routes 2 and 3, indicated above, taken by stock to get to stores, are easier to explain with reference to route 1. (As they were simplified versions of this first route.) For this reason the more complicated route is described here first.

1) Route 1: The description here is split into three main sections:

A) How the stock was moved.

B) How the stock was ordered.

C) The different types of stock priorities used.

A) How the stock was moved.

This discussion is based upon the flow diagram shown in Fig 4.4. The description of this flow diagram is split into 4 basic parts:

a) The requirement of stock.

b) The central storage of stock.

c) The picking of stock.

d) The transportation of stock.

These divisions are quite arbitrary chosen, to make the system's description easier and in reality did not exist. However, these subdivisions do broadly represent the divisions of responsibility that were used by the company. The first subsystem was broadly the responsibility of the company's Supply Managers and Buyers, however, they also needed support, such as accurate computer stock levels, from the company's

Fig 4.4: A diagram showing the Participating company's material and information flows inside their PD system.

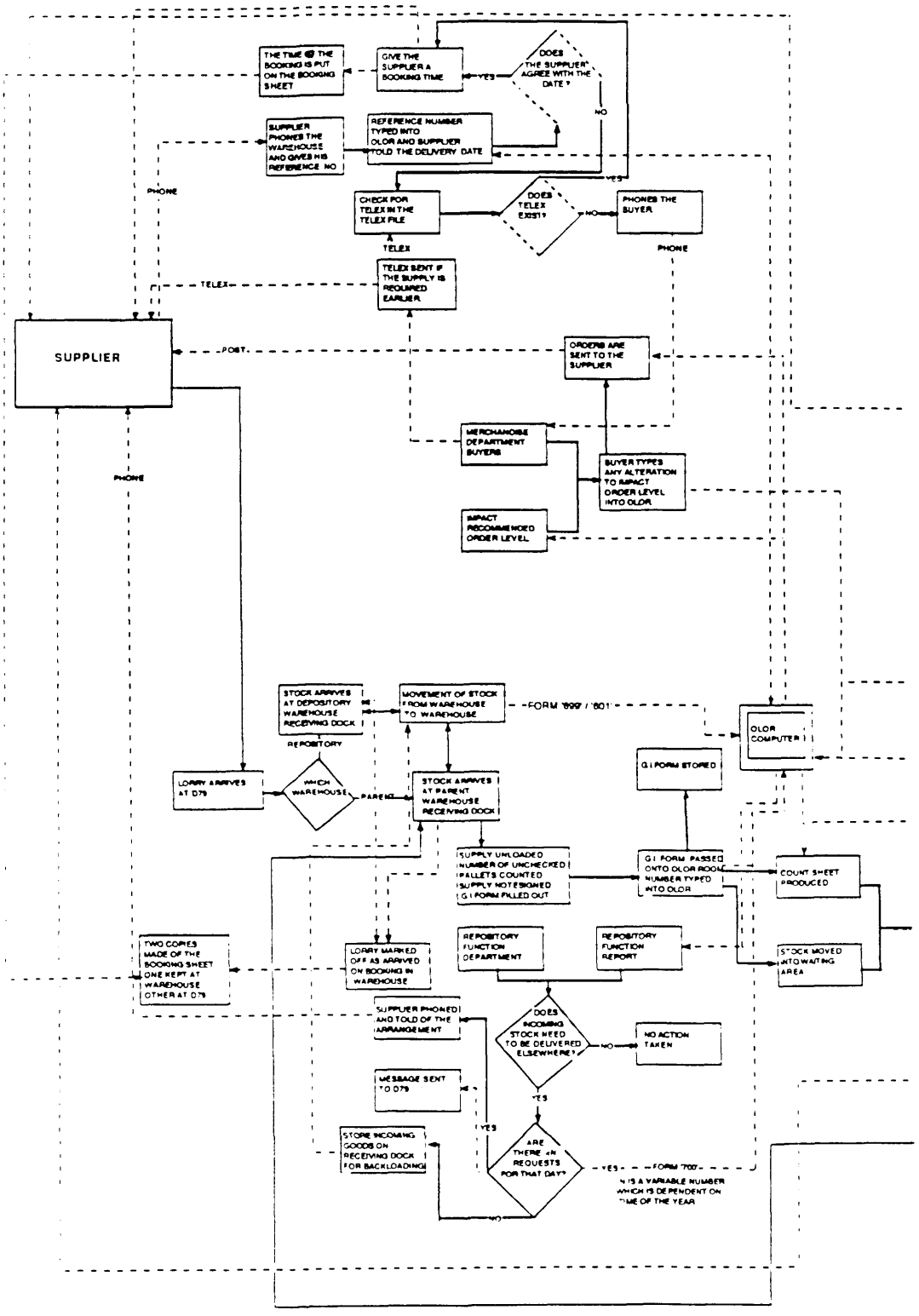


Fig 4.4 (cont) : Diagram showing the Participating company's material and information flows inside their PD system.

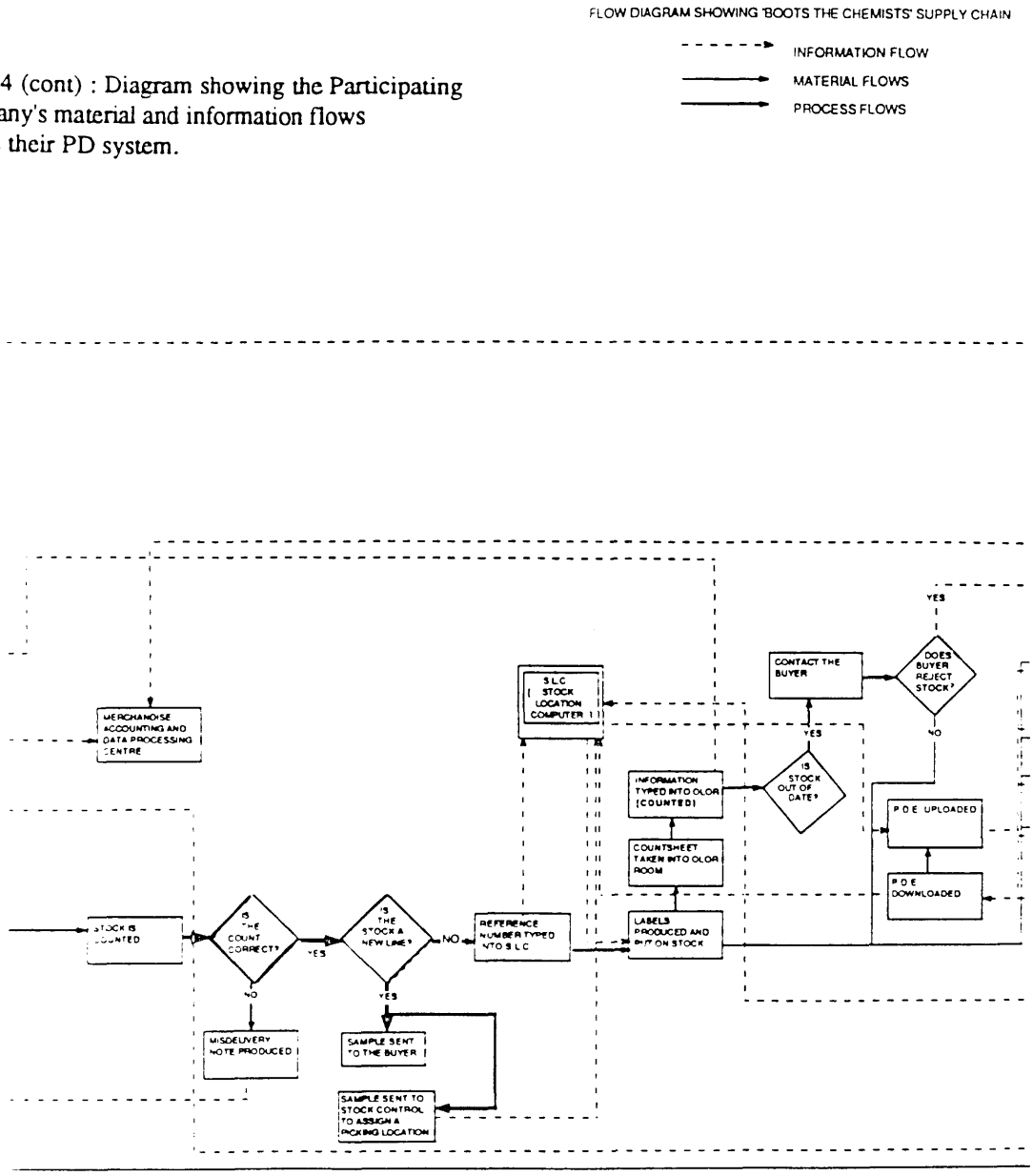


Fig 4.4 (cont) : Diagram showing the Participating company's material and information flows inside their PD system.

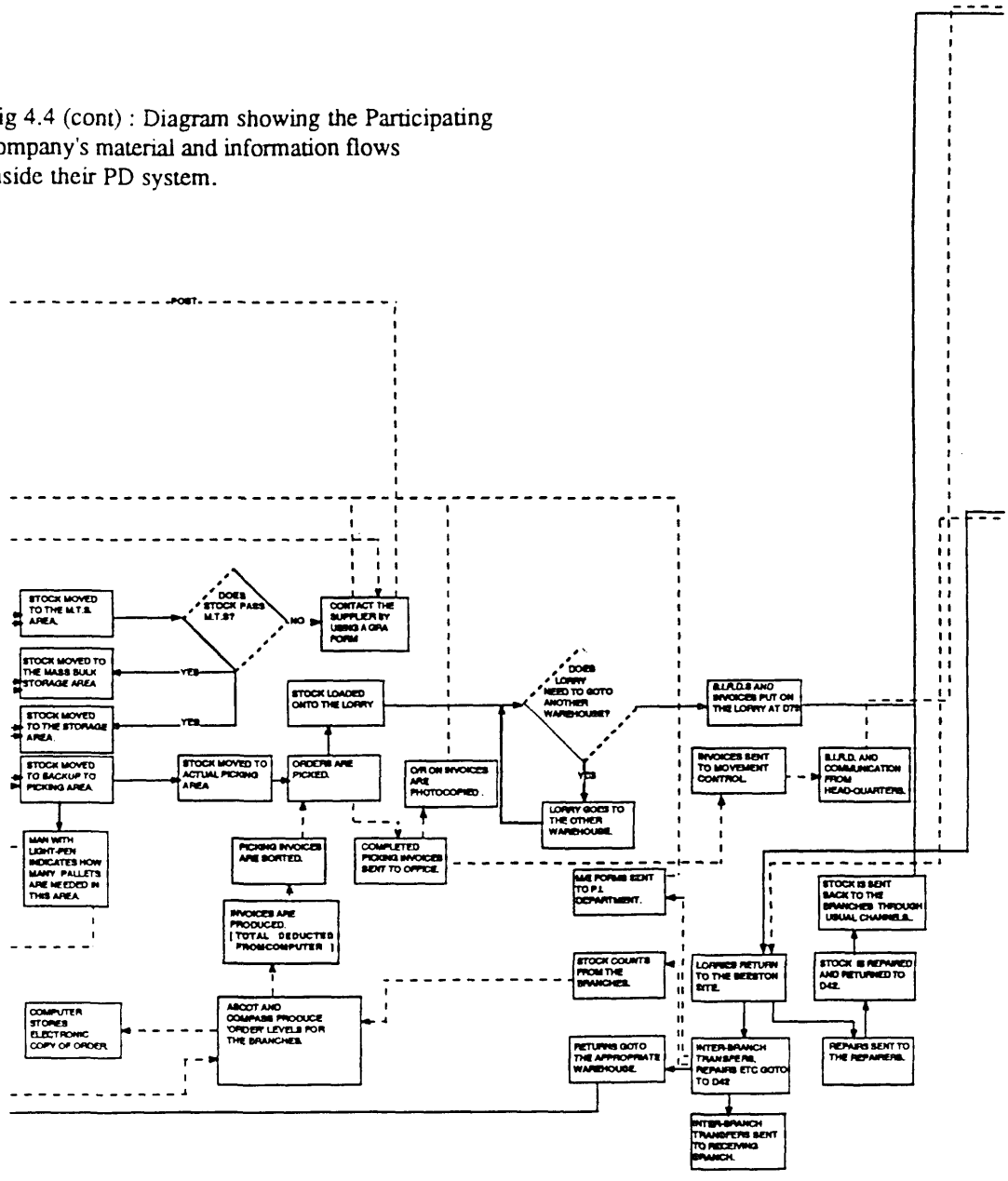
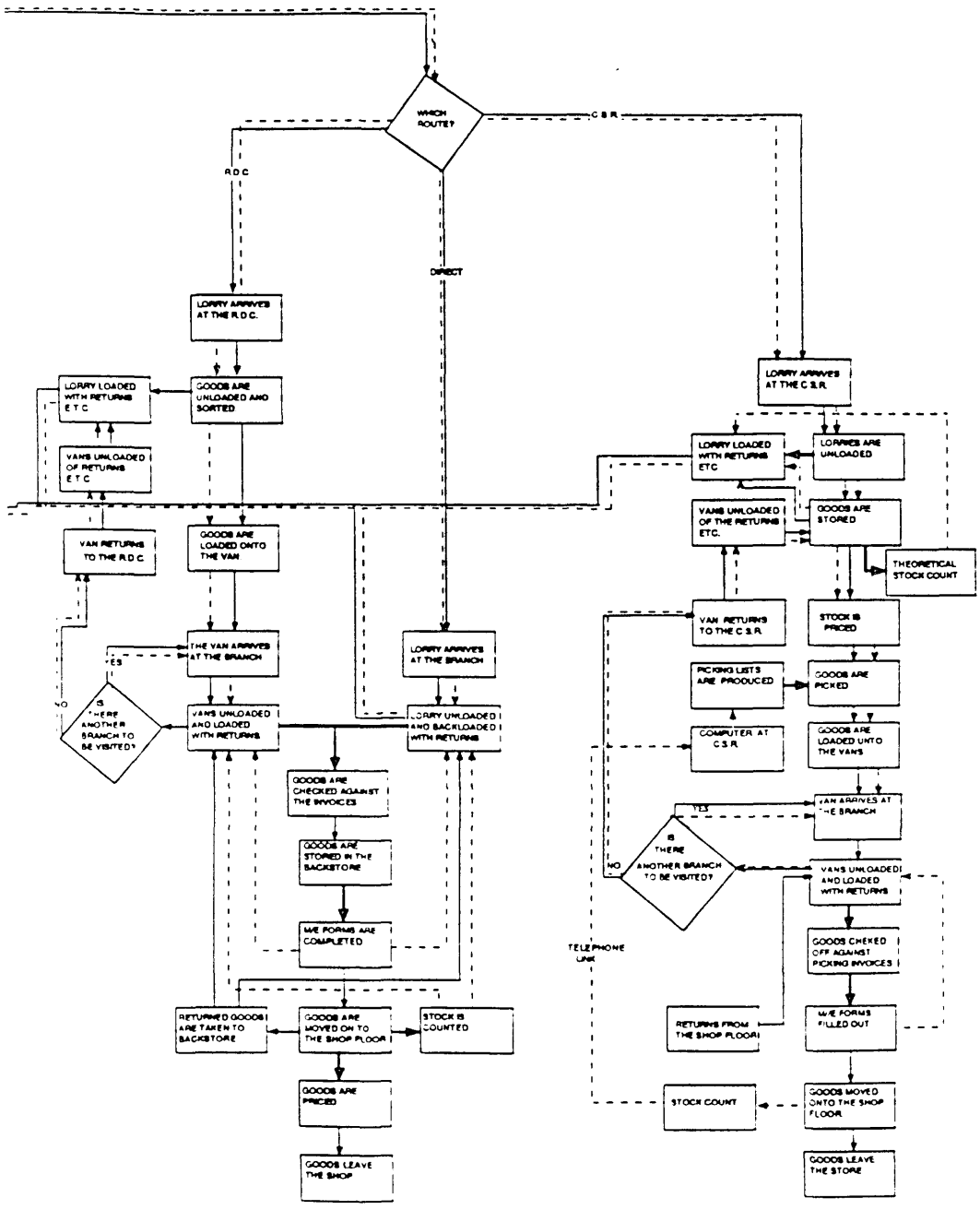


Fig 4.4 (cont) : Diagram showing the Participating company's material and information flows inside their PD system.



warehouses. The second and third subsystems were broadly the responsibility of the company's warehousing function. The fourth subsystem was broadly the responsibility of the company's distribution function .

a) The Requirement of stock: This part of the system was concerned with minimising the chance that the supply chain ran out of stock, whilst at the same time trying to minimise the company's total stock holding levels. This was the Supply Manager's responsibility, as they controlled the stock flow into the system. They did this by telling suppliers, when to supply stock and how much to supply. To do this effectively, Supply Manager needed the following information:

I) The likely demand for this particular line?

II) The warehouse's current stock levels.

III) The required service level.

A computer worked out, for Supply Managers, what it considered the best stock order level and order date to be. These advisory levels were automatically ordered, by post, unless a particular Supply Manager decided to change them. An electronic copy of these orders was stored in the 'on line order retrieval '(OLOR) computer. For new merchandise lines a similar procedure was used but with the orders being worked out by merchandise buyers.

When a supplier received an order; he telephoned the warehouse's receiving dock stating his order delivery date and order reference number, which was then typed into an OLOR terminal. The delivery date specified by the Supply Manager, then appeared on the terminal's screen. If the two dates agreed, the supplier was given a booking in time for the warehouse's receiving dock for that date, or the nearest date afterwards with a vacant booking in time. Booking in sheets were used to

even out the receiving docks workload.

b) The central storage of stock. When a supplier's lorry arrived at the Beeston site, the driver reported to the movement control building. He waited, in the lorry park, until a space in the appropriate warehouse's unloading bay became vacant. This warehouse may either have been the parent warehouse (the stock's normal warehouse) or the repository warehouse (the overfill warehouse). The decision of which warehouse stock was delivered to, was made by the parent warehouse's repository function. The basis of this decision was: If there was enough stock already in the parent warehouse, to cover a sufficient number of days stock demands, then stock was sent to the repository warehouse. Otherwise, it went to the parent warehouse. An ancillary function of this department, was to manage the stock transfer from repository warehouses to parent warehouses and vice-versa. Thus, if this department was not functioning effectively there was a resultant decrease in order fill rate achieved in the warehouses.

On arrival at the warehouse's receiving dock the trailer was unloaded. After the number of unchecked pallets had been signed for, the order reference number was typed into an OLOR terminal. The order details contained in the OLOR computer memory, were printed out on a count sheet. Meanwhile the stock had been moved to the warehouse's holding bay. The stock quantity was checked by comparing the actual amount, by sampling the pallet's contents, against the ordered quantity, indicated on the count sheet. If there were contradictions then a misdelivery note, stating the nature of the error, was sent to the supplier.

The next step was to find a free storage location for each pallet of stock. This task was generally performed by the warehouse's stock location control (SLC) computer. A printer produced labels showing the storage location and stock

reference number, these labels were stuck on the pallets. The stock was then moved, by fork-lift trucks, to the location indicated on the label. The fork-lift truck drivers confirmed, by using their portable data entry (PDE) machines, that the stock had been moved. The PDEs were downloaded into the SLC computer and the orders given for the driver's next set of duties. There were 4 areas where stock was moved to:

I) The MTS storage area. This area held stock awaiting MTS (Merchandise Technical Services) inspection. MTS was a department which checked the quality of certain specified lines entering the warehouses.

II) The main storage area.

III) The bulk storage area, where bulk items were picked.

IV) The stock picking area.

All stock in the main storage area, was eventually moved to the warehouse's picking area. The main storage area was used to provide a buffer to stop the picking area getting over crowded with stock.

c) Picking the Stock: Due to the different physical properties of different warehouses and also the different characteristics of stock warehoused in them, the picking techniques varied from warehouse to warehouse and even inside a particular warehouse. However, the basic outline of the picking procedure was: Stock, in the picking area, was picked against picking invoices and this stock was sent either, on a pallet or in a towntray or in a rollcage. These picking invoices, which represented the store orders, were produced by a computer system known as merchandise accounting. If however a picker tried to pick a certain line and there was none of it in the picking area, then an 0/R was marked on the invoice. These invoices were photo-copied and sent to the data processing centre to alter the computer stock levels.

The stock was then moved to the warehouse's dispatch dock and usually loaded on a lorry going to the RDC. However, sometimes stock was left on the warehouse's dispatch dock, for 24 hours waiting for a lorry. This happened when either stock was picked too late, or a lorry overfill occurred and the amount left over, did not justify using an extra lorry.

d) The transportation of stock. There were basically 3 routes that stock took to get to stores from the warehouse's receiving dock:

I) Stock was sent via a CSR to stores.

II) Stock was moved to a RDC and hence to stores.

III) Stock was sent directly to stores.

I) Stock was sent via a CSR to stores. CSRs were regional warehouses, which held the back store safety stock for about 2000 of the highest volume selling lines for each store in their region. Consequently, these stores did not hold any safety stock, for these lines, other than that was on the shelves. This reduced the space needed at stores, and by combining safety stocks, reduced the company's stock levels.

A stock delivery occurred daily from each CSR to their respective stores. However, not every CSR line was delivered every day, to every store. The frequency, of a particular lines delivery, was dependent on its sales volume for that particular store (higher the sales volume the more frequent the delivery). The store's stock levels were counted, the working day before a delivery, with this information being transmitted, electronically, every evening to the CSR's computer. When stock arrived at a store it was moved, directly to the stores shop-floor. A sample of stock was then checked off against the picking invoices.

II) Stock was sent via a RDC to stores. The reason why RDCs were used was to enable stock going to stores to travel as far as was economically viable in larger, cheaper, vehicles. These loads were then broken down, at the RDC, into van load quantities and sent to stores using smaller vans.

Each working day many lorries, often with stock from more than one warehouse on board, came to each RDC from the central warehouses. The stock was then sorted into different stores and loaded on the appropriate vans. These vans then called at the stores on their route, stock was unloaded and various returns and paperwork from the store put on the van. The van routes were constant, to ensure consistent store delivery times. When stock arrived at a store, various items of paperwork were performed, including recording arrival time and number of pallets, towntrays and rollcages delivered in the goods in transit (GIT) book. The stock was then checked off against the picking invoices and moved to the store's back storage area and hence to the shop floor. On returning to the RDC the vans were unloaded and the store returns loaded on lorries returning to the Beeston site. Whenever possible, these lorries were backloaded with supplier's stock being sent to Boots.

A CSR region was often very similar to a RDC region, consequently, CSRs were often twin located with RDCs, this enabled a higher lorry and van utilisation to be achieved.

III) Stock was sent directly to stores. This was an exception to the rule of the above RDC system, when the stock quantity going to a store merited a complete lorry to itself. Consequently, it was cheaper to deliver

straight to the store rather than trunking via the RDC system.

B The order generating systems used at Boots.

There were two types of stock demands the warehouses had to met:

a) The demand for new lines or promotions of existing lines.

b) The demand generated by the ordering techniques used by stores.

These stock demands are described below:

a) The demand for new lines or promotions of existing lines. This system is too complicated to explain in full here. The stock quantities were set to meet expected demand plus a safety stock margin plus display stock. The stock quantity were shown on picking invoices produced by the merchandise accounting computer.

b) The ordering techniques used by stores. There were several different ways that stores ordered stock:

I) ASCOT orders.

II) COMPASS orders.

III) Hotline orders.

IV) Dispensary ordered stock.

V) Catalogue ordering.

VI) Special order forms.

I) ASCOT ordering was the most commonly used technique in the company. The calculations that were used to get the sales forecast are complicated but briefly: The technique used store's stock level counts, carried out every 4 weeks, to discern the store's sales level. These sales

levels were then used, after eliminating seasonal weightings, in a forecasting system. The resultant sales forecast were then adjusted back for seasonal factors. The stock level shown on invoices were: The sales forecast plus the safety stock required, for a specific service level, minus amount of stock already in the store.

The CSRs were considered, by ASCOT, to be massive stores. The CSR's stock levels were sent to the data processing centre and the order levels worked out as above. A similar technique to ASCOT was used at each CSR to work out the store's demand for CSR supplied stock.

II) COMPASS ordering technique was very similar to ASCOT but was used for ordering seasonal lines. As a result the store's stock counts were performed more frequently.

III) Hotline ordering technique was an ordering technique that should have been used, as the last resort, by store managers when ordering stock. The stores phoned up Head Office, where their orders were accepted and processed. The picking invoices, if stock was available, were produced in the warehouse.

IV) Dispensary ordering technique. Every Boot's store had an ordering terminal originally used for ordering dispensary items. This system was extended to cover all Boot's lines, enabling extra stock orders to be placed. It should be noted that this system was introduced at the end of the research period.

V) Catalogue ordering was a system for stores who did not stock

certain items, to order them, following public demand. This scheme was only being tried out in certain areas of the country.

VI) Special request form reordering technique was a system for stores to order a special delivery of stock. During the course of the investigation, this system was replaced by other special request systems, such as Hotline ordering and dispensary ordering technique.

C) Different types of stock priorities.

There were two distinct classes of stock:

1) First class stock, which was high priority stock, the warehouses picked within a day of invoices being produced.

2) Second class stock, which was lower priority, the warehouses took up to two days to pick these items.

There was also a classification of stock, referred to as FOCUS stock, which the company tried to give a higher attention to in terms of service given to the general public. This stock was always classified as 1st class.

2) Route 2: In this case, instead of suppliers sending stock to the company's warehouses they delivered it directly to the stores. Thus, the company saved the storage and transportation costs. However, there were associated penalties: The supplier generally charged more for the stock because of supplying to more locations, and there was the need for each store to hold all of its own safety stock.

3) Route 3: This delivery route for both moving stock and ordering it was identical to route 1, except that suppliers delivered stock to a RDC or a CSR and which was then

sent to stores on the delivery vans.

4) Ancillary operations of the Physical Distribution system.

There were several operations carried out by PD which were not directly related to the movement of stock to stores.

A) Inter-store transfers. This involved the movement of stock from one store (with excess stock) to another store (with stock shortages). The stock was sent to the donor store's RDC and then to the recipient store, if in the same RDC district. If the two stores were in different RDC areas, the stock was sent centrally and loaded on a lorry bound for the recipient store's RDC, where it was sent to the store. Where possible stock was re-routed inside the same RDC region. Inter-store transfers were under the responsibility of the Supply Managers.

B) The return of town-trays and Roll-containers. It was distribution's duty to bring back used Town-trays, Roll-cages and Pallets, from stores and RDCs, for reuse.

C) Customer repairs from stores were often sent centrally and then to repairers and once repaired, back to the stores.

D) Invoices being sent to the stores: The invoices for stock sent in rollcages were actually sent in the cages. However invoices for stock being sent in towntrays were sent separately. Once stock had been picked the invoices from all warehouses were sent to the movement control building, where they were sorted into stores. All invoices going to a store were placed in an envelope and sent to the RDC and then to the store. Complications, however, occurred when there was an 0/R on the invoice which then had to be photo-copied and had to catch the other invoices up.

E) Bringing stock counts back to the data processing centre. The ASCOT and COMPASS stock counts were brought back to the data processing centre from the stores.

F) 100% returns: 100% returns occurred when stock was no longer required in stores, usually due to a supplier's recall or stock being out of season. The stock was sent back through the RDCs to the Beeston site, where it was sorted and returned either to the appropriate warehouse, or stored ready to be picked up by the supplier.

4.4 Comment:

It can be seen, from the above audit results, that the participating company used a number of different strategies in supplying stock to their stores. These included:

1) The use of central warehouses.
2) The use of regional warehouses (CSRs).
3) The use of redistribution centres.
4) The use of Supply Managers.

A high number of organisations use at least one of these strategies, consequently it is considered that the research findings are of wide interest to the Physical Distribution field.

4.5 Summary:

This chapter has looked at carrying out the 1st level HAS " Understanding the company's PD operation." The HAS was carried out by performing a material and information flow audit of the company's PD operations. Due to the high costs and small increase in effectiveness of carrying out the HAS frequently it was decided that this HAS is more cost effective when used infrequently. The results of the audit indicated that the company were using a variety of supply approaches to deliver their stock. These approaches

included the use of central and regional warehouses and the use of redistribution centres. Due to the broad nature of the Company's PD operations it was felt that the results of this research are widely applicable to other organisations.

CHAPTER 5

DEFINING THE SERVICE MEASURES.

5.1 Introduction.

It was stated, in chapter 3, that an integral part of a service control system, is a human activity system (HAS) which defines the service measures.

This chapter deals with how these service measures for internal customers, can actually be identified. What actually constitutes a service measure will be defined . From this the HASs that are required to do this will be defined. Various approaches are proposed for carrying out each of these HASs. The merits, of each approach are then tested using Checkland's (1987) 3 E test (efficacy, effectiveness and efficiency of an approach) in the case study.

5.2 What activities are required?

Previous studies (such as Christopher et al (1979), Lalonde and Zinzer(1976) and Marr(1982) have not felt it necessary to identify who the service customers are. However, when discussing this matter with the participating company, it became clear that this assumes that it is known who the service customers are and this is not necessarily obvious. Consequently, there are in fact two HASs required to be performed:

1) Identifying who the customers are.

2) Identifying what the service measures are to each customer.

These two HASs are now investigated.

5.3 Identifying the customers.

As no previous work has been done on defining the service customers it is not possible to consult the previous studies. This discussion is divided into two parts: The first looks at who the service customers are, and gives some examples of possible customers. The second looks at how the service customers can be identified.

5.3.1 Who is a service customer ?

None of the previous studies on customer service have directly specified what/who constitutes a service customer. The broad definition, shown below, of who a customer is, will be used in this thesis to determine who the service customers are.

> "The customers of service are: The people, or systems, that are affected by Physical Distribution's service performance/output."

The effects of different PD systems are distinct, and often the environments which they operate in, are also distinct. This means that different PD systems have different customers. There are numerous possible service customers. Included below are a few possibilities:

1) The retailing branches of a firm (the actual recipient of the stock).

2) The production side of the company: Often raw materials are stored by warehousing and need to be quickly available for actual use. Also, accurate information concerning demand is required for production scheduling.

3) The Supply Managers of the company.

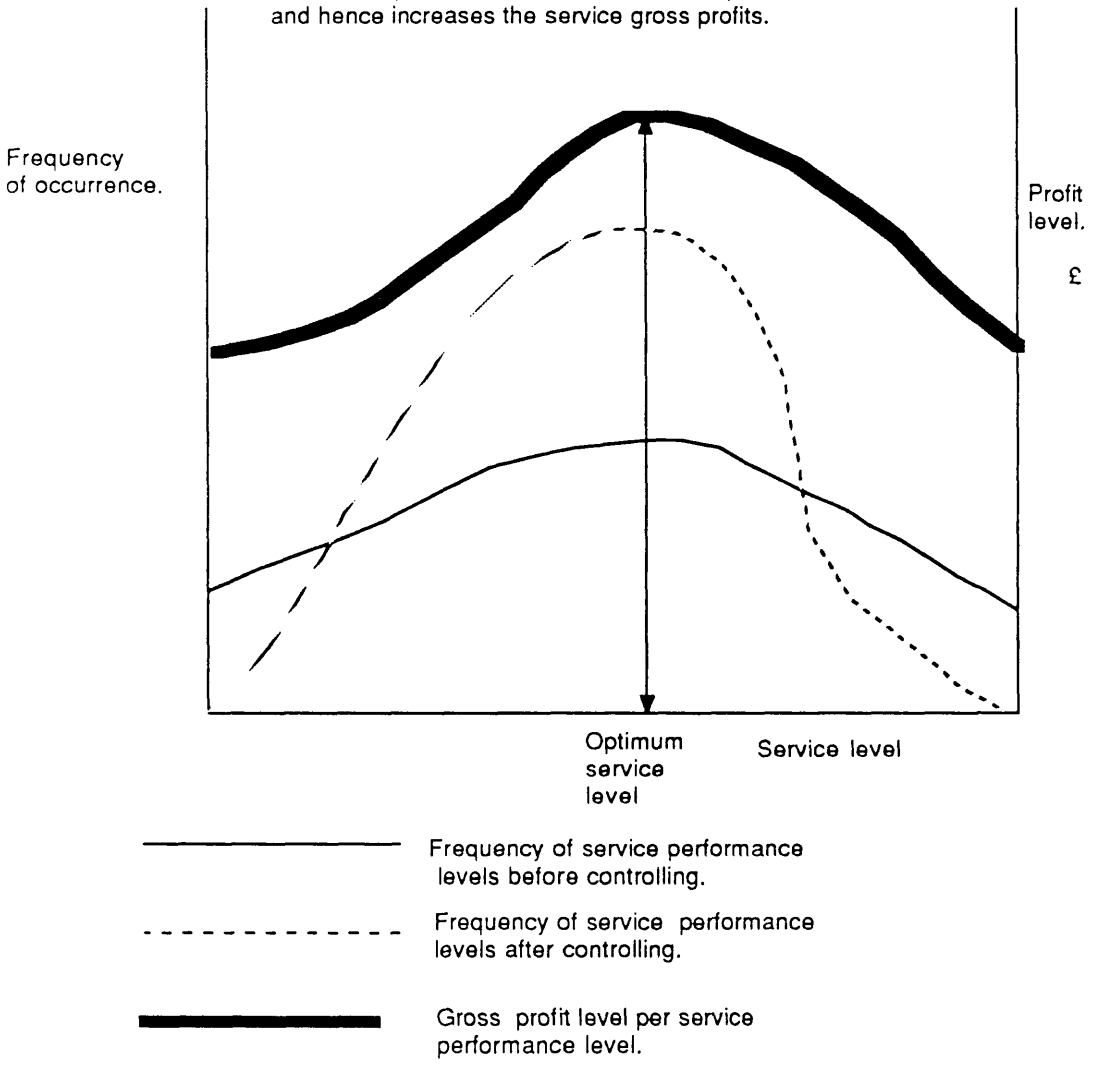
4) The suppliers of stock.

By identifying more service customers the problem domain is extended, consequently increasing the likelihood that more financially viable/productive service measures will be identified. Thus, this means that the advantages associated with controlling service are

increased.

It should be noted that a service measure's financial viability is dependent on the benefits and costs of using it. The benefits are the increases in the gross profits associated with controlling (restricting) the service performance level to the more profitable performance levels. These benefits are illustrated in Fig 5.1.

Fig 5.1: A diagram showing how a control system restricts the service performance to nearer to the optimum solution and hence increases the service gross profits.



The costs of using a service measure are associated with monitoring these are broadly related to the number of measures being monitored, and the ease of monitoring. Consequently a service measure's costs and benefits are difficult to determine until the HASs for evaluating and controlling the service measures, have been investigated and the service control system actually implemented. This means that the system is a learning one

which determines which of the monitored measures are actually financially viable.

5.3.2 Various ways of identifying the customers.

Two approaches are suggested below for defining the service customers.

1) The use of material and information audit results: There are two channels by which the effects of PD's service can be transmitted to customers, namely, the material flow and the information flow channels. Thus, by looking at the information and material flow emanating from PD, and determining the recipients of these flows, it is possible to identify the customers. This can be performed by carrying out an audit of the organisation's material and information flows, such as was described in Chapter 4.

2) The use of brainstorming techniques: Customers can be defined by using 'brainstorming' techniques, such as Nominal Group Technique (Delbecq et al (1975)), with PD personnel.

5.4 Service measure identification.

There are two parts to this discussion: Part one, looks at what is a service measure and the differences between internal and external customer service measures. Part two looks at the techniques that can be used, for identifying internal customer service measures.

5.4.1 What is a service measure?

In chapter 2 it was demonstrated that customer service couples the PD system to the customer's system. Also it was argued that the service measures belong to an abstract

system, which is outside both the PD system and the customer's system. Thus, a customer service measure can be thought of as being a link through which the two system's performances are coupled together. This linking occurs when a service measure is affected by one system performance and then affects the performance of the other system. Consequently, a PD customer service measure can broadly be seen as being:

> "An activity which is affected by PD and has an effect on the customer's operations."

The above definition is clearly applicable whether the customer is internal or external. However it is equally clear that different service situations will arise with different customer operations and PD systems. Thus it is important to ensure that a paericular service measure is relevant to a situation before it is used.

5.4.2 Techniques for defining the service measures.

Unfortunately, it is not easy to design a system which always guarantees to identify every relevant service measures (that is the financially viable ones) to a particular situation. However, an attempt can be made to define as many of these service measures as possible. The basic approach used in this thesis is, therefore, to generate as many measures as possible in an attempt to avoid missing any relevant measures; then try to reduce these down to those that are useful and financially viable. Included below are a few approaches that can be used, singly or collectively, to generate service measures for internal customers. The techniques described are split into two sections: The techniques that have been previously described in the literature, and the techniques that are unique to this thesis.

1) Previously described techniques. In chapter 2, several techniques for generating service measures taken from the literature, were described these are:-

a) Kelly's repository grid technique (Kelly(1955).

b) Nominal group technique (Delbecq et al (1975)).

c) Use of literature survey results.

Kelly's repository grid technique requires at least three sources of service. As internal customers generally receive service from only one source, it is therefore impossible to use this technique.

It is still, however, possible to use Nominal Group Technique which is a brainstorming technique. This can either be used with PD and the different customers separately or used with them together. Often, it is also possible to ask people outside of the problem to define service measures. Doing this often results in unique, unconditioned, measures being generated.

Another approach is the use of literature survey results: It has been indicated that whether a customer is external or internal, has little effect on what constitutes a service measure. This means that service measures identified in the literature may still be relevant. However, a check has to be made to ensure a measure is still appropriate to the situation being investigated. Further more any general measures must be made relevant by translating them into the terminology of the context.

2) Techniques not previously described. Shown, below, are several approaches that have not been suggested, in the literature, before.

a) **Using material and information audit results:** It has already been suggested (in section 5.3.2) that the service effects are transmitted through the material and information flow channels. These flows can be identified by carrying out a material and information flow audit. By considering information in terms of its accuracy, age, and the time the customer has to respond, it is possible to identify service measures. Similarly, by considering material flow, in terms of the flow

rate, it is possible to highlight further service measures.

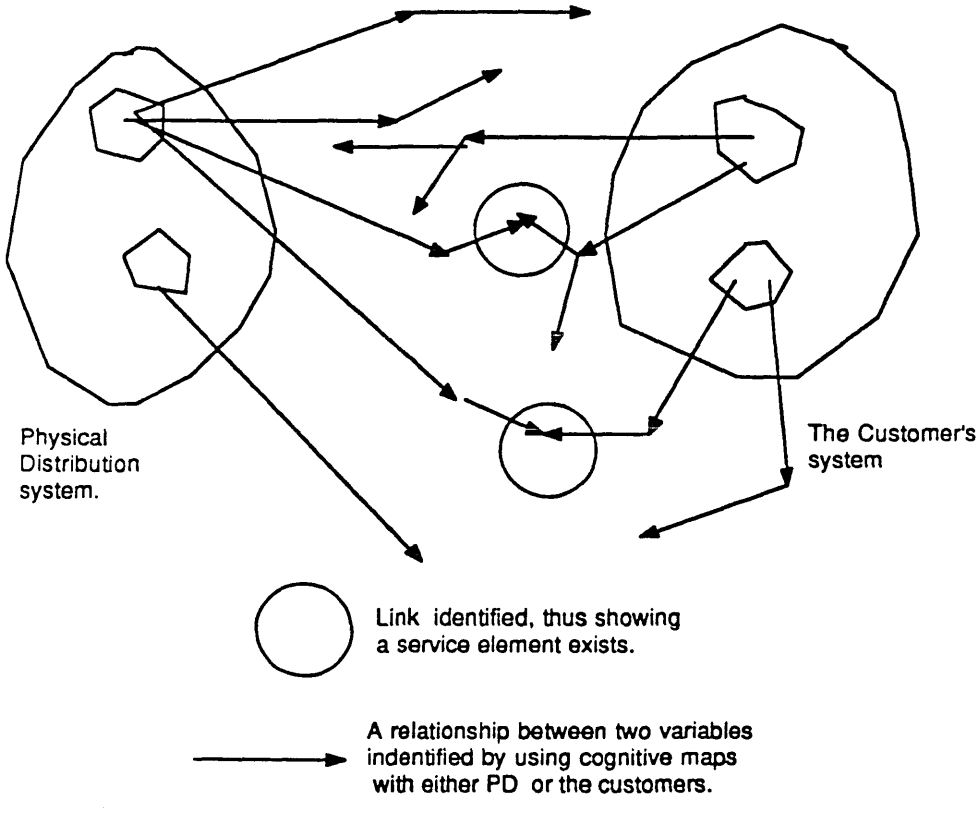
b) Use of cognitive mapping: From the definition of a service measure, contained in section 5.4.1, it can be seen that service affects the customer's operations, and is affected by PD. Thus, by looking at the effects of PD and what affects the customer's operations, it should be possible, by highlighting any crossovers, to identify service measures.

Various views, weltanschauungs, of the customer's system function, and the activities involved in carrying out these functions, can be adopted. With the aid of Eden's (Eden et al (1983)) cognitive mapping, the factors affecting the customer's activities can be highlighted. It is also possible to work forward from the PD system, using cognitive mapping, to look at the effects of PD's activities. By consulting the resultant cognitive maps the common areas linking the two systems together, can be identified, resulting in a service measure being identified. This process is visually demonstrated in Fig 5.2. Due to this method working forward from the PD system and backward from the customer's system it will from now on be referred to as the backward-forward link method.

c) Gaining first hand experience: It is also possible to identify service measures by gaining first hand experience of how PD's operations affect the customer's operations.

3) Summary of techniques. In summary, there are some differences in the techniques that can be used for identifying service measures to internal customers from those that can be used for external customers. (For example Kelly's repository grid technique can not be used with internal customers) Five techniques have been proposed for generating service measures for internal customers. These are shown below:

Fig 5.2: A diagram showing how the backward-forward link method works.



1) The use of nominal group technique.

2) The use of service measures that have been identified in the past.

3) The use of the results of an information and material flow audit which indicates the material and information flowing from the supplier to the customer.

4) The backward-forward link, which uses cognitive mappings to match the effect from the PD system against the influences in the customer's system.

5) Experiencing the effects of PD's operations first hand.

It is assumed, that all the above techniques can also be used for determining service measures for external customers. However, there may be problems, associated with the last three techniques, due to their heavy involvement with the customer's system.

5.5 Reducing the number of service measures.

Initially a large number of service measures can be generated by using the above techniques. This will increase the likelihood that useful (financially viable) measures are included but will also produce a list of measures which needs pruning. There are three main reasons for pruning the number of measures. Firstly, Miller (1956) points out that there is a limit to the number of measures that a controller can manage. This limit is between 5 and 9 measures depending on the circumstances. Secondly, any measures not financially viable should be deleted for reasons of cost. Thirdly, any measures that can be regarded as unnecessary should be removed. A reduction in the number of measures here will lead to a reduction in the workload at a later stage.

The following four approaches are felt to be useful in reducing the number of measures, without involving exhaustive cost and benefit analysis.

1) Making sure that the defined service measures are actual service measures and not service responses-a service response is part of PD, which affects the service measure.

2) Determining the service measures not actually under the control of PD.

3) Combining together of similar measures, to form more comprehensive measures. When two, or more, measures are similar in nature (i.e. in their effects), then often the profits associated with any level of service are also similar. In this case by combining together there is often a reduction in the monitoring/ controlling costs but with limited reduction in the benefits.

4) Using conjoint analysis. It was shown, in chapter 2, that conjoint analysis is a technique which has previously been used to determine the relative importance of

service measures to the customers. (For examples of using this technique see Christopher(1983) and Marr(1982)). This enables less important measures to be discarded.

5.6 Updating the system.

Which service measures and customers are actually relevant and viable will change as the system changes. Thus, there is a need to continuously update the list of viable service measures. The more often this updating occurs, the more effective the HAS becomes. However, the system's efficiency is reduced due to the increase in the costs as a result of the number of times the defining techniques are used. Consequently, a balance needs to be struck between these two conflicting factors to increase the system's productivity. Unfortunately it is difficult to place a figure on how frequently the service measures should be reviewed. However, when a major system change has known to have occurred, there is usually a need for a review (due to the increased effectiveness that would occur). When performing such a review, the technique(s) which have previously shown themselves to be the most successful, tested by using the 3 E test procedure, should be used.

5.7 The 3 E test.

For both of the required HASs (as defined in section 5.2) various ways have been proposed for carrying them out. Thus, there is a need to assess the relative merit of each approach, to know which approaches are best to use when either, updating the system, or using in another similar situation.

The relative merit of each approach, can be assessed by determining how well they perform against the 3 E test. Defined below, are the 3 Es for the 2 HASs: Identifying the customers, and identifying the service measures.

The efficacy of each technique is defined by whether or not it could actually be used.

The relative effectiveness of each technique is determined by the number of service measures, or customers, that are identified compared to the other techniques. Another useful factor is the increase in effectiveness of the system that using any one particular technique generates. This can be measured by considering the number of unique measures (not produced by any other approach), or customers, that each technique produces.

The efficiency of a technique is dependent on the effort required in using it. That is, does it use up valuable resources, such as people's time and money.

The above structure, for testing the relative merits of different approaches in carrying out the 2 HASs, is shown in Fig 5.3.

5.8 Trying out the HAS in the case study.

The various techniques, proposed above, for carrying out both of the HASs, are now tested out in the participating company, described in chapter 4. This discussion is divided into 3 main parts:

1) The use of HAS for determining the customers.

2) The use of HAS for determining the service measures.

3) The 3 E test results for both HASs.

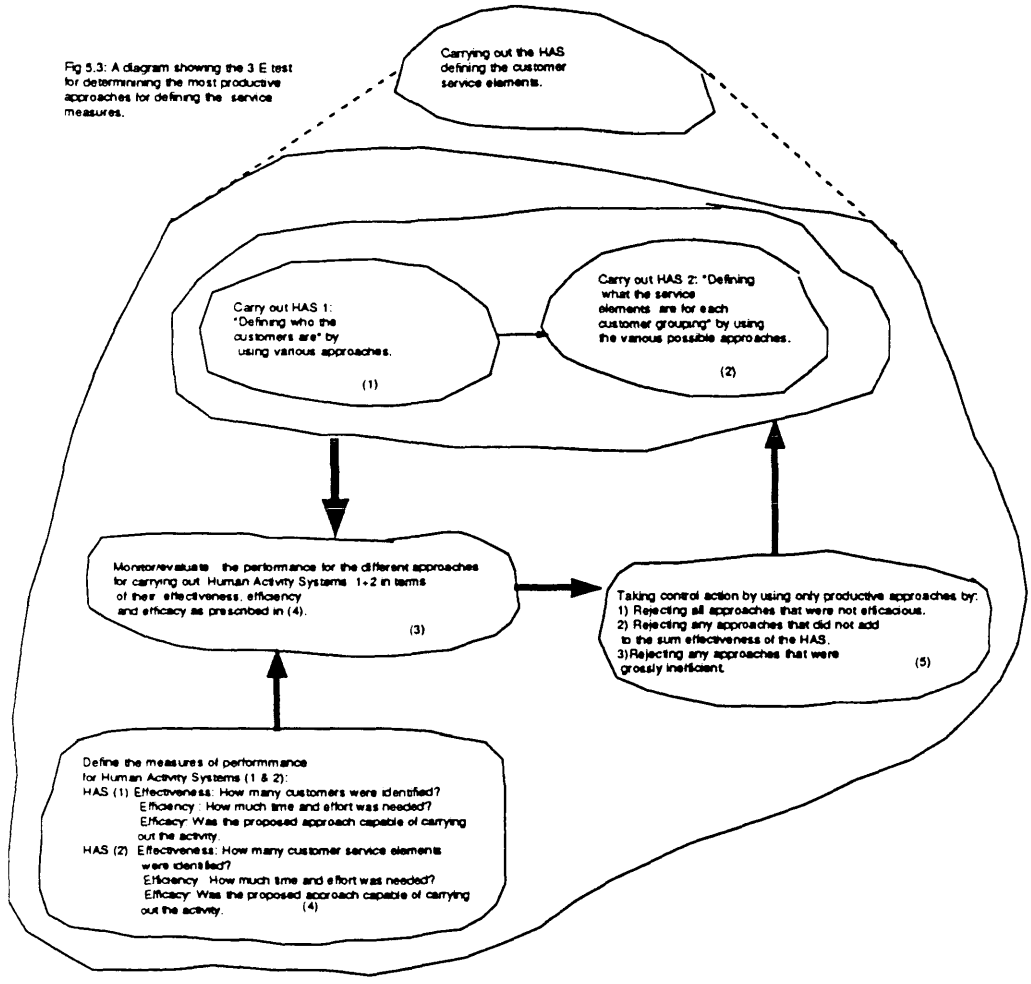


Fig 5.3: A diagram showing the 3 E test for determining the most productive approaches for defining the service measures.

5.8.1 Identifying the customers.

Both of the proposed approaches, using audit results and the use of brainstorming techniques, were used. The audit results, that were used, were those described in chapter 4. Brainstorming sessions were held with the PD personnel. Brainstorming technique determined 5 customers whereas using the audit results only defined 4 customers. This initial analysis generated 5 possible service customers, shown below:

1) The suppliers of stock to the Company.

2) The Company's Industrial Division.

3) The General Public.

4) The Company's Supply Managers.

5) The Company's stores.

It should be noted that the audit failed to identify the company's Industrial division. There was a need to check that the above identified customers were internal and important enough to consider.

The first possibility was discarded, as it was not actually part of the Company, and thus an external customer. However, it should be remembered that, good service to suppliers (such as using easy to understand ordering techniques/forms) can result in better service from them, or even price reductions.

The Company's industrial section had a low level of interaction with PD. Thus, any likely benefit of using a service control system were felt to be minimal. Also, the service to the Industrial section did not substantially affect the service to other customers. Therefore, it was felt 'safe' to ignore the Company's Industrial section, thus reducing the amount of work required.

The General Public are external customers and are consequently outside the bounds of the research.

This left two customer groupings: The Stores and the Supply Managers.

5.8.2 Identifying the service measures.

The previous section identified the internal service customers, which were present in the case study. This section looks at how the service measures were identified for these groupings, and how the number of measures were reduced.

An attempt was made to use all of the techniques proposed in section 5.3.2, for both customer groupings. A comprehensive list of the service measures, identified by each

approach for both customer groupings, can be found in Appendix B. This discussion is split into two parts: The first, looks at identifying the Store service measures; the second, looks at identifying the Supply Manager's service measures.

1) Store manager's service measures.

This discussion initially looks at how the various approaches were used to determine the service measures. From this, a grand list of identified service measures is generated. Following this, an indication is given of how the various approaches for reducing the number of service measures were used. This results in a revised service measure list.

a) How the different approaches for identifying the service measures were used and the actual results.

It proved possible to use all of the five techniques. Therefore, indicating that all were efficacious.

Approach 1: The use of brainstorming sessions. Brainstorming sessions were held with various company personnel, including PD staff and store staff. Often, known examples of service were used to stimulate ideas. This approach produced 24 service measures, with four service measures being uniquely identified, by this approach.

Approach 2: The use of literature survey results. Extensive work has been carried out on identifying customer service measures to stores. However, some of the identified service measures were found to be inapplicable in this situation. A list of the relevant service measures, and their translation into service measures, that were usable for the participating company, is shown below:

1) The Order Cycle time (Christofides and Watson-Gandy(1973), Christopher et al (1979), Lalonde and Zinzer(1976), Marr(1982) and Shycon and Sprague(1975)). This measure translated in the case study into:

a) The number of working days after the expected arrival date that 1st class stock arrived at the store.

b) The number of working days after the expected arrival date that 2nd class stock arrived at the store.

c) The number of working days after the expected arrival date that FOCUS stock arrived at the store.

d) The number of working days after the expected arrival date that CSR stock arrived at the store.

e) The number of working days taken for customer repairs to be returned to the store.

2) Availability of handling special order procedures (Christopher et al(1979), Christofides and Watson-Gandy(1973) and Shycon and Sprague(1975)) this became:

a) The number of working days taken to deliver Hot-line orders to stores.

b) The number of working days taken for stock, ordered from special request forms, to be delivered to stores.

3) The quality of packaging being used (Christofides and Watson- Gandy(1973), Christopher et al(1979), Lalonde and Zinzer(1976) and Marr(1982)) for the case study this became:

a) The level of breakages occurring.

4) The order fill-rate achieved. (Christofides and Watson-Gandy(1973), Christopher et al(1979), Lalonde and Zinzer(1976), Levy(1981), Marr(1982) and Shycon and Sprague(1975)). Which translated in the case study into:

a) The ASCOT service level.

5) Easy to read information on outers (Christopher et al (1979)) which for the case study became:

a) The ease of identifying incoming stock, at stores.

6) Claims procedures, for excess and missing stock. (Christofides and Watson-Gandy(1973), Christopher et al(1979) and Lalonde and Zinzer(1976)) which translated into:

a) The percentage of RDC stock missing.

b) The percentage of CSR stock missing.

c) The percentage of RDC stock excess.

d) The percentage of CSR stock excess.

e) The time spent filling out missing and excess forms.

7) The delivery time and its flexibility (Lalonde and Zinzer(1976)) which became:

a) Is the expected delivery time the optimum for the store?

b) The number of minutes late the RDC delivery van is.

c) The number of minutes late the CSR delivery van is.

8) Be advised promptly if a supplier is unable to, or expects to be unable to, deliver the complete order on time (Wentworth(1976)) which translated into:

a) Notification of change in delivery times.

b) The number of unexpected vans arriving per day.

It is felt that the above service measures, contained in the literature, have a tendency to concentrate on the availability and supply of stock. This is identifiable with the output of the whole company system that is the selling stock to the general public. However, there is

a secondary function of customer service, often ignored, which is: The meeting of the needs of the direct customer to reduce his operational overhead costs. (This is discussed in Chapters 7 and 8 where 2 service types are identified).

Approach 3: The use of material and information flow results, to identify service measures. The audit results, contained in chapter 3, were used for identifying the material and information flows from PD to their customers. The material flows were identified as below:

1) The RDC stock (1st class).

2) The RDC stock (2nd class).

3) The RDC stock (FOCUS stock).

4) The Hotline stock.

5) The Special order form stock.

6) The CSR stock.

7) The customer repairs.

8) The inter-store transfers.

And the information flows were identified as being:

1) The invoices.

This identified for the case study the following 9 service measures:

1) The number of working days after the expected arrival day that 1st class stock arrives.

2) The number of working days after the expected arrival day that 2nd class stock arrives.

3) The number of working days after the expected arrival day that FOCUS class stock arrives.

4) The number of working days it takes for a hotline delivery to occur after it had

been phoned in.

5) The number of working days taken for stock ordered from special request form, to be delivered to stores.

6) The number of working days after the expected arrival day that CSR class stock arrives.

7) The number of working days it takes for customer repairs to be returned to the store.

8) The number of working days it takes for a inter-branch transfer to be completed.

9) The number of working days difference between the stock arriving and the corresponding invoice arriving.

IV) Approach 4: The use of backward-forward link method. Two Weltanschauungs of the store's function were used.

Weltanschauung 1: To provide the general public with the stock they require, as often as possible. This is the well known stock holding problem concerning the likelihood of a stock out occurring. The web of interactions between the two systems (PD and the stores), that was defined by using this method are shown in Fig 5.4. The factors, affecting the likelihood of a stock out, are listed below, along with any associated derived service measures.

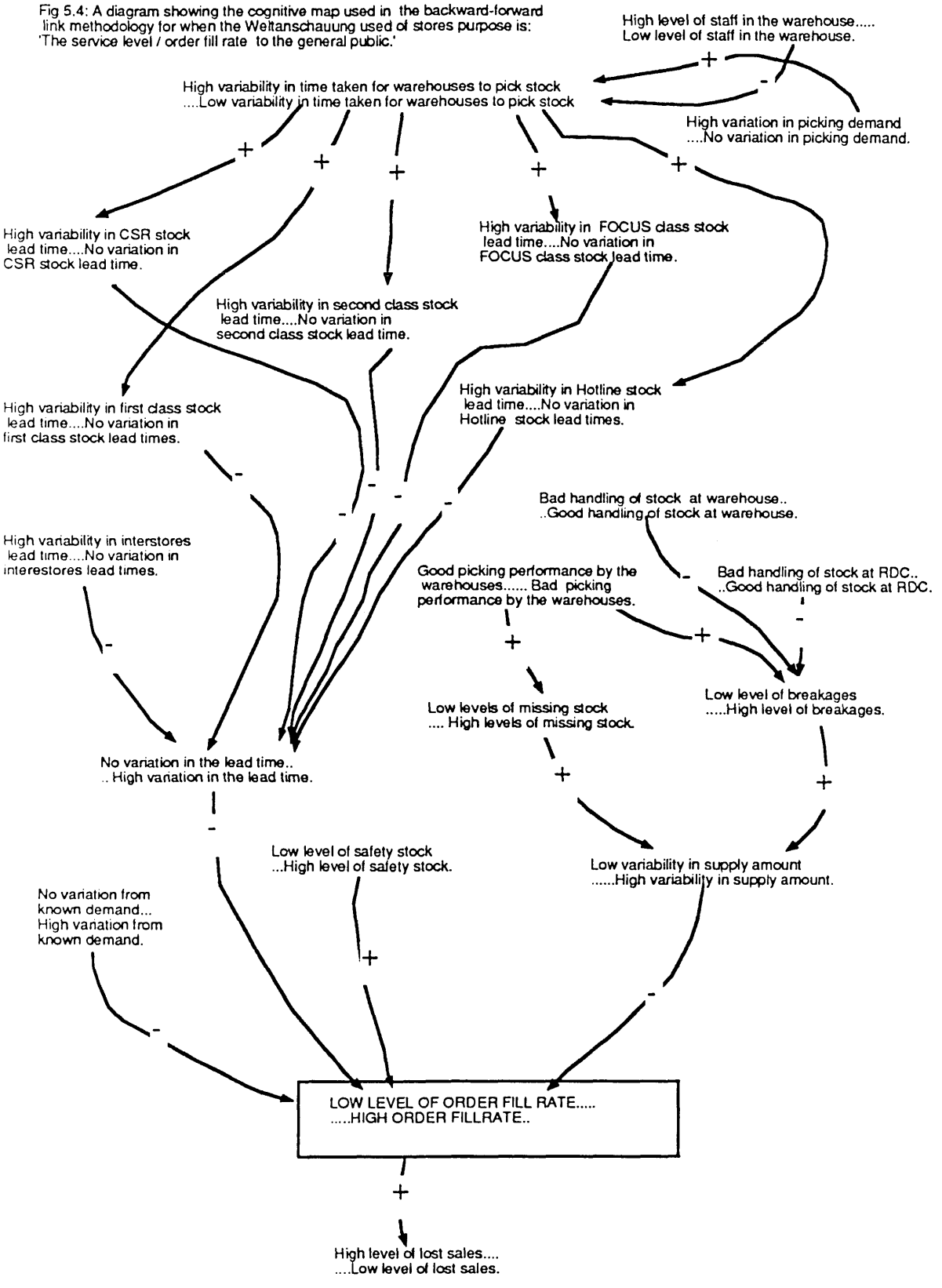
1) The variation from the predicted demand.

No service measures were derived for the case study.

2) The level of safety stock.

No service measures were derived for the case study.

Fig 5.4: A diagram showing the cognitive map used in the backward-forward link methodology for when the Weltanschauung used of stores purpose is: 'The service level / order fill rate to the general public.'



3) The variability in the amount of stock supplied.

a) The level of missing stock.

b) The level of breakages.

4) The variability in the lead times.

a) The time taken for inter-store transfers to be accomplished.

b) The time taken for Hot-line stock to arrive from the production of the invoices.

c) The time taken for 1st class stock to arrive from the time the invoices were produced.

d) The time taken for 2nd class stock to arrive from the time the invoices were produced.

e) The time taken for FOCUS stock to arrive from the time the invoices were produced.

f) The time taken for CSR stock to arrive from the time the invoices were produced.

Weltanschauung 2: "To get stock to the general public at the lowest possible cost". The store's activities which incurred costs, were identified by consulting the store managers. The backward-forward link method was then used to identify the PD's operations which affected these areas. The resultant cognitive map is shown in Fig 5.5. The identified store's activities incurring a cost are listed below, with any associated derived service measures.

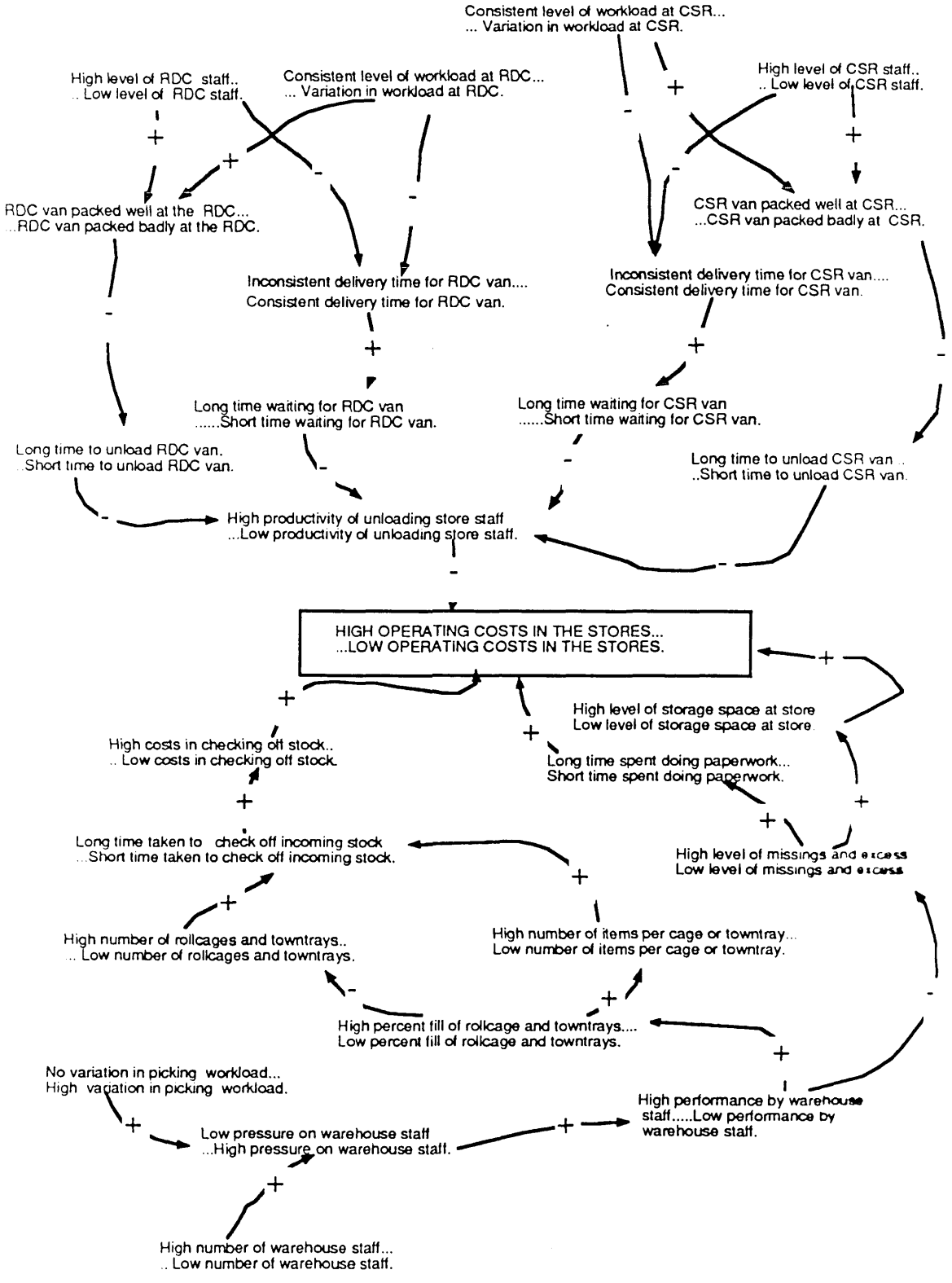
1) The unloading of delivery vans.

a) The time waiting for the RDC van to arrive.

b) The time waiting for the CSR van to arrive.

c) The time spent unpacking RDC containers.

Fig 5.5: A diagram showing the cognitive map used in the backward-forward link methodology for when the Weltanschauung used was: 'The reduction in the stores operating costs.'



d) The time spent unpacking CSR containers.

2) The checking off of incoming stock.

a) The time taken to check off incoming RDC stock.

b) The time taken to check off incoming CSR stock.

3) The amount of storage space used at the store.

No service measures derived for the case study.

4) The filling out of paperwork associated with PD's operations.

a) The time taken to fill out the Missing and Excess forms.

V) Approach 5: The use of first hand experience, to define the service measures. Time was spent in several different stores of the participating company's unloading and storing stock. A cross section of stores were looked at, including large and small ones in different parts of the country. This enabled the different service measures for the different types of stores to be identified. This approach helped in identifying 20 measures, with one service measure, matching delivery outer size to the store's requirements, being uniquely identified by this approach.

b) The list of initial service measures. All the measures, identified above, were amalgamated to produce a initial list of 32 measures, shown below:

1 The number of minutes late that a RDC van is.

2 The number of minutes late that a CSR van is.

3 The time it takes to unload a RDC van.

4 The time it takes to unload a CSR van.

5 The number of working days warning that a store manager receives of a change

in the CSR/RDC van arrival time.

6 The number of working days after the expected arrival day that 1st class stock arrives.

7 The number of working days after the expected arrival day, that 2nd class stock arrives.

8 The number of working days after the expected arrival day that FOCUS class stock arrives.

9 The number of working days it takes for a delivery to occur, after a hot-line order has been phoned in.

10 The number of working days it takes for a delivery to occur, after a catalogue order has been ordered.

11 The number of working days it takes for stock, resulting from a special request form being sent in, to arrive at the store.

12 The number of working days after the expected arrival day that CSR class stock arrives.

13 The number of working days it takes for customer repairs to be returned to the store.

14 The number of working days it takes for an inter-branch transfer to be completed.

15 The number of unexpected vans arriving at the store per day.

16 The number of days warning given of extra vans arriving.

17 The number of times a particular merchandise group is delivered every week.

18 The number of minutes it takes to check off RDC stock per delivery from the time it arrives at the store.

19 The time it takes to check off CSR stock per delivery.

20 The number of minutes spent per day doing M&E (missing and excess) forms.

21 The level of excess RDC stock being delivered, measured by volume.

22 The level of excess CSR stock being delivered, measured by volume.

23 The level of breakages that are occurring, measured as a percentage of items

delivered.

24 The level of missing RDC stock not being delivered.

25 The level of missing CSR stock not being delivered.

26 The level of mis-pricing in CSR stock.

27 The ease of identifying incoming stock.

28 The percentage difference between the actual volume of stock and the expected volume of stock.

29 Matching of delivery outer conditions (size etc) to the stores back store requirements.

30 The number of working days difference between the stock arriving and the corresponding invoice arriving.

31 The ASCOT service level.

32 The compatibility of delivery times to the store procedures.

c) Reducing the number of service measures. The above list of measures was the initial comprehensive list, containing both financially viable and non financially viable measures. Thus, it was required to reduce this list down to the financially viable measures. The initial stage, in this reduction process, was attempted by using the 4 approaches identified in section 5.5.

It should be noted that by the time this reducing stage was attempted, the catalogue ordering system was no longer being used. Consequently, measure 10 was no longer valid.

Approach 1: Identifying the service measures that are really service factors. The effects of all the above service measures on the stores were determined. These effects were then checked against the other measures to see if they were present as other measures; if they were, the first measure was rejected. This approach rejected two measures, shown below:

1) Service measure 27: The ease of identifying incoming stock. This only affects the time taken to check stock off, which is already present as service measure 18.

2) Service measure 29: The matching of delivery outer dimensions (size etc), to the store's back store requirements. This only affects the time to check the stock off, which is already present as service measure 18.

Approach 2 Determining the service measures which are not actually affected by PD. The possible factors, influencing the service level, were identified, by using various methods such as consultation with the company and common sense. Then it was determined whether these factors were actually influenced by PD operations. This approach rejected the following measures:

1) Service measure 12: The number of working days, after the expected arrival day, that CSR class stock arrives. CSR stock was always given priority by PD. Thus, it was virtually guaranteed to arrive on time. Consequently, controlling this service measure would not have increased the performance.

2) Service measure 13: The number of working days it takes for customer repairs to be returned to stores. There are numerous factors influencing this service measure. However, the service factor with the greatest influence is the time taken for repairers to repair the broken item. Consequently, it was felt that this was not a fair measure of PD's performance.

3) Service measure 17: The number of times a particular merchandise group is delivered every week to a store. This was a corporate decision, thus, was not directly under PD's responsibility.

4) Service measure 18: The number of minutes it takes to check off RDC stock. Initially, this was felt to be dependent on the percent fill of the rollcages/towntrays achieved, in the warehouse. This determines the number of cages, towntrays and number of items in each cage/towntray, both of which affect the time taken to check off stock. However, the below analysis shows that any such effect was negligible.

The times taken to unload a **rollcage**, according to the company's figures, were as follows:

Constant time per rollcage: 65 secs

Time per picking item: 15.48 secs

Time per line: 18.17 secs

On average there were 94.9 items per cage and 24.2 lines per cage. Thus, before any change in percent fill, the average time taken to check off an average roll-cage amount of stock, was:

94.9*15.48 +(24.2*18.17)+65 = 1966.2 seconds

However, after a change in percent fill rate of x percent increase, the average time would have been (due to decrease in number of roll cages):

1966.2-((65*x)/100) seconds

which is a percentage decrease of 0.03 x.

By using similar arguments as above, a x percent decrease in fill rate, the percentage increase in time would have been 0.03 x percent.

For checking off **town-trays** the figures were as follows:

Constant time per rollcage: 58 secs

Time per picking item: 14.23 secs

Time per line: 17.86 secs

On average there were 13.3 items per towntray and 5.1 lines per towntray. Thus, before any change in percent fill, the average time to check off an average towntray load of stock was:

13.3*14.23 +(5.1*17.86)+58 = 338.3 secs

Therefore, after a x % increase in percent fill, the average time would have been:

338.3-((58*x)/100) secs

which is a percentage decrease in time of 0.17x percent.

Using similar arguments, as used with an increase in percent fill after a x percent decrease in fill, the percent increase in time would have been 0.17x percent.

Consequently, the percent fill of roll-cages or towntrays has a weak influence on the time taken to check off the stock. Even a 10 % change in the fill of a rollcage or a towntray, a very large change, gives less than 0.5 % or 2% change in the time taken. Therefore, it is felt that PD does not significantly effect this service measure.

5) Service measure 19: The time it takes to check off CSR stock per delivery: Using similar arguments to that used above, for service measure 18, this service measure was eliminated.

6) Service measure 28: The percentage difference between the actual volume of stock and the expected volume of stock. PD does not determine the level of stock going to a store; this was determined by the ordering system. Thus, PD did not

influence the level of this service measure.

Approach 3 The combining together of similar service measures: The effects of the different service measures were investigated by consulting with the company. Service measures which have identical effects, were then combined to form one measure.

Store managers were not held financially accountable for breakages. This meant that, the affects of breakages on the stores were the same as for missing stock. Consequently, the 2 service measures 23 and 24 were combined. Using similar arguments, measures 23 and 25 were combined.

Approach 4 The use of conjoint analysis. Initially, an attempt was made to use a series of pair-wise trade-off matrices to enable the use of conjoint analysis. This would have enabled a figure for the relative qualitative importance of each service measure to each customer to have been calculated. Hence, giving an indication of the measures that are less important, and which, consequently, could be left out. Unfortunately this proved to be impractical, as the customers were often unable to discern any conflict between the two specified measures in the matrix. Therefore, they felt that they could not give, or work out, any ranking judgements.

Revised list of service measures.

After using the above approaches to reduce the number of measures, and ignoring measures now irrelevant, there were 21 store service measures. The list of these measures is shown below:

1 The number of minutes late that a RDC van is.

2 The number of minutes late that a CSR van is.

3 The time taken to unload a RDC van.

4 The time taken to unload a CSR van.

5 The number of working days warning that a store manage receives of a change in the arrival time of a CSR/RDC van.

6 The number of working days after the expected arrival day that 1st class stock arrives.

7 The number of working days after the expected arrival day that 2nd class stock arrives.

8 The number of working days after the expected arrival day that FOCUS class stock arrives.

9 The number of working days it takes for a delivery to occur after a hot-line order has been phoned in.

10 The number of working days it takes for a delivery to occur after a special order form has been sent in.

11 The number of working days it takes for an inter-branch transfer to be completed.

12 The number of working days notice given, to the store manager, of extra vans arriving.

13 The number of minutes spent doing M&E forms per day.

14 The percentage volume of excess RDC stock.

15 The percentage volume of excess CSR stock.

16 The percentage difference of missing and breakages in RDC stock.

17 The percentage difference of missing and breakages in CSR stock.

18 The level of mis-pricing in CSR stock.

19 The number of working days difference between stock arriving and invoices arriving.

20 The ASCOT service level.

21 The compatibility of delivery times to the store procedures.

It should be noted that it is not possible to eliminate the non- financially viable measures at this stage. This can only be done when they have actually been implemented. This is because the financial viability is dependent on how well a performance level is restricted and actual monitoring/controlling costs (see section 5.3.1).

2 Defining the Supply Manager's service measures.

An attempt was made to use all the approaches proposed in section 5.3.2. However, as no previous work had been carried out on service to Supply Managers, it was impossible to use literature survey results. Also, it was not practical, due to the responsibility and the long time it takes for the effects of PD service to be experienced, to actually gain worthwhile experience in performing a Supply Manager's job. Thus, the remaining three approaches were used. Which measures were identified by each approach is shown in Appendix B. Indicated below is how each of the techniques was used with the Supply managers, and the relative effectiveness of the technique.

1) Brainstorming sessions were held with both Supply Managers and PD. This approach identified seven measures, one of which was unique to this approach.

2) Information audit results. This technique used the audit results, contained in chapter 4, to indicate the information flow to Supply managers. The measures were then defined in terms of the accuracy of this information. This technique identified two measures, neither of which were unique.

3) Backwards-forwards link approach. The Supply Managers responsibilities were identified by looking at their job specifications, and also by consulting them. From this the information requirements, from PD, were defined. This technique identified eight measures, two of which were unique.

In all the following 9 service measures were identified:

1) The amount of warehouse space actually available to a Supply Manager compared with the amount that is needed for his stock.

2) The accuracy of the warehouse's computer stock levels.

3) The accuracy of costing the storing of stock in warehouses.

4) For new merchandise lines : the number of working days it took for stock to get to the stores from the date specified, by the Supply Manager, for the stock being delivered to the warehouse.

5) The number of working days it takes for an inter-store transfer to be completed.

6) The number of working days a store was out of stock whilst stock was available in the Physical Distribution system.

7) The number of working days it takes for returning stock to be ready for dispatch in the warehouse, from the time it left the store.

8) For allocation stock, the number of working days after expected delivery date that stock arrives at the store.

9) The usefulness of information being sent to the Supply Manager.

Due to the low number of measures identified, it was felt that there was no need to reduce the number of measures, at this stage.

5.8.3. The 3 E test results for the case study.

This section looks at the efficacy, effectiveness and efficiency of each of the proposed techniques when carrying out the two required HASs in the case study defining the service customers and defining the service measures for each customer.

As this looks at the situation for one particular case study, no general conclusions can be formulated until the approaches are tested out in various other situations. Unfortunately,

this proved impossible, due to time constraints.

In section 5.5.7, the efficacy, effectiveness and efficiency of a technique were defined. This is summarised as follows:

A technique's efficacy is determined by whether, or not, it was possible to use a technique at all. A technique's effectiveness was measured in two dimensions: First, the number of measures/customers identified; second, the number of unique measures/customers identified. The effectiveness results, for the various techniques, are shown in table 5.1 and 5.2. The efficiency of a technique was determined by looking at the level of effort required to use it. This is quite hard to express in an objective manner. Consequently, it is the researcher's impression of the effort involved, that will be given here.

HAS 1 Defining the customers. Both of the proposed techniques were efficacious. The brainstorming technique was both effective and efficient. All the customers were identified and the investigation was completed in a short time. The use of material and information flow audit was not so effective, as it did not identify the company's Industrial Section. Also, it was not very efficient due to the time and cost involved in performing the audit. However this efficiency is increased if the results are used for other reasons. Thus, it would seem that using brainstorming sessions is the best way of carrying out this HAS unless the audit results are used for other purposes

HAS 2 Defining the service measures. All the techniques were efficacious for defining the store's service measures. However, when looking at the Supply Manager's service measures two of the techniques were not efficacious.

The brainstorming approach was the most efficient approach due to its ease of use and short time needed to use it. It was also an effective technique. The effectiveness of this

technique was increased when known examples of service, generated by other techniques, were used as a catalyst for generating more ideas.

The use of literature survey results was quite effective in producing a high number of measures. This technique generated a broad base of measures, which could be used to increase other technique's effectiveness, such as giving examples of service to stimulate ideas. However, using literature survey results was rather inefficient, due to the research time involved.

The use of material and information flow was neither effective nor efficient.

The backwards-forward link approach, although not extremely effective with stores, proved the opposite with the Supply Managers defining all the identified measures, except one. This success was attributable to there being clearly defined job descriptions for the Supply Managers. Experience has shown that the major handicap, to this technique's effectiveness, is the problem of expressing the customer's precise role/ function in the company. This method was efficient, due to the short time required to perform it.

The gaining of first hand experience was effective, when it was possible to use it. It helped in producing measures often disregarded by people as not worth mentioning. Unfortunately to be very effective it involved some considerable investment of time, and hence money. Consequently, this technique was inefficient.

In summary, this simple study has shown that the efficacy of a technique to define the measures of service is dependent on the situation. Of the five techniques proposed the worst seemed to be using the material and information flows. All of the other four techniques had certain merits associated with them. However, the best technique overall, due to its combined effectiveness and efficiency, was felt to be the use of brainstorming techniques.

5.9 Summary.

This chapter has looked at defining the service measures. It was shown that, there are two parts to doing this:

1) Defining the customers.

2) Defining the service measures for each customer.

It was then shown that service customers are not just stock recipients, but also information recipients.

Two techniques were proposed for defining the customers:

a) Using brainstorming sessions.

b) Using material and information flow results.

The relative merits of these two techniques were tested in the case study, against the 3 E test. The use of brainstorming sessions was found to be the best technique.

With the service measures, it was shown that whether a customer is external, or internal, has no effect on which service measures are relevant. This was shown to be dependent on the customer's and PD's operations. However, it was shown that there are differences in which approaches are applicable. Five techniques were proposed for defining the service measures to internal customers, these are shown below:

a) The use of literature survey results.

b) The use of material and information flow results.

c) The use of backward-forward link method.

d) The use of brainstorming techniques.

e) Gaining first hand experience.

When used in the case study, a particular technique's merits was found to be dependent on the situation it was being used in. However, it was felt that the best approach, overall, was the use of brainstorming techniques.

It was shown that, due to the constraints, operating on the HASs, the measures being used should be restricted to those that are financially viable. Four techniques were proposed for reducing the initial number of measures. One of these approaches, the use of conjoint analysis, was found to be impossible to actually use. Unfortunately it was not possible to eliminate the financially unviable service measures at this stage as this can only be determined after they have been implemented.

In summary, this chapter has shown that there are many different service customers, not just recipients of stock. Although customer service measures are the same for both internal and external customers, the techniques that can be used to identify these measures are not the same. It has also been argued that, the best overall technique for defining both service customers and measures, is the use of brainstorming techniques.

CHAPTER 6

DEFINING HOW SERVICE AFFECTS THE COMPANY'S PROFITS.

6.1 Introduction.

It was shown in chapter 3, that one of the requirements of controlling service is to define and achieve a service policy which maximises the total profits. This chapter looks at what human activity systems (HASs) are required in defining and achieving such a policy and how it is proposed that each of these HASs can be carried out. Initially the chapter explores what factors, associated with service, influence the profit level. This investigation will be used to identify the activities (hence the HASs) that are required to define and achieve the best service policy for internal customers. These HASs will be compared against those that are needed for external service customers. For each of the identified HASs suggestions will be made on how they can be carried out.

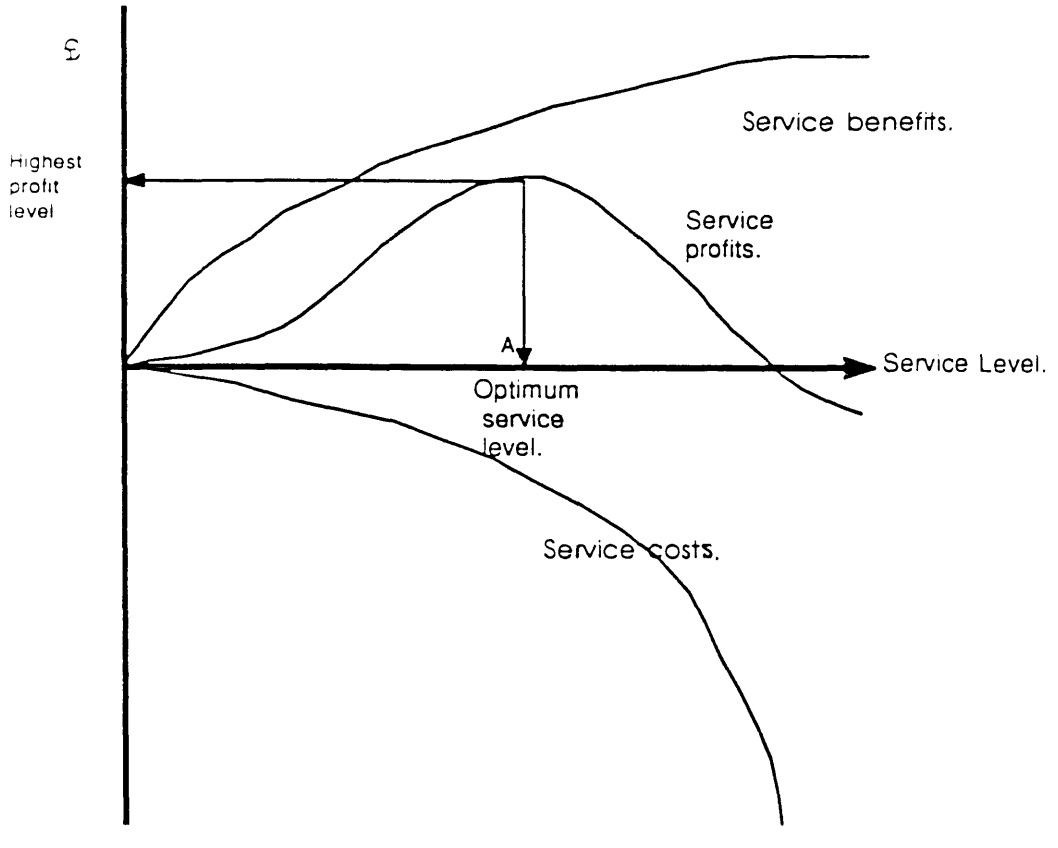
6.2 Factors influencing the profit level.

Shown below, are several factors which influence the profit level being achieved. The first two factors were identified by consulting the customer service literature. However, the other factors were determined after holding discussions with the participating company.

Factor 1. The optimum service level: It was shown, in chapter 2, that previous customer service studies (such as Christopher et al (1979) and Marr(1982)) have argued, that to maximise profits, there is a need to define the optimum service level. This is the service level which has the maximum profit (benefits minus costs)

associated with it. The principle of an optimum service level is demonstrated in Fig6.1, where service level A, the optimum service level, has a higher profit level than any other service level.

Fig 6.1 : A diagram illustrating the concept of there being an optimum service level.



Factor 2. The use of market/service segmentation: Christopher(1983) suggests that it is unusual if all the segments of a customer grouping have the same service benefits. It is also possible that different market segments have different service costs. Consequently, there are often different optimum service levels for each of these segments. This means that by considering these segments individually the gross profits achieved can be increased.

It should be noted that, as well as differentiating between the different customers it is a possible to differentiate between different parts of a service measure. For example, instead of monitoring stock lead times as one measure,different priorities can be assigned to different types of stock.

However there are also penalties. These are the costs associated with differentiating between different parts of a PD system, these include:

a) The increase in PD's costs. For example, a warehouse's administrative costs are increased by differentiating between 1st and 2nd class stock. These costs are generally lower when differentiating between easily differentiated market segments such as geographical regions, rather than particular individual customers. It should be noted that these lower cost markets segments are usually the groupings which can easily have labels attached to them by the participating company.

b) The more service categories there are, the greater the control situation's complexity and, consequently, greater the costs. (This is explored in more detail in Chapter 8).

c) When priority is given to a particular market segment then its service costs are reduced. Unfortunately the remaining segments are likely to have higher service costs than they did originally.

Thus there is a need to strike a balance between the costs and benefits of using market segmentation.

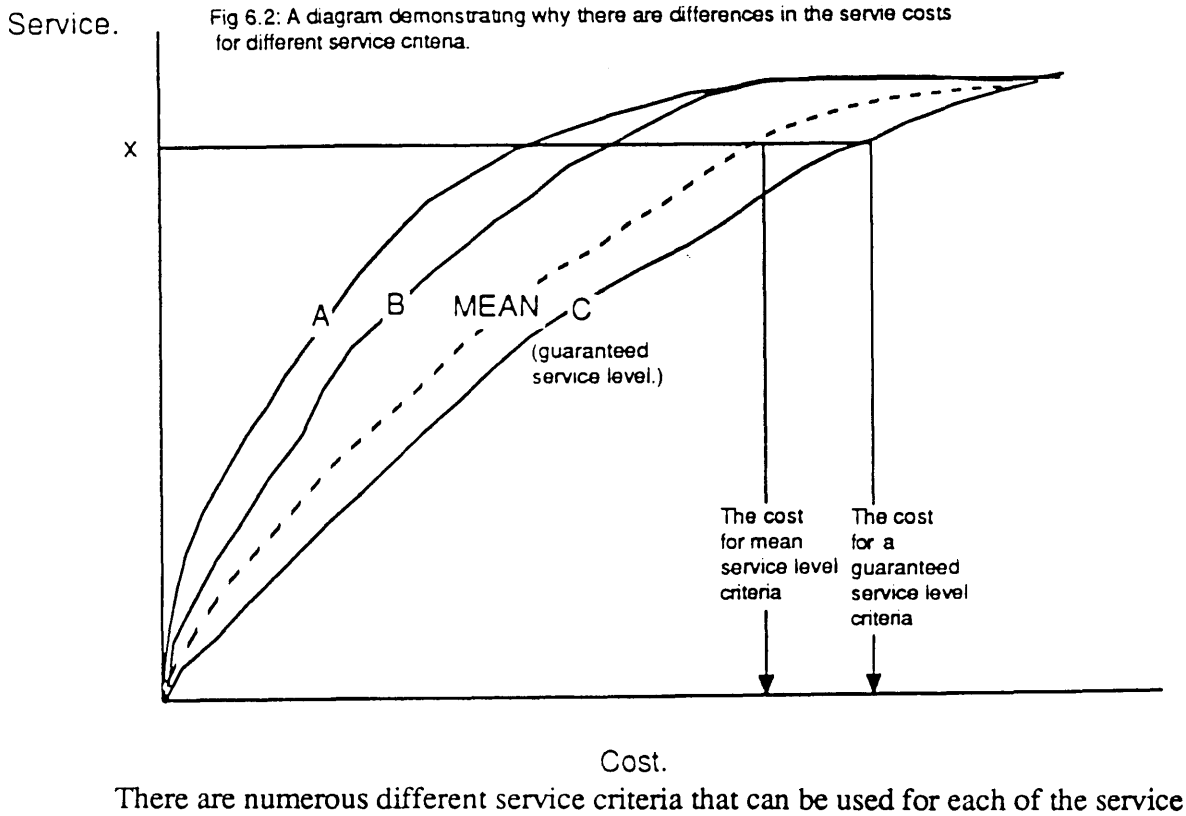
Factor 3. Minimizing the service costs: If service costs can be decreased there will be a resultant increase in the service profits. It should be noted that, as this activity influences the profits for each service level, it should be carried out before determining the optimum service level.

Factor 4. Maximising the service benefits: If the service benefits can be increased

there will be a resultant increase in the service profits. For the same reasons as for factor 3, this activity should be carried out before determining the optimum service level.

Factor 5. The criteria that is being used to test/monitor the service level: Both the service costs and benefits are dependent on the criteria that is being used to test the service level required. The differences in the service costs, for different criteria, are demonstrated here by referring to the situation shown in Fig 6.2; where there is assumed to be only three different system states, A to C. When guaranteeing a X% service level, the costs are determined by the costs of providing a X% service level for state C. However, for the mean service level criteria, the costs are at a lower level, as the service levels below X% for state C are offset by the service level being greater when state A and B occur.

Fig 6.2: A diagram demonstrating why there are differences in the servie costs for different service criteria.



There are numerous different service criteria that can be used for each of the service measures that have been generated in chapter 5. For example, for any lead time service measure, the service criteria could include:

1) The percentage of stock arriving, within a specified number of days.

2) The mean number of days taken for stock to arrive.

3) The variance in the number of days taken for stock to arrive.

4) The longest time taken for the stock to arrive.

The number of such measures, that can be generated, is only limited by the human imagination. Intuitively some measures stand out as being plain ridiculous, whereas others may seem to be more useful. Consequently, a dilemma exists of which performance criteria should be used, how this can be dealt with is outlined in section 6.4. Below is proposed a system which can be used for classifying criteria.

Although not proven, it is proposed that in general that:

> "The service benefits of a service level, for a particular criteria, are correlated to the cost of providing that service level for that criteria."

This means that criteria which have high costs for providing a service level, generally have high benefits, whereas criteria which have low costs generally have low benefits. Thus it is proposed that criteria can be categorised by this relationship between the cost and the benefits. Criteria with high costs and high benefits, can be classified as being tight criteria. Whereas criteria with low costs and low benefits, can be classified as being loose criteria. (An example of a loose criteria is the mean service level and an example of a tight criteria is the mean and variance combined of the service level). It should be noted that this classification system is found useful in later discussions, for deciding what type of criteria should be used in a particular situation.

6.3 The HASs required.

From the above discussion, it can be seen that there are five basic HASs that are required in maximising the profits, these are shown below:

1) Defining what the segments should be.

2) Defining what the criteria should be.

3) Minimising and defining the service costs.

4) Maximising and defining the service benefits.

5) Determining what the optimum service level is.

The interaction of these HASs is shown in Fig 6.3. It should be noted that the defining of the segments and criteria are more fundamental than defining the service costs and benefits, and consequently, should be carried out before these are. How each of these 5 HASs can be performed will be looked at in sections 6.5-6.9.

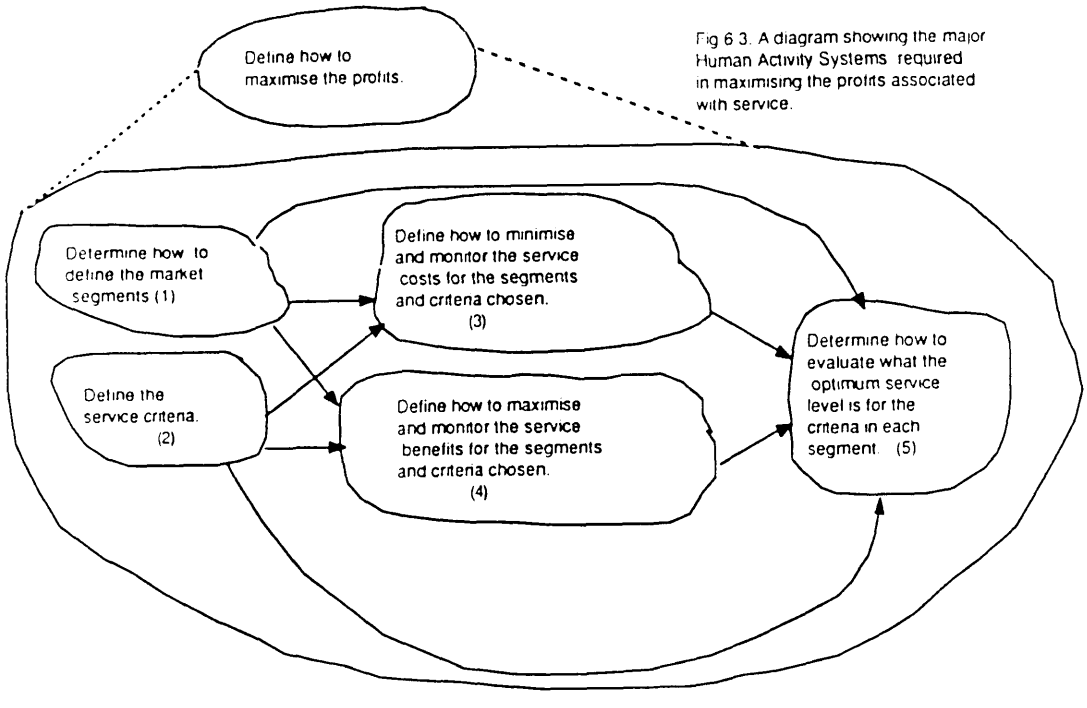


Fig 6.3. A diagram showing the major Human Activity Systems required in maximising the profits associated with service.

6.4. Differences between external and internal customers.

There would appear to be no logical reason why the HASs identified above for internal customers are not equally applicable to external customers. However, no actual extensive work has been carried out in this area. This could be an area where further research could be carried out.

6.5 Defining possible service segments.

The activities required for defining the service segments are shown in Fig 6.4. Unfortunately, for any service measure there are a huge number of possible service segments that can be used. Thus, it would be inefficient to test out the financial feasibility of all the different combinations of the possible segments. Therefore, it is desirable to reduce the number of possible segments down to those that are likely to be useful; then perform a fuller cost and benefit analysis on these remaining segments. Below, are suggested a few approaches that can be used for reducing the number of possible segments.

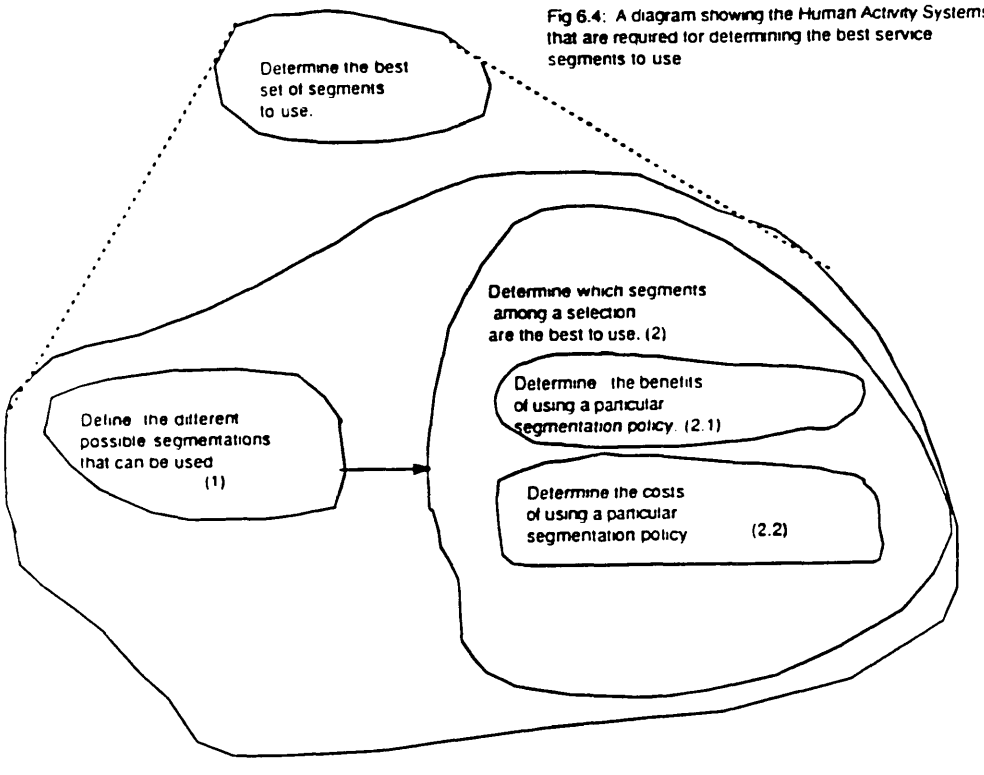


Fig 6.4: A diagram showing the Human Activity Systems that are required for determining the best service segments to use

Approach 1: The use of cluster analysis on questionnaire results, indicating the qualitative value of service to the customers: Christopher (1968) uses cluster analysis, on service utility values, derived by using conjoint analysis on questionnaire results, to identify the groupings of customers who attach a similar importance to various service levels. Consequently, the cluster analysis results give an indication of the segments with similar service benefits. However, there are

often problems with using this approach due to the high costs of differentiating between the different customer segment groupings generated by this clustering.

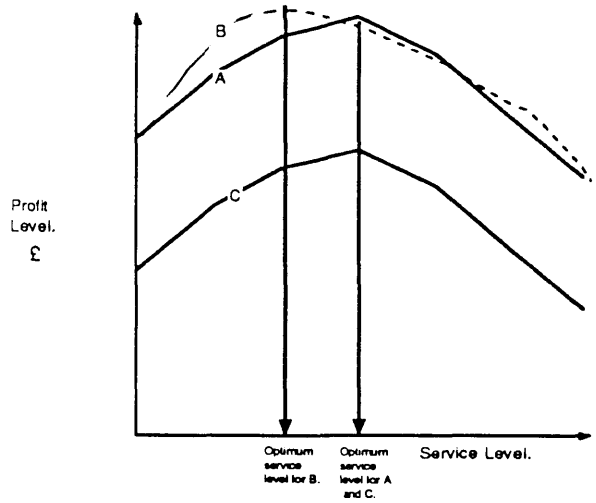
Approach 2: Using the company's classifications of possible segments: Due to the problem of differentiating costs, mentioned above, it is often better to identify by consulting with the participating company, the possible classifications of customer groupings that can easily be used. Then determine, using clustering analysis on questionnaire results, the best possible groupings, using only these classifications.

Approach 3: Comparing the results of the above two approaches: It is possible, by comparing the above two analysis results, to give an estimation of the increased benefits of using the first set of groupings over using the second set of groupings. This gives an indication of whether it is likely to be worthwhile to investigate the extra costs of differentiating, between the more complicated customer groupings. It should be noted that it is better to use K mean clustering techniques, rather than straight forward cluster analysis, as this maximises the differences, (i.e. the advantages) between the different groups.

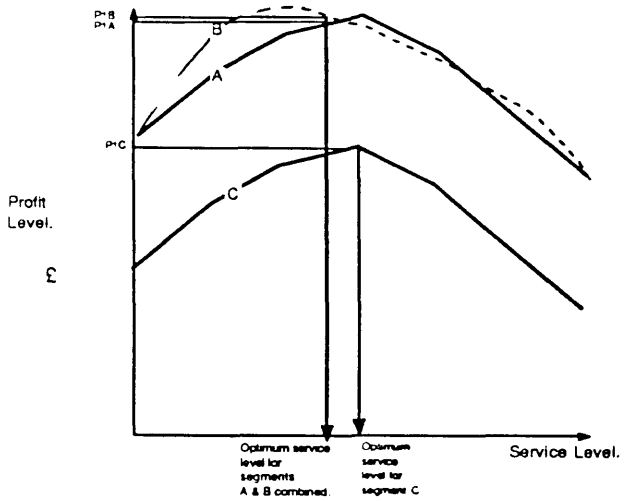
In order to use cluster analysis there is a need for a criterion for deciding which segments should be clustered together. Intuitively it would seem sensible, to use the profit levels of the different service levels for each service segment. However it is suggested here that the criterion that should be used is the optimum service level of the different service segments. This is because it is felt that having similar optimum service levels is more important than having similar profit curves. The advantages of this are demonstrated with reference to the situation shown in Fig 6.5; where customers A and C should be grouped together rather than A and B as P2A+P2B+P2C is greater than P1A+P1B+P1C, where P1A is the profit from customer A when segmentation 1 is used. It should be noted that, these segments (A and C) would be clustered together if the optimum service levels were used.

Fig 6.5: A diagram illustrating the point that the optimum service level should be used as the criterion for clustering segments together rather than the individual segment's service profit levels.

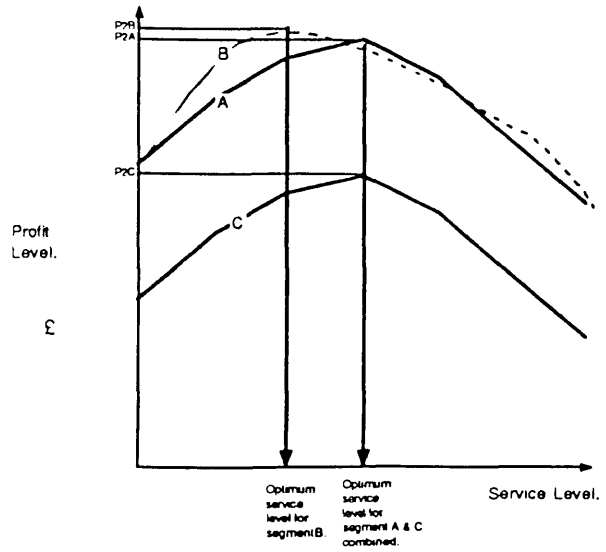
The individual segment profit levels.



Situation 1: The effect of grouping A with B.



Situation 2: The effect of grouping A with C



However, if a cluster analysis was performed, on the profits associated with a service level, then the groupings would be A with B.

Unfortunately questionnaire results give only an indication of the likely service benefits. Thus, when using questionnaire results it is impossible to use the optimum service level to determine the segmentation. However, it is proposed that the shape of the benefit curves can be used to give an approximation to this. It is assumed that 2 segments which have similar shaped, parallel, benefit curves (that is a fixed amount between the 2 curves for all the service levels) have similar optimum service levels. It is proposed that similar shape benefit curves can be identified by standardising the questionnaire results and then carrying out a cluster analysis on these revised results. The questionnaire results are standardised by having a standard highest value judgement for all of the different segments. This is done, by adding fixed amounts to particular respondent's value judgements to ensure that all respondents having a common highest value judgement. For example, if the top value judgement that can be given is 6 and one particular respondents highest value is 5, then 1 would be added to all his judgement values. It should be stressed that, this does not necessarily mean that each customer gives the same service level as being the best in his eyes. This approach assumes that either each of the segments have the same costs, or that the service costs are uncorrelated to the benefits.

6.6 Determining the service criteria.

This section looks at determining what service criteria should be used to evaluate the service level. The activities that are required in doing this are shown in Fig 6.6. Unfortunately, due to the high number of possible criteria, it is unproductive, or even impossible, to test out the financial feasibility of all these possible criteria. Thus, as with determining the

segments, there is a need to reduce the number of possible criteria before attempting this. Consequently the discussion below is divided into 2 sections. The first looks at how the best service criteria amongst a selection of possible criteria can be determined. The second looks at reducing the number of possible criteria down to those that are likely to be more beneficial.

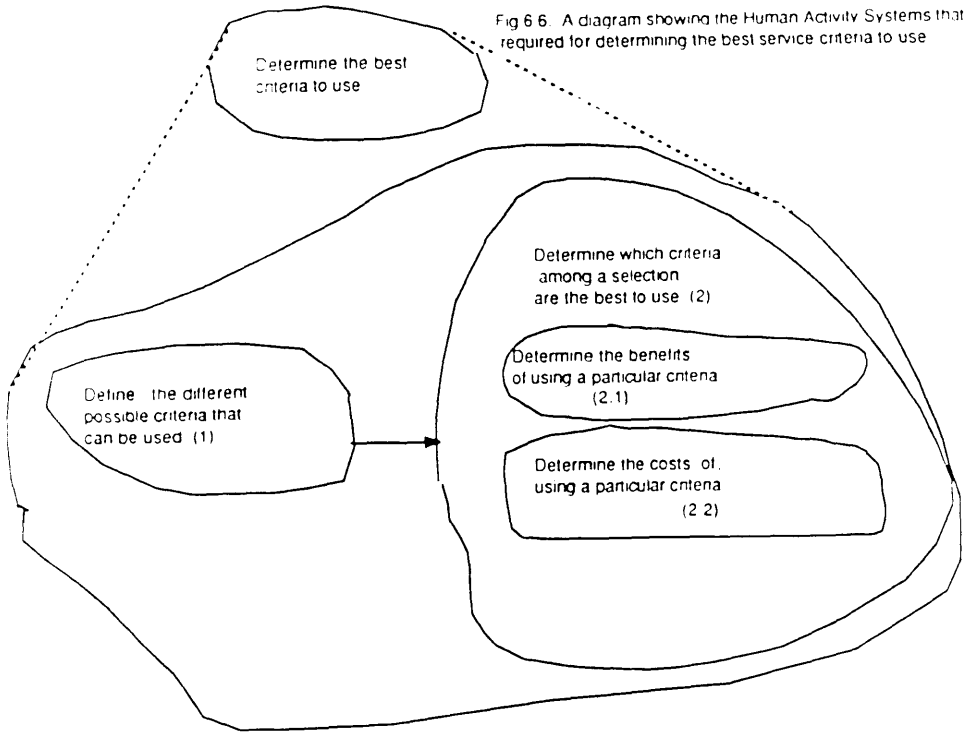


Fig 6.6. A diagram showing the Human Activity Systems that are required for determining the best service criteria to use

6.6.1 Determining the best criteria.

For each combination of service measure and criteria, there is an optimum service level, with an associated maximum profit level. The differences in these maximum gross profit levels, for different criteria, indicate the relative benefits of using the different service measure criteria.

The cost of using a particular criteria is the expense of controlling the service measure for that particular criteria. Some criteria are more expensive to monitor than others. Thus, the service criteria that should be chosen is the one which has the largest nett profit: that is gross profits (the profit level of the optimum service level) minus the controlling costs.

However, this only considers using one criteria to monitor the service. It is also possible to use two, or more, criteria simultaneously. For example, monitoring the mean and variance of a service measure. Again, the relative nett profit of doing this has to be determined.

6.6.2 Reducing the number of possible criteria.

Various approaches for reducing the number of possible criteria are explored below:

Approach 1: Consulting with the company to determine what criteria are likely to be useful: This can be done by holding discussions and brainstorming sessions with the company.

Approach 2: Using the tight/loose criteria classification system: If the service benefits associated with a tight criteria are not much different to the service benefits associated with a loose criteria, then the greater costs of a tight criteria, are likely to outweigh the benefits. Thus, it is more likely that the loose criteria is the best type of criteria to use.

Generally a tighter criteria allows less variation in performance than does a loose criteria. Consequently if variation in the service level has little effect on the total benefits, then the difference between the benefits of using the different criteria types, is small. An example of this is when the benefits increase linearly with service. This is demonstrated in Fig 6.7. However, if variations in the service level do affect the total benefits then the differences between the types of criteria are greater, indicating a tighter service criteria (restricting the service levels) is more likely to be beneficial. This point is demonstrated in Fig 6.8.

Fig6.7. A diagram illustrating the principle of that when variation in the service has little effect on the total benefit level then there is only a small difference in the benefits between using a tight and loose criteria.

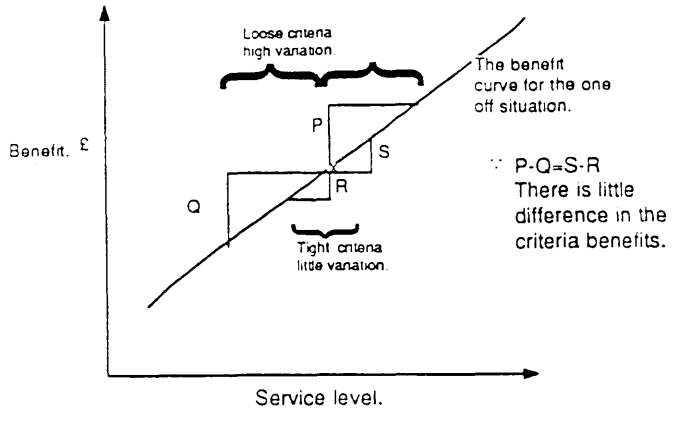
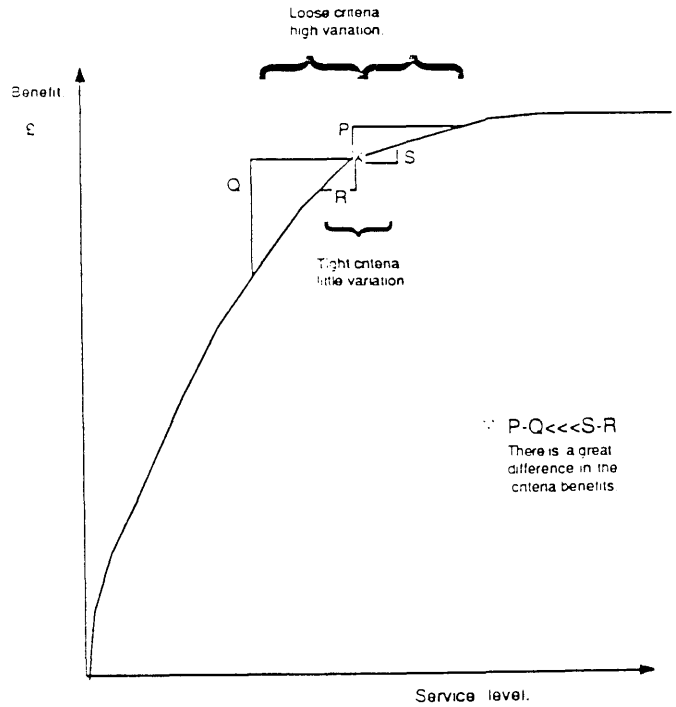


Fig6.8. A diagram illustrating the principle of that when variation in the service level does effect the total benefit, then there is a big difference in the benefits between using a tight and loose criteria.



The above example suggest that an indication of the differences in the benefits between using different criteria, can be determined by looking at the shape of the standard service benefit curve. An indication of the shape of this benefit curve can be given by using questionnaires results indicating the customer's value judgements on various possible service levels.

Also, by using the reverse argument small cost differences between using the 2 different type of criteria would indicate that it is more likely to be beneficial to use a

tight criteria.

Approach 3: Determine if the criterion has the desired effect on the customer's system. It should be noted that some criteria can be fixed by PD to make themselves look 'good' without giving the actual desired effect on the customer's operations. An example of this is the lateness of the arrival of delivery vans were measuring the mean time is not good enough. As a van's late arrival on one day could be cancelled out by its early arrival the next day.

6.7 Minimising and defining the service costs.

This section starts by looking at whether any differences exist between the service costs for external customers and internal customers. Following this the influences on the service costs are examined. This enables various ways of reducing the service costs to be determined. These cost reductions are demonstrated on a standard example. Finally, the HASs required for minimising and defining the costs are identified and possible ways of carrying out these HASs are explored.

6.7.1 Differences between internal and external customers.

The service costs are affected by the PD system and not by the customer's system. Thus who the customers are should not influence the service costs. Therefore, it is proposed that there are no differences in the costs for internal and external customers. Consequently any results from previous studies, on defining service costs, are still valid.

6.7.2 What influences the service costs ?

In chapter 2 it was indicated that extensive work on service costs has been reported in the

literature. Unfortunately these investigations have mainly concentrated on two service measures: The order fill rate and the lead time. However in chapter 5 it was shown that there are often many other areas of service. Thus it is felt that there is a need to determine a universal framework for defining the service costs for all of these different service measures. This will be defined below by looking generally at what influences the service level and from this determine how the service costs can be both minimised and determined.

The service level, is a function of all of its service factors (defined as the parts of the PD system, or its environment, which affect the service level).

i.e. SL(i)= F(SF(i1),SF(i2)....)

Where SL(i)= Service level of measure i

and SF(ij)= The level of the jth service factor affecting service measure i.

Essentially, there are two types of service factors:

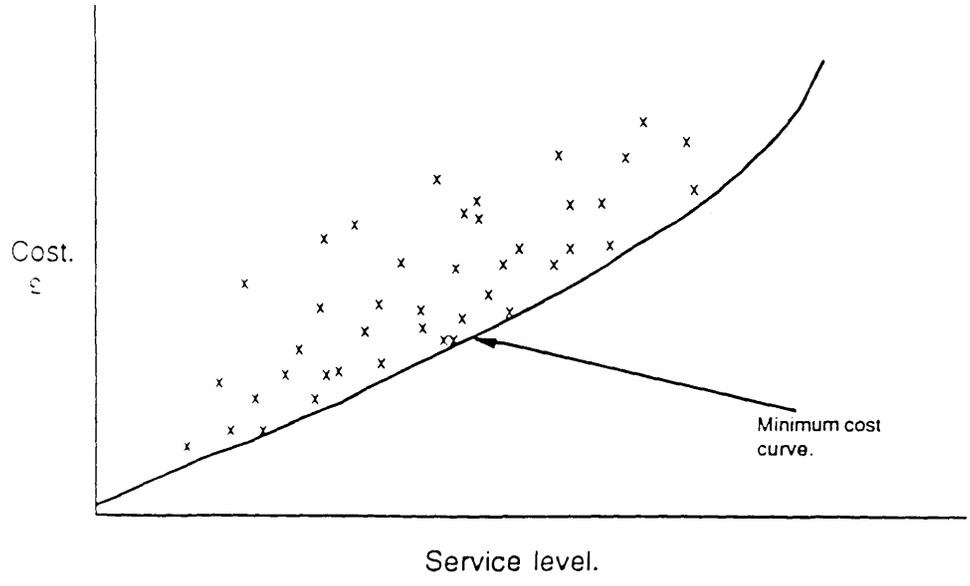
1) Those not under PD's control. These constitute the disturbances hitting the PD system.

2) Those under PD's control. These constitute PD's response to the disturbances.

The effect that the disturbances have, when hitting the PD system, is determined by the service response levels. For every set of disturbances, there are numerous different responses that can be adopted, each with its own specific effect (service level achieved and cost). Thus, for every disturbance, there are numerous service to cost profiles. An example of this, for a particular set of disturbances, is shown in the scatter plot represented in Fig6.9. For every set of disturbances, there exists a set of responses, which produce the specified service level at the minimum cost. However, the costs are usually greater than this minimum value. Various ways of reducing the costs down towards this minimum level are investigated below. For simplicity and consistency, one general example will be mainly used to demonstrate the possible effect that these approaches can have on the service costs.

This example does not prove that there will always be cost reductions but demonstrates the possible cost savings can be achieved.

Fig 6.9: A diagram showing the scatterplot for the service costs for a particular set of disturbances. The curve of the minimum cost for a particular service level is also shown.



The general example is as follows: The service level, in this example, is dependent on just two service factors, a disturbance (such as level of workload) and a response (such as the level of manpower). If the response is greater or equal, in value, to the disturbance then a 100% service is achieved. Otherwise, the service level is defined as being: The response level/disturbance level x 100. Generally, the disturbances are assumed to be normally distributed with mean value of 100 and SD value of 5. Two criteria are looked at: The mean service level (a loose criteria) and the service level which is guaranteed to occur, at least 99 % of the time (a tight criteria). The formula for calculating the service level for a response level of X units for the 2 specified criteria is shown below:

For the mean criteria:

$$\text{Service level} = \Phi(U) + \frac{1}{\sqrt{2\Pi}} \int_{u}^{\infty} \frac{X e^{\frac{X^2}{2}}}{U} dx$$

Where $u = (X-\mu)/\sigma$

X= response level, σ = Standard deviation of the disturbances.

μ = Mean of the disturbances.

$\Phi(U)$ is the cumulative distribution function of a standardised normal variable

It should be noted this service level is best calculated by using numerical approximation methods.

For the service level guaranteed 99 % of the time:

Service level= $X/(\mu+2.325\sigma)$

It should be noted that, $\mu + 2.325\sigma$ is the 99% confidence interval for a normal distribution.

An example, of this sort of situation, would be an order picking system where the disturbances are the amount of work required to be done (measured in standard man hours) and the response would be the level of manpower available (measured in man hours).

6.7.3 Ways of reducing the costs.

Three approaches are looked at below for reducing service costs:

1) Having an accurate model of the system's dynamics.

2) Reducing the uncertainty, in the disturbances by linking measures together.

3) Reducing the effect of uncertainty in the disturbances by responding to the individual disturbances differently.

These approaches were determined by looking at how PD reduced their costs for specific service situations in the participating company. From these situations, general cost reducing principles were formulated.

Approach 1: Having an accurate system model. Two of the consequences, on service costs, of having an accurate model are now studied. This is followed by a discussion on what information is required for formulating an accurate model.

Consequence I: Making trade offs between service responses: If a controller does not have an accurate model, he is incapable of making rational decisions concerning the trade off between different service responses. The simple example, indicated, below, demonstrates this point: There are two service responses, A and B, and it is assumed that the disturbances are constant. The service level is defined by the addition of the two service responses. The cost of each response level is as below:

	A		B	
level	1	2	1	2
cost	2	5	1	3

By having this knowledge, a controller can determine the optimum combination of A and B to produce any service level between 2 and 4. For example, if a service level of 3 is required then the optimum combination is A=1 and B=2, with cost=5. However, a controller who does not have this accurate model, may mistakenly choose A=2 and B=1, with cost=6. It should be noted that for this approach to be effective the controller also

needs to know the costs of the different service response levels. An example of this situation is the lead time of sending stock to stores where there is a need for coordination between the cost and time for Warehousing to pick stock and the cost and time for Distribution to send stock to the stores.

Consequence II: The need for a corporate approach to providing a service level. Sometimes service factors are under the company's control but not under PD's control. If no coordination exists between these departments then there is likely to be an increase in the service costs. This point is demonstrated by the example of the order lead time where there needs to be coordination between PD and the data processing centre. This is shown below, where it is assumed that there are only two parts to this service measure: The order processing time and the time taken for PD to send the stock. Possible times taken and costs, for these two tasks, are shown below:

Data processing time			Time taken by PD.		
Days	1	2	3	Days 1	2	3
Cost	6	3	1	Cost 9	4	2

For a 4 day order cycle time the cheapest way costs 7 units, with each department taking 2 days. However, if data processing centre take 3 days, reducing their costs, then PD have to decrease their time to 1 day. This leads to the total cost being 10 units instead of 7 units.

This demonstrates Christopher's(1983) point that for customer service to be effective it has to be a corporate concept in the company. It is interesting to note that there is a service trade-off occurring in this example between the data processing centre and the PD system.

Thus it has been shown that having an accurate system's model can have an advantageous effect on service costs. How an accurate model can be generated will be discussed in chapter 8. However, whatever modelling technique is used there will be a need to have knowledge of the service level was achieved and the service factor level.

Approach 2: Linking measures together. This section, consists of two parts. The first looks at how disturbance variations affect the service costs. The second demonstrates how these effects can be reduced by linking several service measures together.

I) The effect of uncertainty, in the disturbances, on the service costs: The hypothesis to be tested here is that less uncertainty in the disturbances generally leads to lower service costs.

The effect of disturbance variations is investigated here, by looking at the effect that various disturbance standard deviation has on the general service situation described in section 6.7.2. This was done by keeping a constant mean disturbance workload level of 100 units and varying the standard deviation of the disturbance spread. Three different standard deviations were investigated:- 2 units, 5 units and 10 units. These investigation results are shown in Table 6.1.

An example of the calculations to produce these results are shown below

The example of the disturbance level being normally distributed with mean 100 and SD of 5 will be used. Let response level, X, be 102 units.

Table 6.1: Table showing the effect, on the service costs, of different disturbance SDs for the 2 criteria: The mean service level and the service level guaranteed 99% of the time.

	Mean service level.			Service level guarenteed 99%.		
Cost	SD=2	SD=5	SD=10	SD=2	SD=5	SD=10
80	80.03	80.20	80.76	76.45	71.66	64.91
82	82.04	82.21	82.70	78.36	73.46	66.53
84	84.04	84.21	84.61	80.27	75.25	68.15
86	86.04	86.22	86.47	82.18	77.04	69.78
88	88.04	88.21	88.25	84.09	78.83	71.40
90	90.04	90.18	89.95	86.00	80.62	73.02
92	92.04	92.11	91.54	87.91	82.42	74.65
94	94.04	93.93	93.00	89.82	84.21	76.27
96	96.03	95.59	94.33	91.73	86.00	77.89
98	97.89	97.01	95.50	93.65	87.79	79.51
100	99.26	98.14	96.51	95.56	89.59	81.14
102	99.86	98.94	97.36	97.47	91.38	82.76
104	99.99	99.46	98.05	99.38	93.17	84.38
106	100.00	99.75	98.61	100.00	94.96	86.00
108	100.00	99.90	99.04	100.00	96.75	87.63
110	100.00	99.96	99.36	100.00	98.54	89.25
112	100.00	99.99	99.60	100.00	100.00	90.87
114	100.00	100.00	99.76	100.00	100.00	92.49
116	100.00	100.00	99.88	100.00	100.00	94.12
118	100.00	100.00	99.95	100.00	100.00	95.74
120	100.00	100.00	100.00	100.00	100.00	97.36

For the Mean criteria:

$$\text{Service level} = \Phi(U) + \frac{1}{\sqrt{2\Pi}} \int_{u}^{\infty} \frac{Xe^{\frac{-X^2}{2}}}{U} dx$$

$X=102 \quad \therefore U=2/5=0.4$

$\Phi(u)=0.6554$

$\frac{1}{\sqrt{2\Pi}} \int_{u}^{\infty} \frac{Xe^{\frac{-X^2}{2}}}{U} dx$ can be approximated by numerical methods.

If a trapezium rule approach is used with intervals of 1 unit then

$$\frac{1}{\sqrt{2\Pi}} \int_{u}^{\infty} \frac{Xe^{\frac{-X^2}{2}}}{U} dx = \sum_{I=1}^{\infty} \left[\Phi\left(\frac{102-\mu+I-1}{\sigma}\right) - \Phi\left(\frac{102-\mu+I}{\sigma}\right) \right]_{101.5+I}^{102}$$

The summation of this is shown in the table below:

I	Φ [(2+I−1)/5] − Φ[(2+I)/5]	102/(101.5+I)	PRODUCT
1	0.0703	0.99512	0.06995
2	0.0624	0.98551	0.06146
3	0.0532	0.97608	0.05195
4	0.0436	0.96682	0.04215
5	0.0343	0.95775	0.03285
6	0.0260	0.94883	0.02467
7	0.0189	0.94009	0.01777
8	0.01315	0.93151	0.01249
9	0.00885	0.92308	0.00082
10	0.00570	0.91480	0.00521
11	0.00354	0.90667	0.00321
12	0.00210	0.89678	0.00189
13	0.00121	0.89083	0.00108
14	0.00066	0.88311	0.00058
15	0.00035	0.87554	0.00030
16	0.00018	0.86809	0.00016
17	0.00009	0.86076	0.00008
18	0.00007	0.85356	0.00006
		Σ	0.33404
		Φ(U)=	0.65540
		SERVICE LEVEL	0.98944

Service level guaranteed 99% of time criteria.

Service level=102/(100+(2.325x5)=91.38%

The analysis results are shown graphically in Figs 6.10 and 6.11. These results indicate that for the example explored, for low service levels the mean criteria costs are not tremendously affected by the different disturbance SDs. However, as the service level required increases, so does the effect of the disturbance variations. This is due to the costs of a high mean service level being largely dependent on the costs for the higher disturbance levels. (This is because the service level for the other disturbances remain constant as they have already reached 100 %). The greater the disturbance variation the slower this increase in the service level. However, when low mean service levels are required, it is slightly advantageous to have high disturbance variations. This is because the lower service levels are more

affected by the rate of service increase for the smaller disturbance levels (which is greater with higher disturbance variation) than the increases for the higher disturbance levels.

Also the analysis results demonstrate for the example investigated that the costs for guaranteeing a service level, 99% of the time, are more affected by disturbance variation than the mean service level criteria.

Fig 6.10: A graph showing the effect of variation in the disturbances on the service costs for the mean service level- for the standard example.

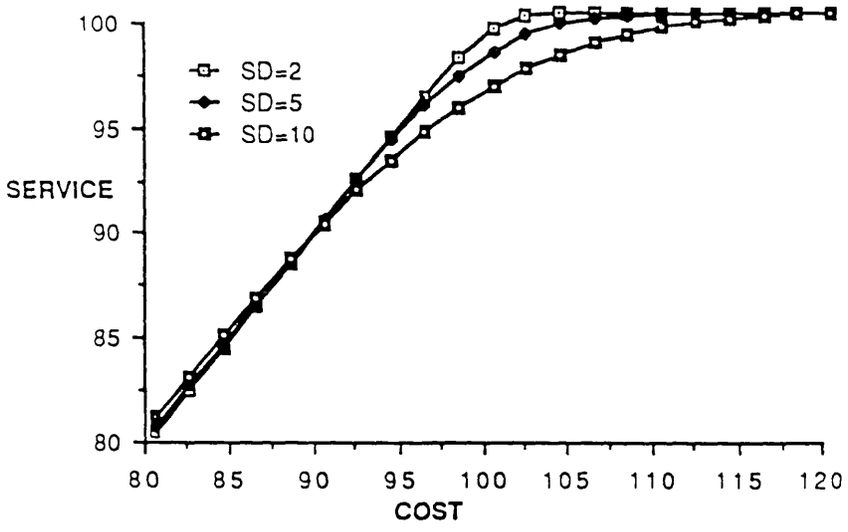
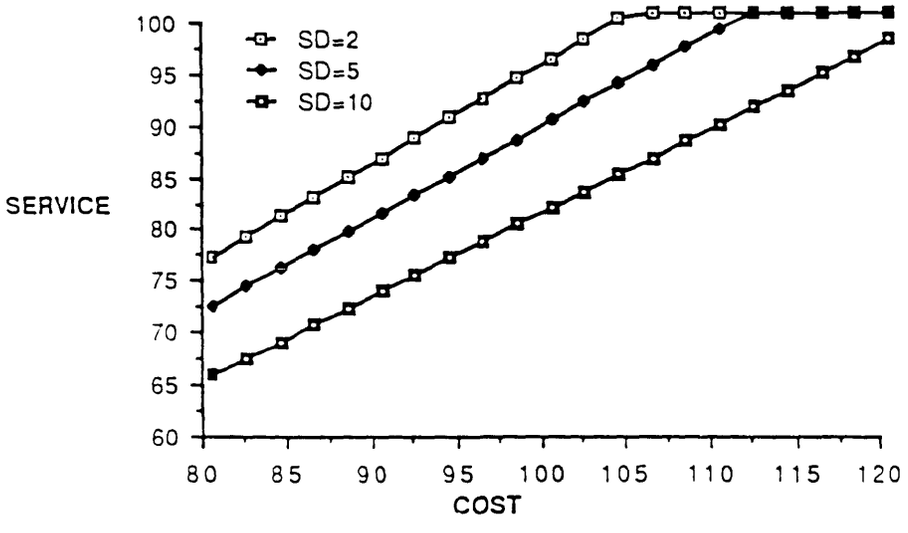


Fig 6.11: A graph showing the effect, of variation in the disturbances, on the service costs for the service level guaranteed 99% of the time- for the standard example.



In summary, the analysis results demonstrate that disturbance

uncertainty/variation can influence the service costs and this can have a greater effect when guaranteeing a service level, 99% of the time (a tighter criteria), than on the mean service level (a loose criteria). Generally an increase in disturbance variation levels leads to an increase in the service costs.

II) Reducing the service costs by linking service measures together: By linking two, or more service measures together enables the common service responses to be shared between the different service measures. This reduces the effect of the disturbance variations. This is because there is a reduction in the overall disturbance variation in relation to the mean disturbance level (this is a result of the disturbances variances being added together rather than the standard deviations being added together). Another advantage is that disturbance variations for one service measure highly influenced by these variations such as tight service criteria, can be shifted on to other service measures less affected by these variations. These two effects, on the costs are now investigated. It should be stressed that this approach gives a controller further options and does not exclude the option of keeping things as they are. This means that this approach, if managed sensibly, cannot make a situation any worse.

Effect 1: The reduction in the overall disturbance uncertainty. It has been shown, that the disturbance SD can influence the service cost. However, when service measures are linked together their individual disturbances variances are combined. This reduces the overall effect of the disturbance uncertainty which usually leads to a beneficial effect on the service costs.

The following results, shown in Table 6.2, indicate the costs reductions that are achievable by using this approach for the standard example. It is assumed that there are two measures each with disturbances normally distributed with a mean value of 100 units and SD of 5 units, which are combined together. Thus, when combined together they have a mean level of 200 units and a SD of 7.07. The results, are shown in Fig 6.12 and Fig 6.13. As expected, these results indicate a reduction in the service costs. This reduction, is greater when guaranteeing a service level, 99 % of the time. This is not surprising,as it was shown earlier, that this criteria's service costs were more vulnerable to disturbance variations. An example of this saving would be combining together of safety stocks by joining two warehouses together.

Effect 2: Shifting disturbances onto other measures: How the disturbance variations for one service measure can be passed on to another service measure is demonstrated here by looking at the

Table 6.2: Table showing the cost saving that are achieved when reducing the overall disturbance uncertainty, by linking two similar service measures together.

	Mean service level.		99% Guarantee.	
Cost.	Seperate.	Linked.	Seperate.	Linked.
180	90.18	90.11	80.62	83.16
184	92.10	92.10	82.42	85.01
188	93.93	94.05	84.21	86.86
192	95.59	95.88	86.00	88.71
196	97.01	97.46	87.79	90.56
200	98.13	98.66	89.59	92.40
204	98.94	99.41	91.38	94.25
208	99.45	99.79	93.17	96.10
212	99.75	99.94	94.96	97.95
216	99.90	99.98	96.75	99.80
220	99.96	100.00	98.54	100.00

Fig 6.12: A graph showing the cost reductions, in the mean service level, due to reduction in the overall disturbance levels, achieved by linking measures together, for the standard example.

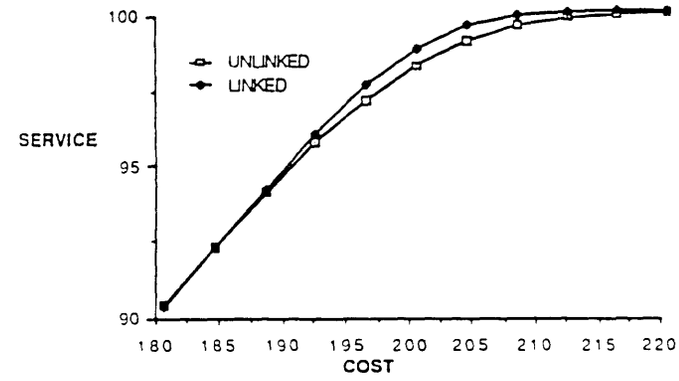
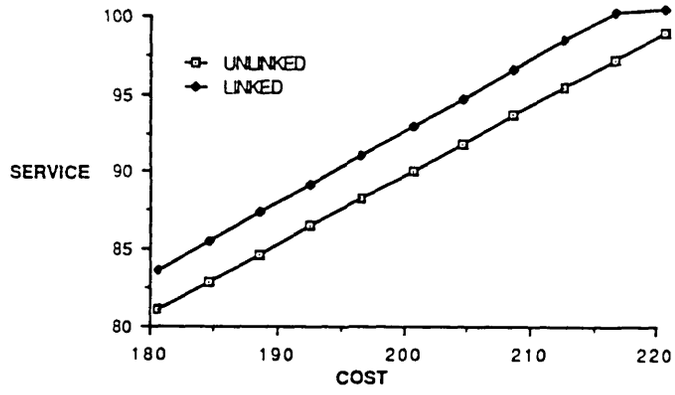
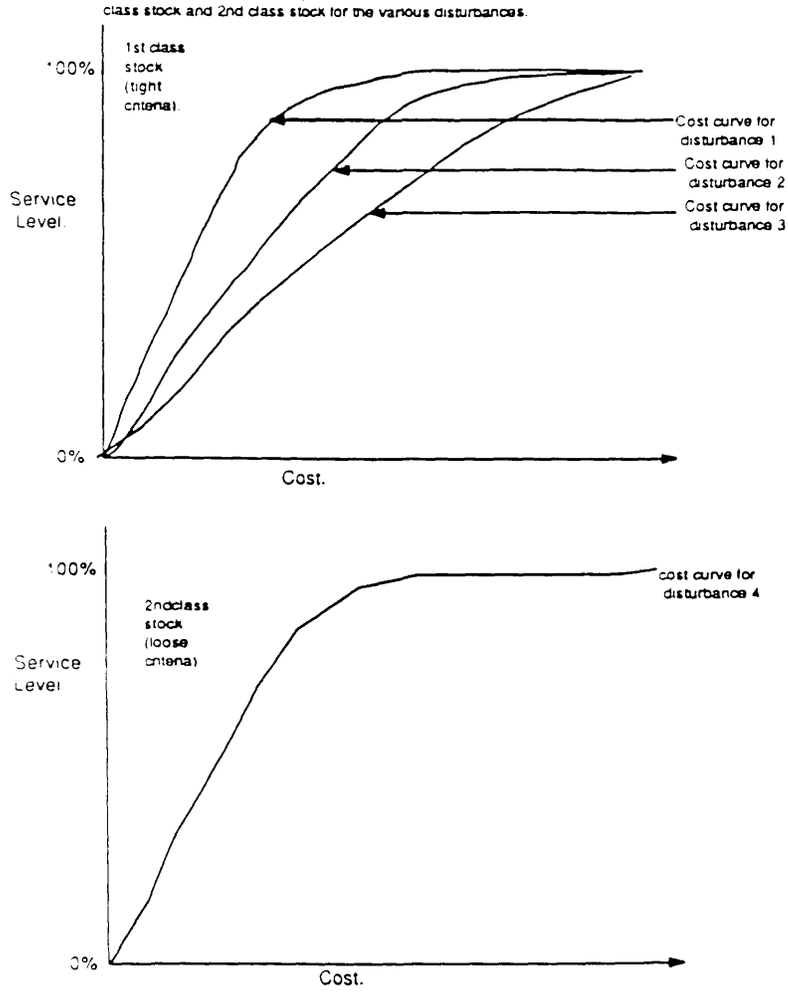


Fig 6.13: A graph showing the cost reductions, in the service level guaranteed 99% of the time, due to reduction in the overall disturbance levels, achieved by linking measures together, for the standard example.



picking of warehouse stock. let it be assumed that there are two classes of stock with different types of criteria, 1st class having a tight criteria and 2nd class having a loose criteria. Here there are three disturbances 1-3, for 1st class stock. There is one disturbance, 4, independent of disturbances 1-3, hitting the system for 2nd class stock. The possible graphs of the service costs for the 2 situations, are shown in Fig 6.14.

Fig 6.14 A diagram showing the different service cost curves for 1st class stock and 2nd class stock for the various disturbances.



Normally, if a controller wants to guarantee a service level for 1st class stock he needs enough response staff to meet disturbance 1 requirements. Consequently there are excess staff when disturbances 2 and 3 happen. However, when linked to picking second class stock, these excess staff can be transferred to picking this stock. (If these two service measures were not linked, then these excess staff would be wasted). This approach enables a guaranteed service level to be achieved at the mean service cost for all disturbances, rather than at the cost of the disturbance with the highest service cost. The above principles are demonstrated with reference to Fig 6.15. where staff levels assigned to picking first class stock are set to A -enough to pick the stock if disturbance 1

occurs. However, if disturbance 2 or 3 occur then the staff levels used are B or C.Thus, levels A-B, or A-C, are transferred to picking second class stock. It should be noted that for picking first class stock the disturbance level is determining the staff level being used.

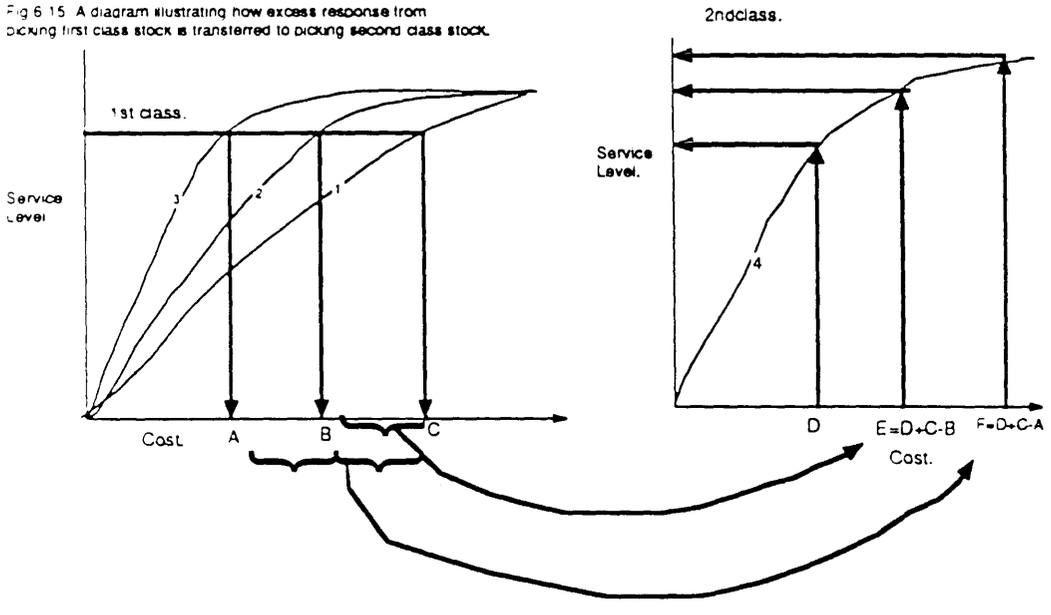


Fig 6.15 A diagram illustrating how excess response from picking first class stock is transferred to picking second class stock.

In this situation second class stock is used to cushion picking first class stock from the effects of the disturbance variations. This is useful, as service costs of first class' criteria, tight, are highly vulnerable to disturbance variations. However, there is an increase in the costs for picking second class stock resulting from the variation in the response level being used. Fortunately this usually has only a small effect due to the mean service cost curve usually being almost linear, see Fig 6.11. Consequently this generally means that, the decreases in the second class stock gross profit margin are outweighed by the gross profit increases, for the first class stock. It should be noted that the costs of picking second class is the cost of staff assigned to picking second class stock only plus

the mean cost of the staff transferred from picking 1st class stock (this varies according to the disturbance level and service level required for first class stock).

The cost savings that are possible by using this approach are now demonstrated for the standard example. Guaranteeing a service level 99 % of the time criteria was linked to the mean service level criteria. A response level of 120 units was fixed for the 99% guarantee service measure with the excess response, and cost, being transferred to the mean service criteria measure. It is expected that there should be a decrease in the 99% guarantee measure costs and a slight increase in the mean criteria's service costs. The results of this analysis are shown in Table 6.3. As was expected the results, shown in Fig 6.16 and Fig 6.17, indicate that cost savings are achieved for the service level guaranteed 99% of the time service measure. Also, as expected, there is a slight increase in the costs for the mean service criteria measure.

It has been suggested that the increase in costs of the measure receiving transferred response was dependent on whether its service cost curve was linear or not. The principles underlying this fact are shown in Fig 6.18. If the part of the curve which the transferred response is effecting, that is between A and B in Fig 6.18 is linear then there is no effect on the costs. However, if the portion of the service cost curve affected by the response is not linear then there will be an effect on the costs. Two important consequences follow from this:

Table 6.3: Table showing the cost savings that are achieved by linking two measures together for the standard example. (Where the service level guaranteed 99% of the time is linked to the mean service level criteria).

	Mean service level.		99% Guarantee.	
Cost.	Seperate.	Linked.	Seperate.	Linked.
80	80.20	80.20	71.66	80.97
82	82.21	82.20	73.46	83.00
84	84.21	84.18	75.25	85.02
86	86.22	86.15	77.04	87.04
88	88.21	88.08	78.83	89.07
90	90.18	89.96	80.62	91.09
92	92.11	91.76	82.42	93.11
94	93.93	93.42	84.21	95.14
96	95.59	94.93	86.00	97.17
98	97.01	96.23	87.79	99.20
100	98.14	97.32	89.59	100.00
102	98.94	98.18	91.38	100.00
104	99.46	98.82	93.17	100.00
106	99.75	99.28	94.96	100.00
108	99.90	99.59	96.75	100.00
110	99.96	99.77	98.54	100.00
112	99.99	99.89	100.00	100.00
114	100.00	99.94	100.00	100.00
116	100.00	99.97	100.00	100.00
118	100.00	99.99	100.00	100.00
120	100.00	100.00	100.00	100.00

Fig 6.16: A graph showing the effects, on the service costs, of linking the two criteria together, for the mean service criteria (the recipient of the transferred response) - for the standard example.

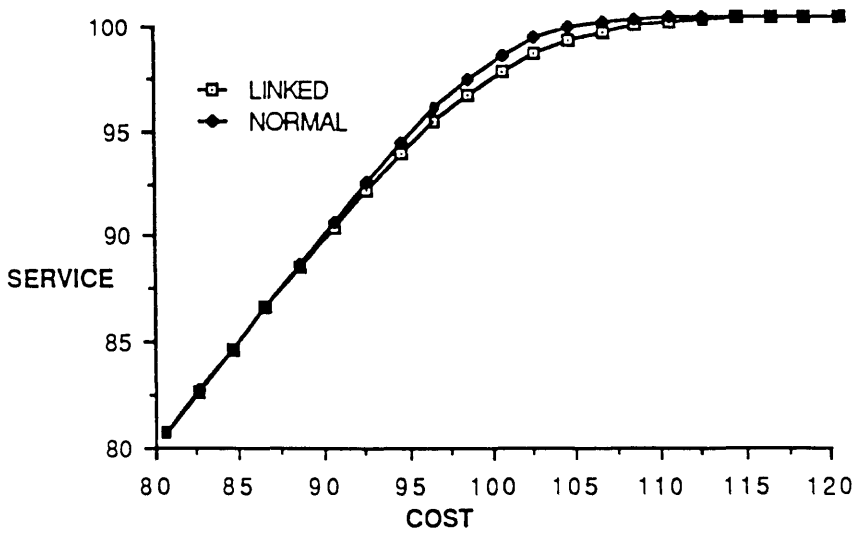


Fig 6.17: A graph showing the effects, on the service costs, of linking the two criteria together, for the service level guaranteed 99% of the time criteria (the donor of the transferred response) - for the standard example.

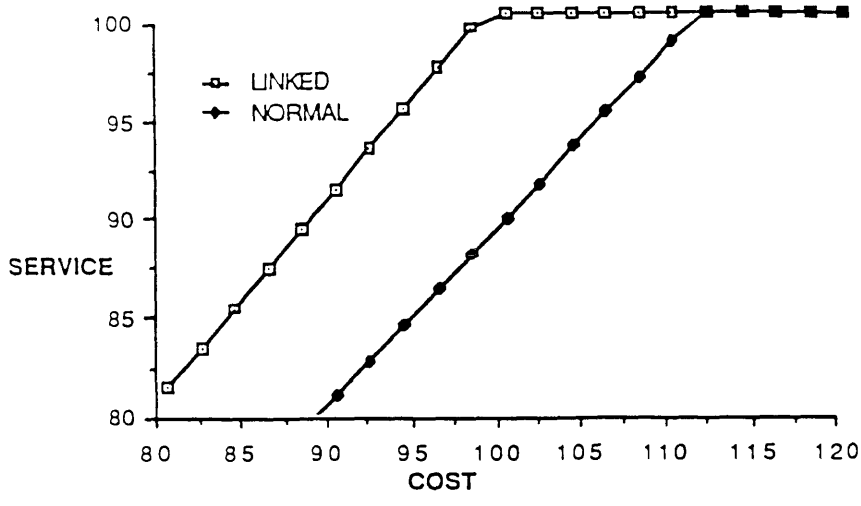
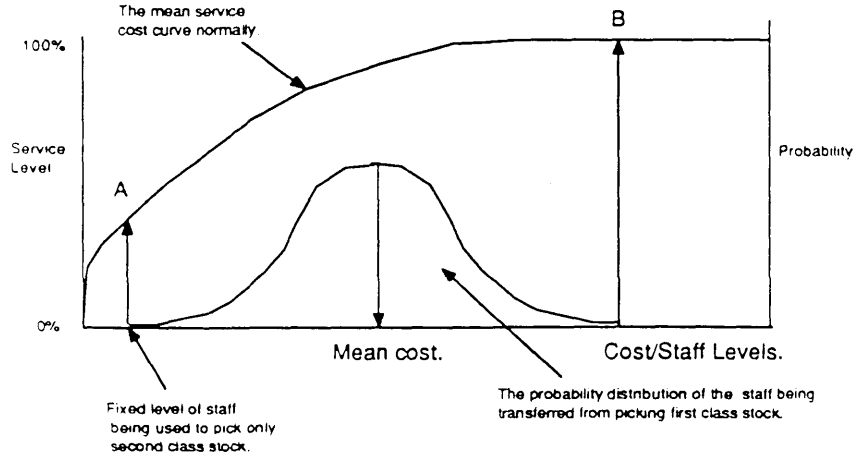


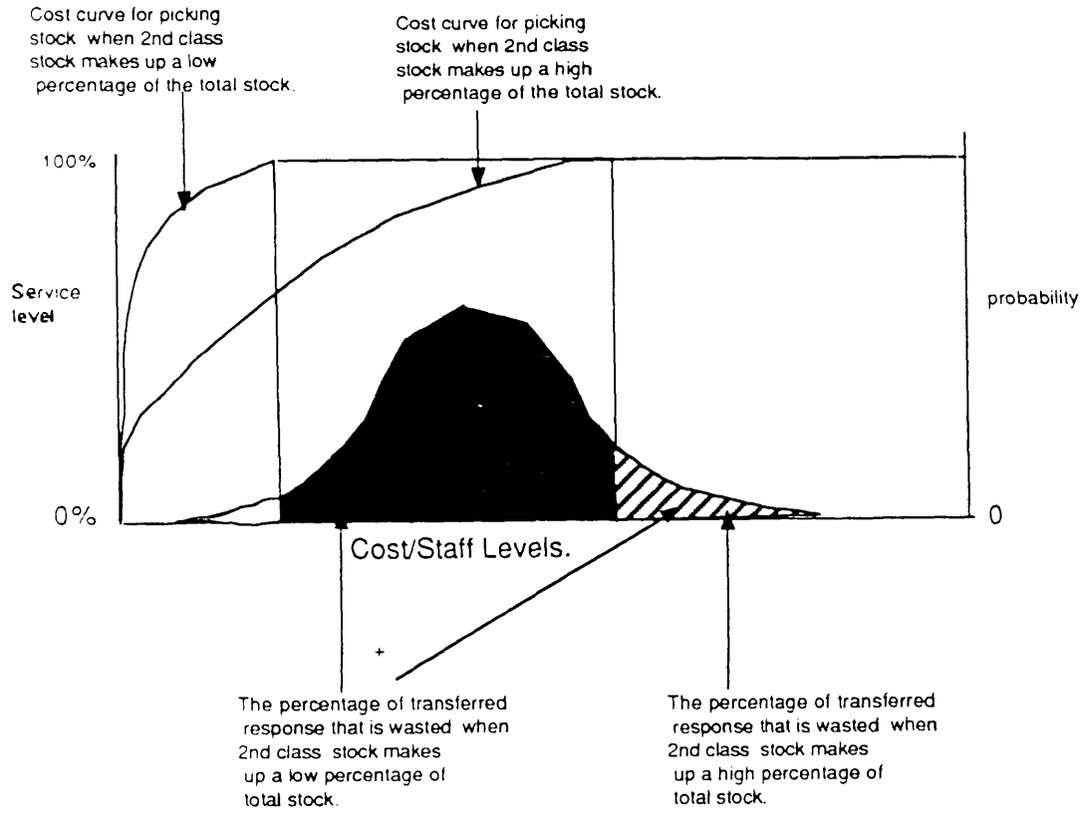
Fig 6 18 A diagram showing the principles underlying the need for the cost curve to be linear inorder for no cost increases to occur, in the recipient service situation, when transferring excess service responses to it.



Consequence 1: That the service costs increase if the part of the recipient service measure's service cost curve that is linear is decreased. This happens when the proportion of the total workload, disturbances, covered by the recipient service situation decreases. For example, if the level of second class stock, as a proportion of the total stock being picked in a warehouse, is decreased then there will be an increase in the

relative costs of picking second class stock. This principle is illustrated in Fig 6.19, where the proportion of the response that is not increasing the total service level is increased. That is a high percentage of the service response level is wasted.

Fig 6.19: A diagram showing why the service costs in the recipient service situation increase when this situation handles a low proportion of the total workload.



Consequence 2: That if the variation in the response being transferred is increased then the service costs of the recipient service measures will be increased. This situation happens as the service level of the donor service measure is increased.

Both of these consequences are now explored for the example considered earlier in this section. Where a service measure

guaranteeing a service level 99% of the time is linked to a service measure which has only to achieve a mean service level.

Consequence 1, decreasing the proportion of the workload handled by the recipient of the transferred response: The distribution of the disturbance, level of workload, needed to be handled by the donor service situation was kept constant as being normally distributed with mean of 100 and SD of 5. However, the distributions of the workload facing the recipient service situation was varied. Three scenarios were investigated. These are shown below:

Scenario 1: The level of workload facing the recipient service situation is normally distributed with mean of 100 and SD of 5.

Scenario 2: The level of workload facing the recipient service situation is normally distributed with mean of 50 and SD of 2.5.

Scenario 3: The level of workload facing the recipient service situation is normally distributed with mean of 25 and SD of 1.25.

The results of this analysis are shown in Table 6.4. It should be noted that the service costs have been standardised so as to allow comparison of the results of the different scenarios. This means that the costs of scenario 2 have been doubled and that the costs of scenario 3 have been quadrupled. A

Table 6.4 Table showing the effect on the service costs, for the 3 different scenarios of the recipient service situation's handling various proportion of the total workload.

		Scenario.		
Cost.	Unlinked.	1.	2.	3.
80	80.20	80.20	80.04	78.40
82	82.21	82.20	81.96	80.04
84	84.21	84.18	83.83	81.63
86	86.22	86.15	85.65	83.17
88	88.21	88.09	87.40	84.65
90	90.18	89.97	89.07	86.05
92	92.11	91.76	90.65	87.39
94	93.93	93.43	92.11	88.65
96	95.59	94.93	93.45	89.83
98	97.01	96.23	94.65	90.94
100	98.14	97.32	95.70	91.97
102	98.94	98.18	96.62	92.92
104	99.46	98.83	97.39	93.81
106	99.75	99.28	98.02	94.59
108	99.90	99.59	98.54	95.32
110	99.96	99.77	98.94	95.97
112	99.99	99.89	99.25	96.56
114	100.00	99.95	99.48	97.07
116	100.00	99.98	99.65	97.53
118	100.00	99.99	99.77	97.93
120	100.00	100.00	99.85	98.27

uniform service level of 98% was kept for the donor service situation. The results are shown in Fig 6.20. and seem to support the hypothesis that decreasing the proportion workload of the whole workload handled by the recipient service situation can increase the relative service costs. Consequently indicating that there is a need to be cautious when choosing what service measures can be linked together.

Consequence 2: That the service level required by the donor service situation affects the costs of the recipient service situation. This hypothesis was tested for the 3 scenarios indicated above. Various levels of service required in the donor service situation were set. These service levels were set as follows: 80%, 90%, 95% and 98%. The results of this investigation are shown in Table 6.5. Again the service costs for the different scenarios have been standardised to allow a comparison to take place.

Fig 6.20: Graph showing the effect that handling different proportions of the total workload has on the service costs in the recipient service situation for the different scenarios.

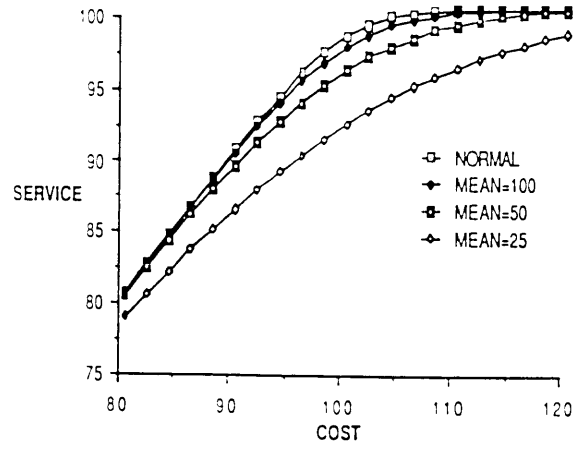


Table 6.5: A table showing the effect (for the 3 different scenerios) that different required service levels in the donor service situation has on the service costs in the recipient service situation when two service measures are linked together.

	Scenerio 1				Scenerio 2				Scenerio 3			
service level / Cost	80%	90%	95%	98%	80%	90%	95%	98%	80%	90%	95%	98%
80	80.20	80.20	80.20	80.20	80.14	80.09	80.06	80.04	79.19	78.78	78.54	78.40
82	82.20	82.20	82.20	82.20	82.10	82.02	81.98	81.96	80.93	80.46	80.21	80.04
84	84.20	84.19	84.19	84.18	84.02	83.92	83.86	83.83	82.61	82.09	81.81	81.63
86	86.18	86.17	86.16	86.15	85.90	85.77	85.70	85.65	84.23	83.66	83.36	83.17
88	88.14	88.11	88.10	88.09	87.73	87.56	87.46	87.40	85.97	85.17	84.85	84.65
90	90.04	90.00	89.97	89.97	89.47	89.26	89.15	89.07	87.26	86.60	86.26	86.05
92	91.87	91.81	91.77	91.76	91.12	90.86	90.73	90.65	88.67	87.97	87.61	87.39
94	93.58	93.49	93.45	93.43	92.65	92.35	92.20	92.11	89.98	89.25	88.88	88.65
96	95.12	95.01	94.96	94.93	94.03	93.71	93.54	93.45	91.21	90.45	90.07	89.83
98	96.45	96.33	96.27	96.23	95.26	94.92	94.75	94.65	92.34	91.57	91.19	90.94
100	97.54	97.42	97.36	97.32	96.33	95.98	95.81	95.70	93.38	92.61	92.22	91.97
102	98.40	98.27	98.22	98.18	97.23	96.89	96.72	96.62	94.32	93.56	93.17	92.92
104	99.01	98.91	98.86	98.83	97.96	97.64	97.48	97.39	95.17	94.42	94.04	93.81
106	99.43	99.34	99.31	99.28	98.54	98.26	98.11	98.02	95.93	95.20	94.83	94.59
108	99.85	99.63	99.60	99.59	98.99	98.74	98.61	98.54	96.60	95.90	95.55	95.32
110	99.93	99.81	99.79	99.77	99.32	99.11	99.01	98.94	97.18	96.53	96.19	95.97
112	99.97	99.90	99.89	99.89	99.56	99.39	99.30	99.25	97.69	97.08	96.76	96.56
114	99.99	99.96	99.95	99.95	99.72	99.60	99.53	99.48	98.12	97.56	97.26	97.07
116	100.00	99.99	99.98	99.98	99.83	99.74	99.68	99.65	98.49	97.98	97.70	97.53
118	100.00	100.00	99.99	99.99	99.90	99.84	99.80	99.77	98.79	98.34	98.09	97.93
120	100.00	100.00	100.00	100.00	99.94	99.90	99.87	99.85	99.05	98.65	98.42	98.27

Scenerio 1 recipient service situation has mean disturbance level of 100 units.
Scenerio 2 recipient service situation has mean disturbance level of 50 units.
Scenerio 3 recipient service situation has mean disturbance level of 25 units.

The results shown in Fig 6.21, Fig 6.22 and Fig 6.23 indicate that the service level required in the donor service situation can affect the service costs in the recipient service situation. However, this effect is greatly reduced when the recipient service situation deals with a high proportion of the total workload.

Fig 6.21. Graph showing the effect that the different service levels in the donor service situation has on the costs in the recipient service situation for scenario 1 (mean disturbance level is 100 units).

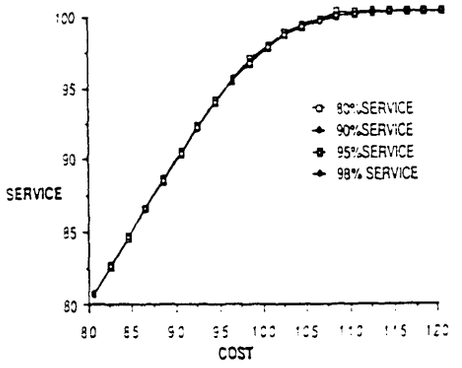


Fig 6.22. Graph showing the effect that the different service levels in the donor service situation has on the costs in the recipient service situation for scenario 2 (mean disturbance level is 50 units).

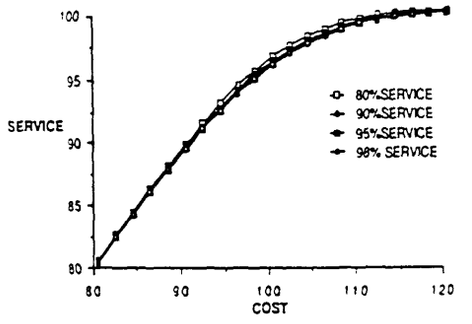
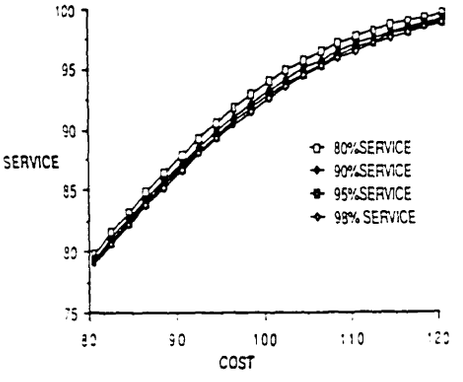


Fig 6.23. Graph showing the effect that the different service levels in the donor service situation has on the costs in the recipient service situation for scenario 3 (mean disturbance level is 25 units).



However it must be stressed that for this approach, of linking service measures together, to be viable, there is a need to be able to transfer the excess response from

one service measure to the other service measure. For example it is often impossible to transfer excess staff from a London warehouse to a Glasgow warehouse.

Approach 3: Responding to the individual disturbances differently. This section, looks at how the service costs can be reduced, by responding to each disturbance differently. A general discussion on the underlying principles of this approach is followed by the illustration of the savings achieved in the standard example. An indication is then given of the activities required in a system which responds to the individual disturbances differently. A comparison is then made of this approach against the approach of linking service measures together.

I) General introduction: The disturbances, hitting the PD system, can not be affected by PD. However, the effect these disturbances have, on the service level, can be influenced by PD's responses. These responses determine the transformation of the disturbances into service levels. Ideally this transformation should change to reflect the disturbance changes. That is PD should tailor their responses, to the particular disturbance occurring, in order to achieve a particular service level. This generally results in a reduction in the service costs. For example, if a warehouse manager knows the picking workload, he can then determine the manpower required to achieve a particular service level, thus, reducing his costs. As with linking of service measures together this approach if managed successfully should not increase the service costs as it is possible to leave the situation as it was before.

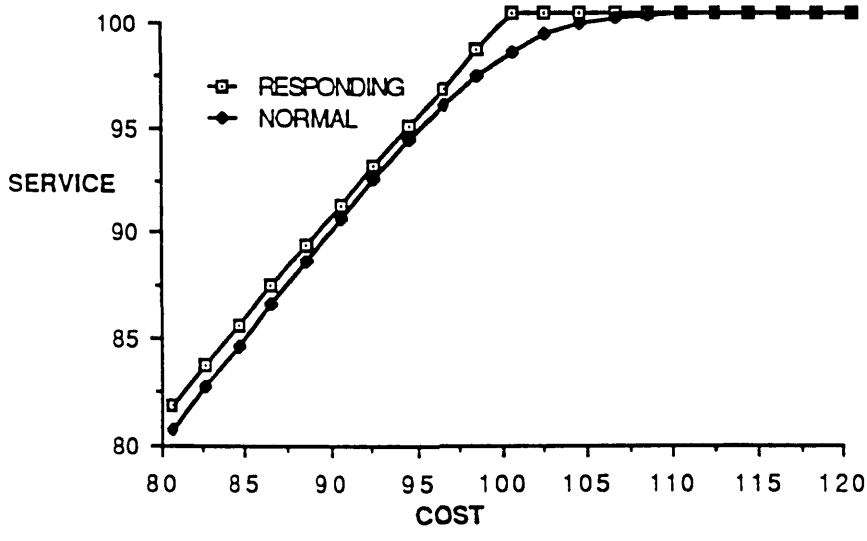
II) Example of the saving achieved for the standard example: The service costs when meeting each disturbance differently, for the standard example, are shown below in Table 6.6, along with service costs when not meeting each disturbance differently. The results, shown in

Fig6.24 and Fig 6.25, demonstrate that service cost reductions are achievable by responding to disturbances differently.

Table 6.6 : A table showing the cost savings produced by responding to each disturbance differently, for both of the critena, in the standard example.

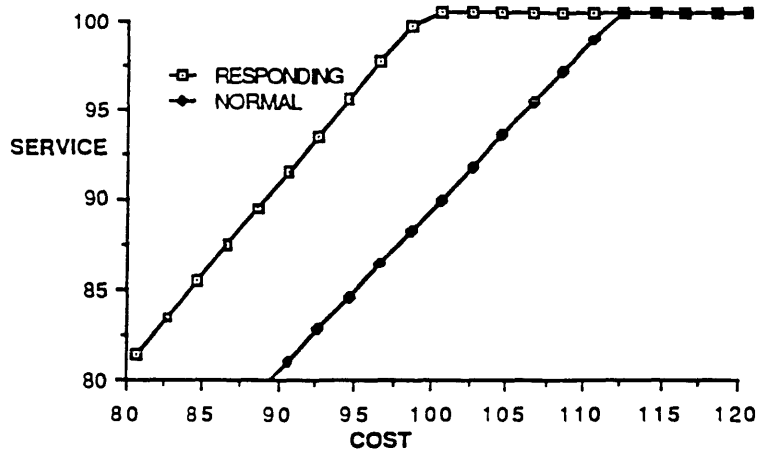
	Mean service level.		99% Guarantee.	
Cost	Normal	R.T.D.	Normal	R.T.D.
80	80.20	81.34	71.66	80.97
82	82.21	83.26	73.46	83.00
84	84.21	85.16	75.25	85.02
86	86.22	87.05	77.04	87.04
88	88.21	88.94	78.83	89.07
90	90.18	90.83	80.62	91.09
92	92.11	92.70	82.42	93.11
94	93.93	94.55	84.21	95.14
96	95.59	96.40	86.00	97.17
98	97.01	98.22	87.79	99.20
100	98.14	100.00	89.59	100.00
102	98.94	100.00	91.38	100.00
104	99.46	100.00	93.17	100.00
106	99.75	100.00	94.96	100.00
108	99.90	100.00	96.75	100.00
110	99.96	100.00	98.54	100.00
112	99.99	100.00	100.00	100.00
114	100.00	100.00	100.00	100.00
116	100.00	100.00	100.00	100.00
118	100.00	100.00	100.00	100.00
120	100.00	100.00	100.00	100.00

Fig 6.24: A graph showing the cost reductions achievable, for the mean service level criteria, by reponding to each disturbance differently, for the standard example.



III) The activities that are required to be performed: There are several activities required when responding to the disturbance differently.

Fig 6.25: A graph showing the cost reductions achievable, for the service level guaranteed 99% of the time criteria, by reponding to each disturbance differently for the standard example.



These are indicated below:

i) Actually defining what the disturbances are.

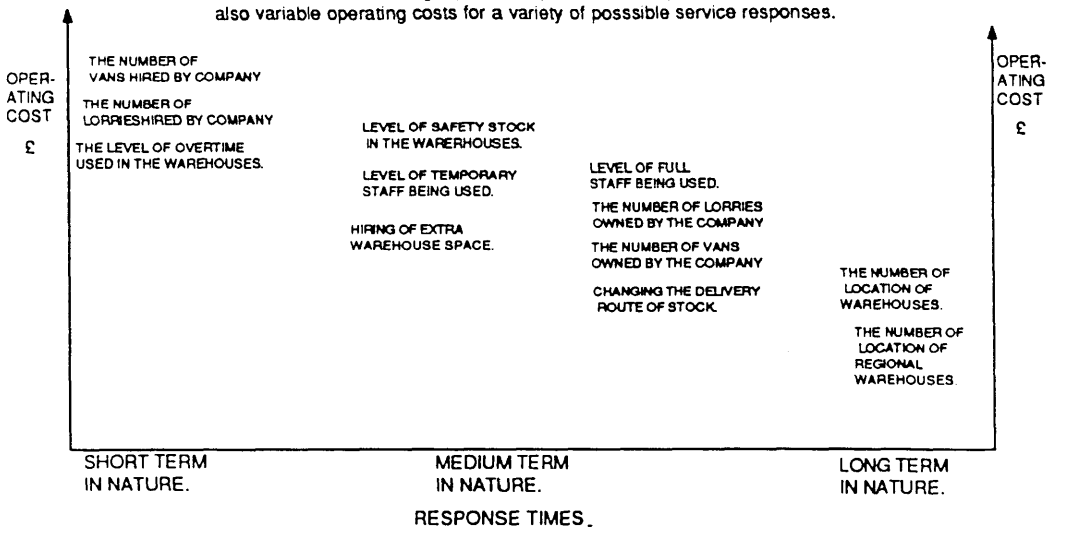
ii) Defining what the disturbance levels are.

iii) Being able to respond to the changes in disturbance levels quickly enough: If the disturbances change quicker than it is possible to change the responses then there is no point in changing the response level to meet these disturbance changes. If an attempt is made it will only result in oscillatory behaviour occurring Consequently there is a need to define the rate at which each response service factor can be changed and the rate at which the disturbance level are changing. Table 6.7 shows a possible spectrum for whether various PD responses can be changed in the short term, medium term, or only in the long term.

iv) Knowing what the disturbance level will be in the future: By knowing what the disturbance levels will be in the future gives PD

more time to react to the disturbances. This means that it is more likely to be able to respond to the disturbance changes.

Table 6.7: Table showing a possible spectrum of response times and also variable operating costs for a variety of posssible service responses.



v) Defining the transitional fixed costs, associated with changing the response level. Counteracting the savings associated with reacting to different disturbances differently, there are often transitional costs associated with changing from one response level to another. These transitional costs have to be defined to make sure that they do not outweigh the savings achieved. An example of this is the question of the number and location of warehouses. The operating costs would imply regular changes to reflect market changes where as the transitional costs of relocating and building warehouses would not.

IV) Comparison with linking service measures together: By comparing Fig 6.25 with Fig 6.17 it can be seen that the graphs are in fact identical. This is because, by being able to transfer excess response, to another service situation, makes it possible to respond to each of the disturbances differently. Thus these two approaches have similar effects on the service costs. However, there are advantages associated with both of

these approaches. The advantages of linking service measures together is that there is no need to know the disturbance level. The advantages of reacting differently to the different disturbances are that there is no need to have another service measure to link to. Also there are no problems associated with the increased costs in the service situation that is receiving the transferred excess response.

Consequently, probably the best approach is to attempt to use a combination of the two approaches, by reacting to the long term disturbance changes, such as the more predictable seasonal variations, by changing the response level and dealing with the more short term 'unpredictable' changes, by linking service measures together.

6.7.4 Conflict between different cost reducing techniques.

Unfortunately, there is often a conflict between responding to each disturbance differently and making trade-offs between the different service responses. This is generally because the service responses whose response levels can be changed quickly are usually more expensive in nature. An example of this conflict is the use of overtime in warehouses. The trade-off between service responses would say that overtime should not be used, however responding to each of the disturbances, argues that overtime should be used. Thus a compromise between these extremes has to be decided upon. This can only be done by, considering the long term costs.

6.7.5 Differences in long term and short term costs.

It has been argued that there is a need to have an accurate situation model and also that the costs have to be considered in the long term. So far the discussion has assumed that the service level is independent of time. Unfortunately this is not always true. Often the long

term costs are different to the short term costs. This happens when the following two cases occur:

Case 1: The disturbance levels are affected by previous service levels (cumulative disturbances). This is the situation when work not completed in one time period, is carried over to the next.

Case 2: The resources, responses, are not perishable (cumulative responses). This is the situation when unused responses, in one time period, can be used in the next.

Thus there are 4 separate possible situations. Each is shown and discussed below for the standard example, quoted in section 6.3.1 for the mean criteria only. The results for this analysis are shown in Table 6.8. The service situations are shown initially and after 10 time intervals. It is assumed that a constant response level is retained throughout the 10 time periods.

Situation 1. Neither the disturbances nor the responses are cumulative: Fig6.26 shows the overall mean service level, after 10 10 time periods. and Fig 6.27 shows the initial mean service level. These graphs are identical. This is due to the situation being the same every time. Thus, this situation is time independent.

Situation 2. The disturbances are not cumulative but the responses are: The overall mean service level, after 10 time periods, is shown in Fig 6.28. Initially the service curve is the same as situation 1. The service level then gradually increases. Although not stated here it can be proved, by induction, that the service level increases monotonically with time. When the response is greater than 100 units (the mean disturbance level) then the service level's least upper bound is 100 %. As in theory none of the response is ever 'wasted'. This makes it possible to react to each disturbance level, no matter what the disturbance level is, by having

an endless level of response. However, in practice this is not correct as there is a cost associated with storing the excess response.

Table 6.8 : A table showing the initial service costs and the service costs after 10 time periods for the 4 different service situations
Situation 1: Neither the disturbances nor the responses are cumulative.
Situation 2: The disturbances are not cumulative but the responses are.
Situation 3: The disturbances are cumulative but the responses are not.
Situation 4: Both the disturbances and the responses are cumulative.

Cost	Normal	Situation1	Situation2	Situation3	Situation4
80	80.20	80.20	80.20	00.00	00.00
82	82.21	82.21	82.21	00.00	00.00
84	84.21	84.21	84.21	00.00	00.00
86	86.22	86.22	86.22	00.00	00.00
88	88.21	88.21	88.22	00.00	00.00
90	90.18	90.18	90.22	00.00	00.00
92	92.11	92.11	92.22	00.00	00.00
94	93.93	93.93	94.10	00.00	00.00
96	95.59	95.59	96.17	00.00	00.00
98	97.01	97.01	98.03	00.00	00.00
100	98.14	98.14	100.00	00.00	96.93
102	98.94	98.94	100.00	97.00	100.00
104	99.46	99.46	100.00	99.03	100.00
106	99.75	99.75	100.00	99.67	100.00
108	99.90	99.90	100.00	99.88	100.00
110	99.96	99.96	100.00	99.96	100.00
112	99.99	99.99	100.00	99.99	100.00
114	100.00	100.00	100.00	100.00	100.00
116	100.00	100.00	100.00	100.00	100.00
118	100.00	100.00	100.00	100.00	100.00
120	100.00	100.00	100.00	100.00	100.00

Fig 6.26: A graph showing the original cost curve for situation 1: When neither the disturbances nor the responses are cumulative.

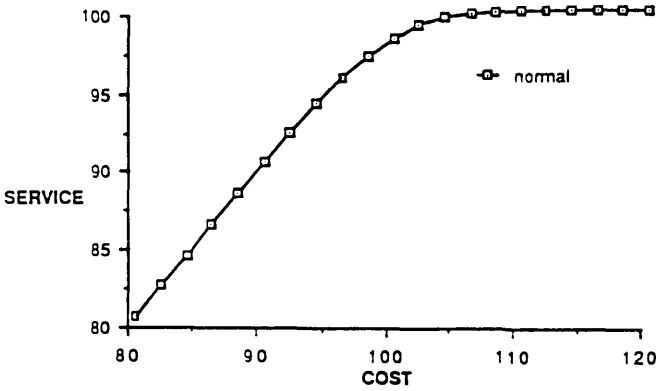


Fig 6.27: A graph showing the cost curve after 10 time periods for situation 1: When neither the disturbances nor the responses are cumulative.

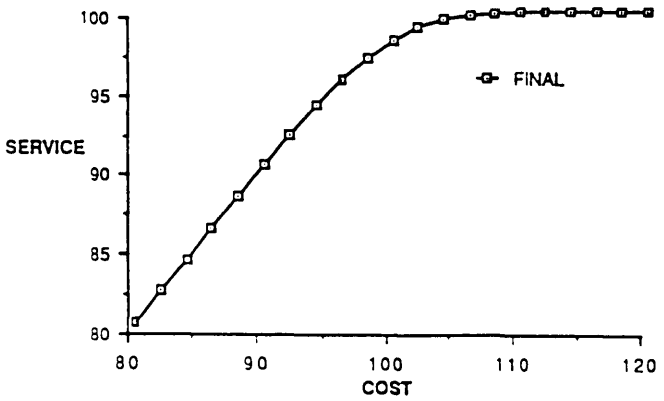
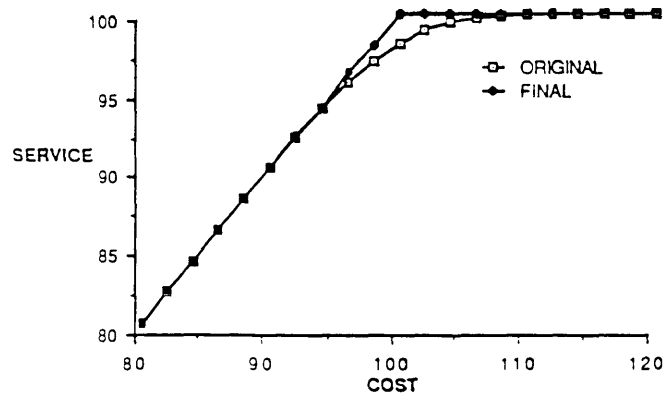
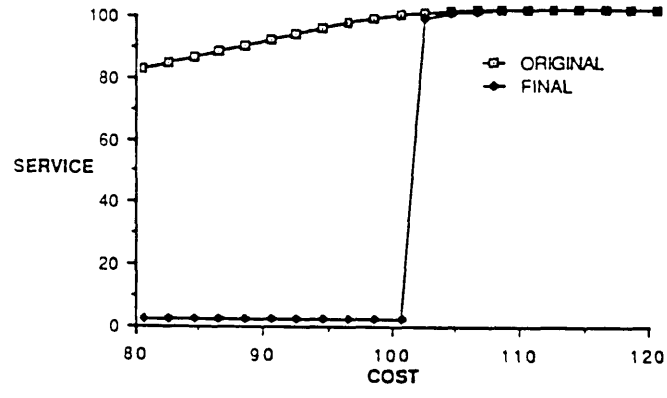


Fig 6.28: A graph showing the cost curve after 10 time periods, against the original cost curve, for situation 2: When the disturbances are not cumulative but the responses are cumulative.



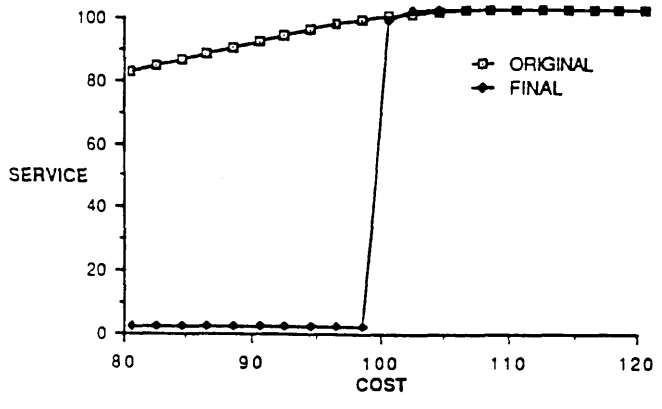
Situation 3. The disturbances are cumulative, however, the responses are not: The overall mean service costs, after 10 time periods, is shown in Fig 6.29. This shows that, if a controller does not respond with a response level at least equal to the mean disturbance rate, the the system will soon go completely out of control.

Fig 6.29: A graph showing the cost curve after 10 time periods, against the original cost curve, for situation 3: When the disturbances are cumulative but the responses are not cumulative.



Situation 4, both the disturbances and the responses are cumulative: Fig 6.30 shows the overall service costs, after 10 time periods. The service level is dependent, in the long term on which effect- the disturbances or the responses- is more dominant. Due to the competition between these two effects, the rate at which the service level tends to its limits is slower than either situation 2 or situation 3.

Fig 6.30: A graph showing the cost curve after 10 time periods, against the original cost curve, for situation 4: When both the disturbances and the responses are cumulative.



The above analysis has shown that the service costs are dependent on the particular situation and that often the long term service costs are different to the short term. Consequently, to have an accurate picture of the service situation, the system's behaviour through time has to be analysed.

6.7.6 Defining the service costs.

Below are described two basic approaches that can be used to determine the service cost:

Approach 1 The use of analytical models to 'predict' the service costs: The above discussion has shown that the service costs are partly dependent on the disturbance levels occurring. Thus, if the disturbance levels are known and an accurate model of the system's dynamics is held by PD, then the service costs can be calculated beforehand. For a particular set of disturbances, PD should know the response that will be used and the effect this has on the service level. Consequently the costs and service level are known. This sort of system is referred to as being a feedforward system.

Approach 2. Monitoring the costs and the service level. To use this approach, there is a need to define the service responses for each service measure.

Then there is a need to monitor the service level being achieved and the level/cost of each service response. Thus, there are 3 basic activities in this approach:

I) Defining the service factors for a service measure.

II) Defining the service factor costs/monitoring the service factor level.

III) Monitoring the service level.

This sort of system is referred to as being a feedback system.

6.7.7 Summary of the HASs required.

The above discussion, has highlighted several ways of minimising and defining the service costs. In order to be successful each of these approaches require certain activities to be performed. Fig 6.31 shows these activities/ HASs.

6.7.8 How can the required HASs can be carried out?

This section looks at defining possible ways of carrying out the HASs, described in the last section. Each of the required HASs shown in Fig 6.31 are identified along with possible approaches for carrying each of them out.

HAS 1: A HAS which determines a quantitative model of the relationship between the service factors (both the responses and disturbances) and the service elements: For some service measures there are well defined quantitative models for the relationship between service factors and the service measure published in the literature. An example of this is the order fill rate service element. Where appropriate these models can be used. However there are often no such nice quantitative models existing for a service measure, in the literature. Thus there is a need to define/generate a model.

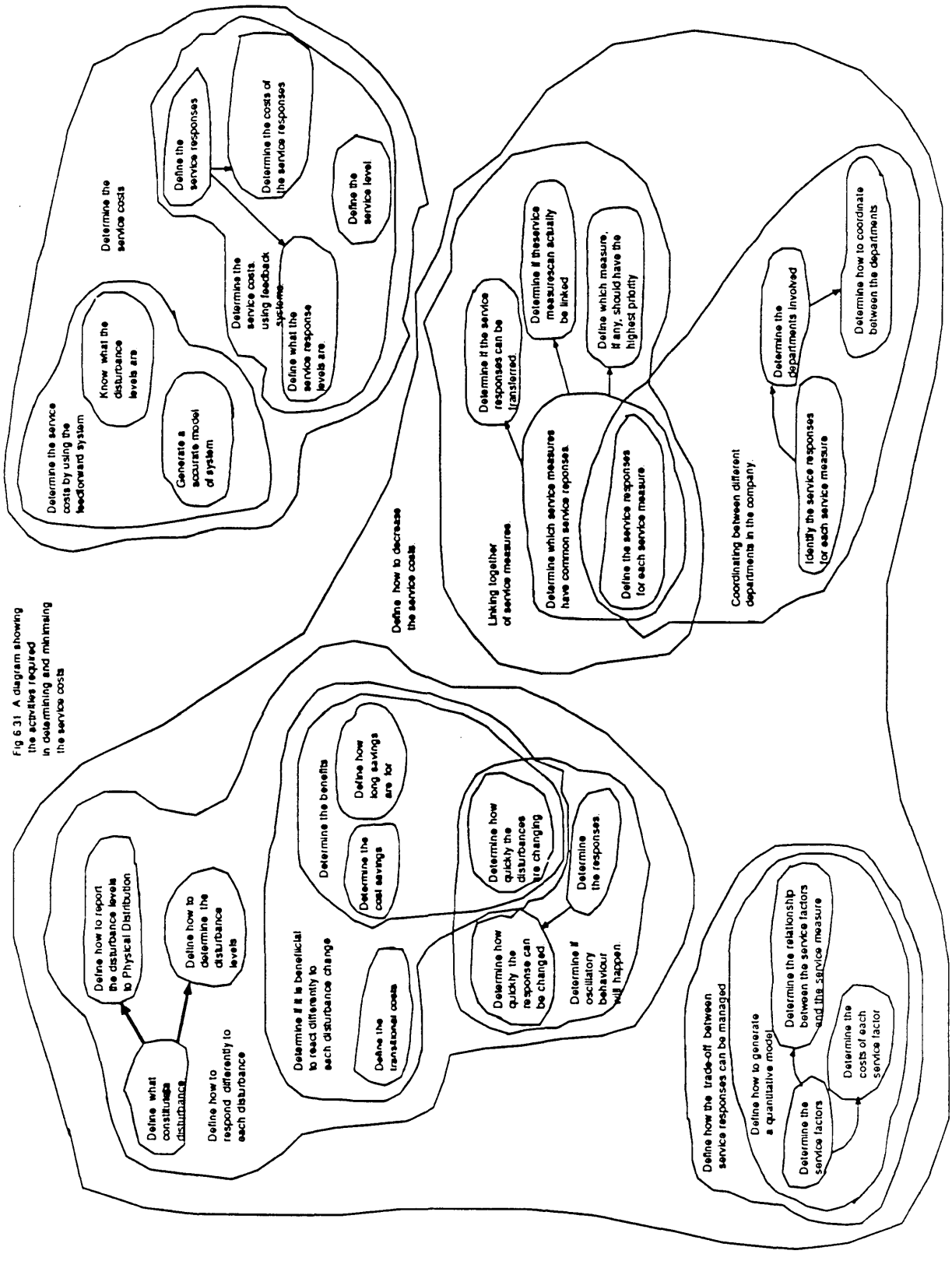


Fig 6.31 A diagram showing the activities required in determining and minimising the service costs

The first step in defining such a model is to determine the service factors- both the responses and disturbances- for a particular service measure. One way of doing this is to consult with the company's experts and asking them to define what they consider to be each service element's service factors. Sometimes this requires defining a service factor in terms of further service factors, in order to make it meaningful. (For example, a feasible service factor for the stock lead time service measure is, the time it takes for a warehouse to pick the stock. However, this in turn -if it is to be useful to PD- requires to be defined in terms of the service factors: the amount of stock to be picked and the number of pickers). These relationships are easily represented by Eden's (1983) cognitive maps, as described in chapter 2.

These maps can then be used to help redefine the experts thinking on the subject, or to pool several experts thoughts into one map. After identifying the service factors, for a service measure the next step is to define a relationship between them. Unfortunately, this is usually very hard to actually do because of the lack of opportunity to carry out model building tests in the organisations. Many different types of modelling techniques such as regression analysis may prove to be useful here. In chapter 8, a possible modelling technique, is proposed which may help in doing this.

It should be noted that often universal models can be used as a framework for generating models for a particular situation. For example, certain disturbances can be translated into the level of workload required to be done, with the different service responses being translated into the level of workload that can be managed.

HAS 2: A HAS which defines the service response costs: Usually the cost of service responses are already known by the company. Other times service responses can be defined in terms of other responses whose costs are known, in the

system. However, to do this the relationship between these responses has to be defined. This can be done by using techniques proposed in HAS 1 described above.

HAS 3: A HAS which determines which service measures can be linked together: Before two measures can be linked together there is a need to identify that there are common service responses. The cognitive maps that were produced for HAS 1 can be used to deduce these common service responses.

HAS 4: A HAS which determines which of the linked service measures, if any, should be given priority: This can be done by consulting with the company.

HAS 5: A HAS which determines what the disturbances are: These disturbances can be determined by consulting the cognitive maps produced for HAS 1.

HAS 6: A HAS which determines what the disturbance level is going to be: It is proposed that there are basically three ways this can be done:-

a) The use of statistical models: It may be possible to predict the likely level of disturbances, from previous disturbance levels, by using various forecasting techniques.

b) Determining the disturbance level by knowing other departments performance level: Often a disturbance is the performance from another part of the company and, consequently, is known. It should be noted that if this situation happens it also shows that there is a need for coordination between PD and this other department.

c) Determining the disturbances level from known facts. For example the level of warehouse workload can be calculated from the level of stock orders

and the number of different items being picked. This approach can also be used for predicting what the likely disturbances are going to be in the future.

HAS 7: A HAS which determines how quickly the service response level can be changed: After the responses have been defined it is possible to identify how quickly these can be changed. This can be done by consulting with the participating company. It is also possible to actually monitor the speed with which changes can occur. Another possible approach for certain service responses is to consult the literature on the subject.

HAS 8: A HAS which determines how quickly the disturbance changes: This can be done by monitoring the frequency of disturbance changes.

HAS 9: A HAS which defines the transitional costs of changing from one response level to another: An indication of this figure can be discerned by consulting with the company. Also, an indication can be found by consulting the literature.

HAS 10: A HAS which reports information from one HAS to another HAS. All the reporting systems are looked at, collectively in chapter 8.

6.8 Defining and maximising the service benefits.

Initially, this section compares the service benefits for external customers with the service benefits for internal customers. The service benefits for internal customers are then looked at in greater detail. The activities required for defining and maximising these benefits are then highlighted. An indication is then given of how these activities can be carried out.

6.8.1 Differences between internal and external customers.

It was shown in Chapter 2, that previous customer service studies have considered the benefits of service to external customers to be the increase in the sales levels resulting from an increase in the service level. However it would seem logical to say that the service benefits to internal customers, are concerned with the decrease in the customer's costs, resulting from an increase in the service level. Thus there is a difference in the service benefits supplying to an internal customer, than to supplying to an external customer. The service benefits to external customers is connected with the image of the supply company that service portrays to the customers, whereas the benefits to internal customers is concerned with the actual effect service has on the customers.

Following from the above argument it can be seen that service to internal customers is concerned with the trade-off of costs between the PD system and the customer's system. Whereas, service to external customers is the trade-off between PD's costs and the sales levels achieved, which is determined by the company's image.

Unfortunately this causes a problem with trying to use either cluster analysis or the tight loose criteria classification on questionnaire results in order to reduce the number of possible service segment and criteria. (As prescribed in sections 6.3 and 6.4). This is due to the internal customer service benefits not being determined by the image of the company, in the eyes of the customer, as in the case of external customer. However, if the service effects, the financial benefits, are assumed to be correlated to the qualitative impression a service level gives to a customer then, it is still possible to use questionnaires. It will be assumed here that this is valid and that, consequently, questionnaires can be used to reduce the number of possible segments and criteria.

6.8.2 What are the service benefits?

It has just been argued that the service benefits to internal customers are associated with the reductions in the customer's costs. Thus, to look at the service benefits it is necessary to look at the effect service has on the customer's operational costs. This effect is investigated below:

The performance level in the customer's system can be described as below:

PL(I)= F(SM(J),CR(k),CD(L))

Where PL(I)= Performance level of activity I

SM(J)= Level of service measure J

CR(K)= The level of the customer responses to his disturbances.

CD(L)= The disturbances hitting the customers system.

It is useful to consider the customer service measures as being part of the customer's response to the disturbances hitting his system. The benefits of a service level are thus defined as being the reduction in the costs of the customer's other responses to the disturbances hitting his system..

For each particular set of disturbances hitting the customer's system there will be different total costs of these other customer responses. A simple example of how the service benefits are determined from the costs of the customer responses is shown in Table 6.9.

It follows from the above discussion that the following points, about service benefits are true:

1) That by defining the service benefits and the reductions in the customer's costs, the service objectives are being set to meet the customer's performance objectives at the lowest cost. This is discussed in more detail in chapter 8.

Table 6.9: A table showing an example of: How the service benefits are calculated from the total costs of the customer's responses.

Service level.	Cost of the customer responses to complete his required operations.	Service benefits.
1	9	9-9=0
2	6	9-6=3
3	4	9-4=5
4	3	9-3=6
5	2	9-2=7
6	1	9-1=8

2) That as the disturbances hitting the customer's system are constantly changing, so will the service benefits be also changing.

3) That when a service level affects two or more of the customer's operations then the benefits for each of these operations can be merged together to produce a combined service benefit.

6.8.3. Defining the service benefits.

As with the service costs the service benefits can be 'predicted' by using a feedforward system. To do this there is a need to have an accurate model of the customer's system and to know what the disturbances hitting the customer's system are. It is also possible to determine the service benefits by using a feedback system where there is a need to know the customer response levels and service level being achieved by PD.

6.8.4. Increasing the service benefits.

If a service customer is informed of the expected service level he can then use this knowledge to determine what the best combination of his responses, given this service level, are. This results in an increase in the service benefits. It should be noted that this is similar to the situation where PD respond differently to each different disturbances to reduce their costs, where the service level is a known disturbance level, hitting the customer's system.

6.8.5 The HAS required.

From the above discussion it follows that the HASs shown in Fig 6.32 are required for defining and maximising the service benefits.

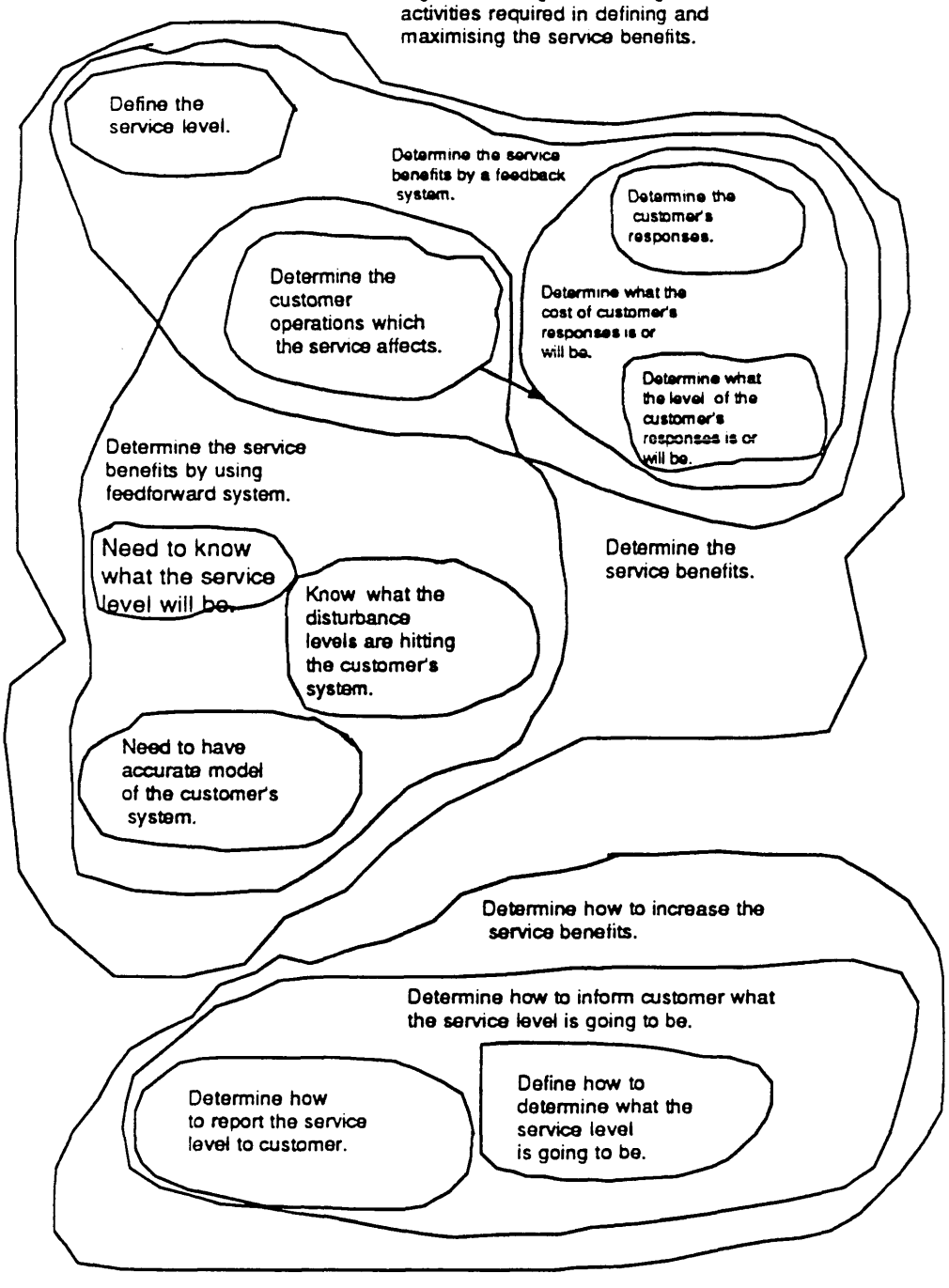
6.8.6 How can the HASs be carried out.

Below are listed the HASs, shown in Fig 6.32, that are required to determine and increase the service benefits. For each of these identified HASs, various approaches for carrying them out are also proposed.

HAS 1: A HAS which indicates which customer operations the service affects and what customer's responses also affect these operations: These areas can be identified by consulting with the customers and using cognitive maps to represent the ideas generated.

HAS 2: A HAS which monitors the service performance level. All monitoring systems are discussed collectively in chapter 8.

Fig 6.32: A diagram showing the activities required in defining and maximising the service benefits.



HAS 3: A HAS which monitors the customer's response levels. All monitoring systems will be discussed collectively in chapter 8.

HAS 4: A HAS which monitors the performance level of the customer operations. All monitoring systems will be discussed collectively in chapter 8.

HAS 5: A HAS which determines a model of the customer's system. How this

HAS can be carried out has already been discussed, for carrying out HAS 1 in section 6.7.8.

HAS 6: A HAS which determines the disturbance levels. How this HAS can be carried out has already been discussed, for carrying out HAS 5 in section 6.7.8.

HAS 7: A HAS which informs the customers what the service level is. All monitoring systems are discussed collectively in chapter 8.

6.9 Evaluating what service level is required.

This section looks at the HAS that evaluates what the optimum service level is. A general discussion on this system is followed by a discussion on how the profit levels can be increased by using this system productively. An indication is then given of the activities required to be present and how these activities can be carried out.

6.9.1 General discussion on the system.

This system uses the service benefits and costs to determine the service profits. From these service profit levels the company's service objectives are set- the service level which maximises profit level. These service objectives are then reported to PD and the customers.

The optimum service level is determined by the differences in the profits, (consequently, the differences in the costs and benefits) of the different service levels. Therefore it is more efficient if the service costs and benefits are standardised before reporting to the evaluator- that is the differences in the costs for the different service levels are used rather than the actual value. This reduces the level of information that needs to be reported. For example, it is pointless reporting that the costs of all the service levels has increased by

X pounds, as this will not effect what the optimum service level is.

6.9.2 Increasing the profits achieved.

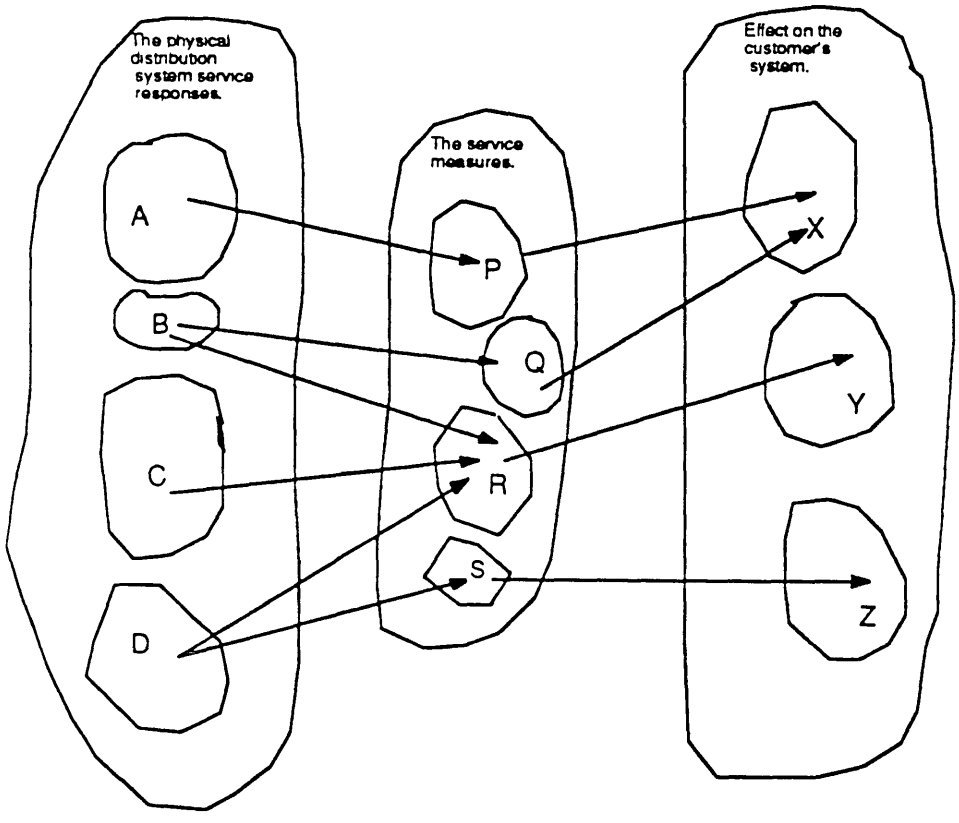
Below are proposed two approaches which can be used to increase the total profits being generated by this system.

Approach 1, changing the service level required more frequently: As the service costs and benefits change so often does the optimum service level. Thus there are advantages, associated with constantly altering the service level required to reflect these changes in the optimum service level. However, there are problems connected with constantly altering the service level required. These changes result in both PD and the customers having to change their operations. If the changes are frequent then, this often leads to oscillatory behaviour occurring in the system- due to PD and the customers not being able to respond in time. However this problem is reduced when feedforward systems are used to monitor the service benefits and costs and to report changes because this gives more time for them to react.

Thus it is really advisable to restrict the number of changes. This means that it is more beneficial to deal with the larger and more long term changes in the service costs and benefits. Consequently there is a need to filter out the smaller or short time changes in the service costs and benefits. Similarly it would be unproductive for the system to report any small or short term changes in the required service level as it is unproductive for PD and the customers to attempt to react to these changes. This idea is discussed in more detail in chapter 8 when dealing with monitoring systems. It should be noted that this approach tries to increase the system's effectiveness for a particular level of efficiency and cost and hence increase its productivity.

Approach 2, looking at two, or more, service measures collectively: As is demonstrated in Fig 6.33, often one service response affects more than one service measure. It should be noted that, in Fig 6.33 service response B affects both service measures Q and R. An example of this is the level of warehouse staff which affects both the order lead time and level of missing stock. This causes problems, when deciding which service measure should be 'charged' for the cost. It is also indicated in Fig 6.33 that two service measures can often affect the same customer operation. In Fig 6.33 both service measures P and Q affect the customer operation X. An example of this is the stock order lead time and the warehouse's order fill rate, both affecting the store's order fill rate to the general public. This can cause problems when determining the service benefits of the individual measures.

Fig 6.33: A diagram showing a possible service situation to illustrate when it may be advantagous to evaluate two, or more, service measures together.



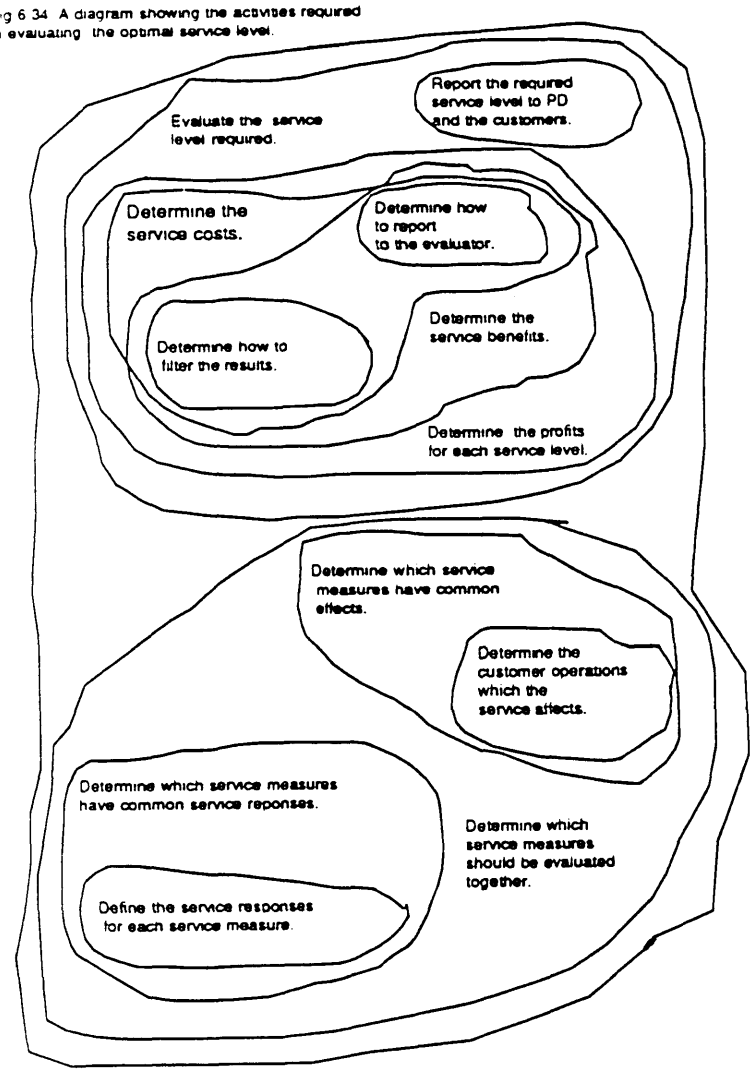
These problems can be dealt with by considering the interconnected, interdependent service measures together as one service measure vector. From this the optimum

combination of the various service measures can be chosen in the normal way. However this means that the service to profit graph becomes multi-dimensional. This can cause problems due to the level of information- variety- needed to be handled by the evaluating system. It should be noted that service measures that are linked together due to their interdependency, should be considered in this manner.

6.9.3 The HASs required.

From the above discussion, it can be seen that the activities shown in Fig 6.34 are required to be performed when evaluating the service level required.

Fig 6.34 A diagram showing the activities required in evaluating the optimal service level.



6.9.4 How can the HASs be carried out?

How the reporting systems should be carried out will be dealt with in chapter 8. The service measures which are beneficial to consider together can be determined by looking at the cognitive maps produced for each service measure and identifying from these maps the service measures that have common responses or effects.

6.10. The activities required for maximising the profits.

Sections 6.3-6.7 have looked at the activities that are required for the 5 main approaches identified for maximising the profit associated with service. This section looks at the combination of all these activities. This combination is shown in Fig 6.35. It can seen that, there are principally four different types of HASs contained in Fig 6.35.

Type 1 Decision making HASs (DMSs), which make infrequent decisions of a long term nature. An example of this is deciding which segments should be used.

Type 2 Decision making HASs (DMSs), which make frequent decisions of a short term nature. An example of this is deciding how to respond to changes in the disturbances.

Type 3 The HASs which define what specific information needs to be reported to the DMS.

Type 4 The HASs which report information to the decision making HASs. It should be noted that these HASs are being used continuously.

The output of the Type 1 and 3 HASs shown above does not change frequently, therefore the effectiveness of these HASs is not decreased very much by reducing the frequency of their use. Consequently it is probably more cost effective/productive to use these HASs occasionally as the advantages of the increased efficiency outweigh the penalties associated

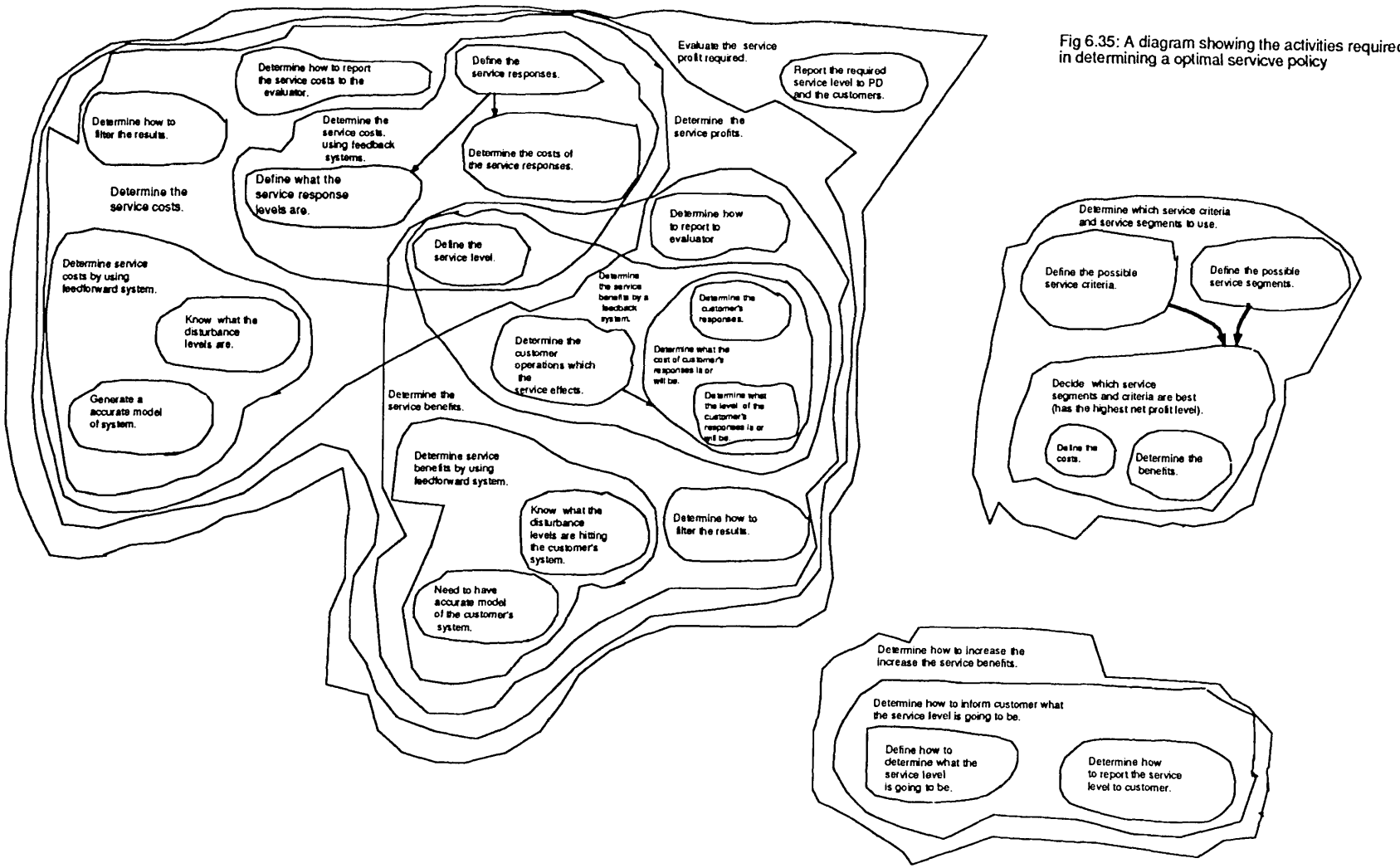


Fig 6.35: A diagram showing the activities required in determining a optimal servicve policy

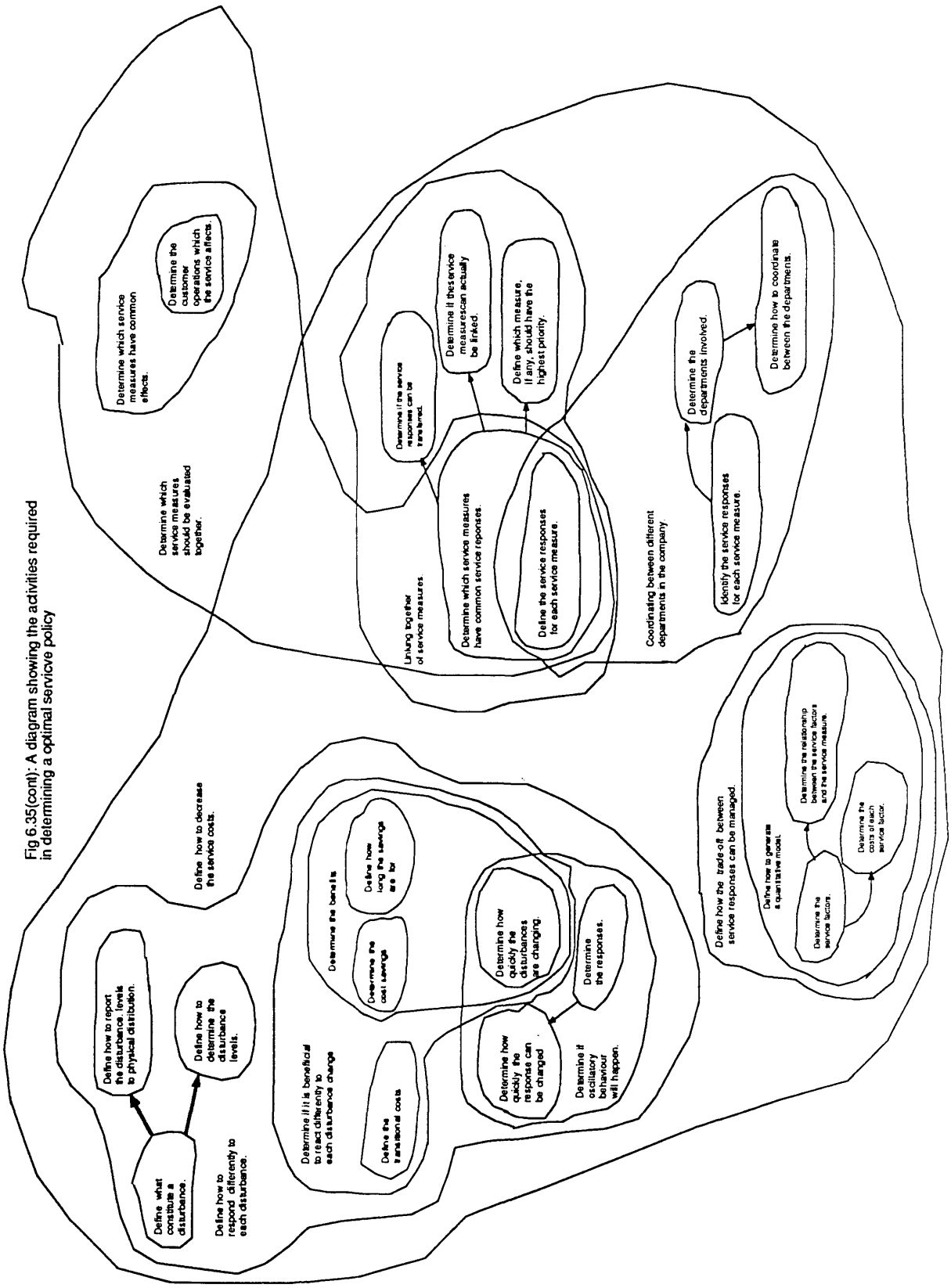


Fig 6.35(cont): A diagram showing the activities required in determining a optimal servicve policy

with the decrease in the effectiveness. Thus, it is proposed that these HASs should be used initially at the start of a service project and then regularly used again to update the information. Chapter 7 will look at the carrying out of these 2 types of HASs.

In contrast for type 2 and 4 HASs the output of these HASs are constantly changing. Thus, it is probably more cost effective to use these systems continuously. Chapter 8 will deal with these 2 types of HAS.

6.11 Summary.

This chapter has looked at determining the service policy which maximises profits. Five main components to this process were identified. These are shown below:

1) Determining the service criteria.

2) Determining the market segmentation being used.

3) Minimising the service costs and defining the service costs.

4) Maximising the service benefits and defining the service benefits.

5) Determining the optimum service level, the service level achieving the highest profit level.

The activities required for carrying each of these processes were identified and also, any differences in these activities which are required when the customer is external as to when the customer is internal. The main differences in these two situations were found to be in the service benefits. The service benefits for internal customers were found to be concerned with the decrease in the customer's costs whereas with external customers the benefits are concerned with the increase in sales.

An indication was also given where appropriate how each of the identified HASs could actually be carried out. These activities required to be carried out were classified as being

more cost effective when either used infrequently or when used frequently.

Chapter 7 will look at carrying out the activities that are more cost effective when performed infrequently. Chapter 8 will look at HASs that are more cost effective when carried out continuously.

CHAPTER 7

THE HUMAN ACTIVITY SYSTEMS THAT ARE USED INFREQUENTLY FOR DEFINING AND ACHIEVING THE BEST SERVICE POLICY.

7.1 Introduction.

This chapter looks at performing some of the Human activity systems (HASs) defined in chapter 6 as being needed to define and ensure the best service policy is achieved. The HASs looked at in this chapter are those that were defined in chapter 6 as likely to be more cost effective/ productive when used infrequently. These HASs concentrate on defining the criteria, market segments and the disturbances, service responses and effects of each service measure. The measures which can be linked together or may be beneficial to evaluate together are also determined. (The remaining HASs which were defined as likely to be more productive when used frequently will be looked at in chapter 8).

The various approaches that were proposed in chapter 6, for carrying out each of the required HAS are outlined.

Criteria will be examined by using the 3 E test to determine the relative merits of each of these approaches. An indication will be given of the actual approaches that were used with the participating company and where appropriate why these differed from the proposed techniques.

A summary of the information derived, relating to the service measures defined in chapter 5, when using these approaches with the participating company will also be included.

Where appropriate general points concerning controlling service will be drawn out of the results.

7.2 What Human Activity Systems are required?

It was shown in the last chapter that several HASs are required in defining the service policy which maximises the company's profits. These are shown in Fig 6.35. This chapter deals with the HASs which are felt to be more cost effective when used infrequently. These are:

1) Determining the service criteria for each service measure.

2) Defining the market segments.

3) Identifying the need for coordination between different service responses in the same department.

4) Defining the need for coordination between different departments.

5) Defining what the disturbances are.

6) Defining what the transitional costs are.

7) Defining how quickly each response can be changed.

8) Defining which measures can be linked together.

9) Defining which of the service measures, if any, should be given priority when linked together.

10) Defining the customer's operations affected by the service measure.

11) Defining the customer responses which affect the customer operations which are affected by a service measure.

12) Determining which customer measures are beneficial to evaluate together.

7.3 Carrying out and testing the HASs.

This sections is split into two subsections. The first looks at how it was proposed in chapter 6 that the HAS should be carried out and the 3 E test criteria for testing the relative merits of these different approaches. The second looks at what approaches were actually used with the participating company.

7.3.1 Proposed approaches and the 3 E criteria.

In chapter 6, often several different approaches were suggested for carrying out each of the above HASs. These are shown in Table 7.1. Table 7.2 shows the 3 E criteria that were defined for each of the HASs. Unfortunately there was often a problem associated with determining the effectiveness of a particular approach. This was because there is often no absolute yardstick to measure an approach's effectiveness against; making it often impossible to determine its absolute effectiveness. (This meant it was hard to determine whether it is likely that an unidentified approach is more effective). However, it is still possible to determine the relative effectiveness of the different identified approaches by comparing their effectiveness values.

Carrying out the HASs.

This section indicates how the HAS were actually carried out with the company, consequently indicating which of the approaches, shown in Table 7.1, were actually feasible with the participating company. (This thus indicates whether a particular approach proved to be efficacious when used with the participating company). It should be noted that when using cognitive mapping the maps produced represent only the researcher's impression of the relationship as described by the company personnel and thus may not be the actual relationship that exists in reality.

Table 7.1: A table showing the different approaches that can be used to carry out each of the HASs.

HUMAN ACTIVITY SYSTEM NUMBER.	THE HUMAN ACTIVITY SYSTEM REQUIRED.	THE DIFFERENT POSSIBLE WAYS OF CARRYING OUT THE HUMAN ACTIVITY SYSTEM.
1	DEFINING THE POSSIBLE CRITERIA FOR EACH SERVICE MEASURE.	1)THE USE OF BRAINSTORMING SESSIONS WITH PD AND THE CUSTOMERS. 2)THE USE OF THE LOOSE/TIGHT CRITERIA, CATEGORISING SYSTEM, ON THE QUESTIONNAIRE RESULTS. 3) DETERMINE CRITERIA WHICH ARE SUBJECTIVE. 4) ACTUALLY DETERMINE THE FINANCIAL FEASIBILITY OF THE DIFFERENT CRITERIA.
2	DEFINING THE MARKET SEGMENTS.	1)THE USE OF BRAINSTORMING SESSIONS WITH PD PERSONNEL. 2)THE USE OF QUESTIONNAIRES TO GAUGE THE DIFFERENCES IN THE BENEFITS FROM THE DIFFERENT SEGMENTS IDENTIFIED IN 1. 3)THE COMPARISON OF K MEAN CLUSTER ANALYSIS RESULTS AGAINST THE SEGMENTS SUGGESTED IN 2. 4) ACTUALLY DETERMINE FINANCIALLY WHAT SEGMENTS SHOULD BE USED .
3	IDENTIFYING THE NEED FOR COORDINATION BETWEEN THE DIFFERENT SERVICE RESPONSES INSIDE THE PD SYSTEM.	1) THE USE OF COGNITIVE MAPPING TECHNIQUES , WITH PD PERSONNEL, TO IDENTIFY THE SERVICE RESPONSES FOR A PARTICULAR SERVICE MEASURE. THUS, IDENTIFY ALL THE SERVICE RESPONSES FOR A SERVICE MEASURE WHICH ARE INSIDE OF PD.
4	IDENTIFYING THE NEED FOR COORDINATION BETWEEN PD AND OTHER DEPARTMENTS.	1) THE USE OF COGNITIVE MAPPING TECHNIQUES , WITH PD PERSONNEL, TO IDENTIFY THE SERVICE RESPONSES FOR A PARTICULAR SERVICE MEASURE. THUS, IDENTIFY THE DEPARTMENTS WITH SERVICE RESPONSES WHICH, ARE OUTSIDE OF PD.
5	IDENTIFYING THE DISTURBANCES FOR EACH SERVICE MEASURE.	1) THE USE OF COGNTIVE MAPS WITH PD TO IDENTIFY WHAT AFFECTS THE SERVICE LEVEL AND FROM THIS IDENTIFY THOSE FACTORS WHICH ARE OUTSIDE OF THE COMPANY'S CONTROL.
6	DEFINING WHAT THE TRANSITIONAL COSTS ARE FOR A PARTICULAR SERVICE RESPONSE.	1) CONSULT WITH THE EXPERTS IN THE COMPANY. 2) THE USE OF OUTSIDE SOURCES. 3) ACTUALLY MONITOR THE CHANGES AND THE COSTS
7	DEFINING HOW QUICKLY EACH RESPONSE CAN BE CHANGED.	1) CONSULT WITH THE EXPERTS IN THE COMPANY. 2) THE USE OF OUTSIDE SOURCES. 3) ACTUALLY MONITOR THE CHANGES.
8	DEFINING THE MEASURES THAT CAN BE LINKED TOGETHER.	1) IDENTIFYING THE MEASURES WHICH HAVE COMMON SERVICE RESPONSES. THIS CAN BE DONE BY CONSULTING THE COGNITIVE MAPS WHICH WERE PRODUCED BY CONSULTING WITH THE PD PERSONNEL.
9	DEFINING THE CUSTOMER'S OPERATIONS WHICH ARE AFFECTED BY A PARTICULAR SERVICE MEASURE.	1) CONSULT THE SERVICE CUSTOMERS OVER WHAT THEY CONSIDER THE EFFECTS, OF THE SERVICE ELEMENT, ON THEIR SYSTEM TO BE. THIS CAN BE REPRESENTED BY USING COGNITIVE MAPS.
10	DEFINING THE CUSTOMER'S REPONSES WHICH AFFECT THE SAME OPERATIONS AS THE SERVICE MEASURE AFFECTS.	1) CONSULT WITH THE CUSTOMER'S , TO IDENTIFY THEIR RESPONSES WHICH AFFECT THE SAME AREAS AS THE SERVICE ELEMENT DOES. THESE RELATIONSHIPS CAN BE REPRESENTED BY USING COGNITIVE MAPS
11	DETERMINE WHICH SERVICE MEASURES ARE BENEFICIAL TO EVALUATE TOGETHER.	1) DETERMINE WHICH SERVICE MEASURES AFFECT THE SAME CUSTOMER OPERATIONS AS EACH OTHER BY CONSULTING THE COMBINED COGNITIVE MAPS OF THE SERVICE MEASURES 2) DETERMINE THE SERVICE FACTORS WHICH AFFECT 2 OR MORE SERVIICE MEASURES BY CONSULTING THE COMBINED COGNITIVE MAPS OF THE SERVICE MEASURES.

Table 7.2: A table showing the effectiveness, efficiency and efficacy of a particular approaches for carrying out the HASs in chapter 7.

HUMAN ACTIVITY SYSTEM NUMBER.	THE HUMAN ACTIVITY SYSTEM REQUIRED.	THE EFFECTIVENESS OF A PARTICULAR APPROACH.	EFFICIENCY OF A PARTICULAR APPROACH.	THE EFFICACY OF A PARTICULAR APPROACH.
1	DEFINING THE POSSIBLE CRITERIA.	FOR HOW MANY SERVICE MEASURES DID THIS APPROACH ACTUALLY SUGGEST WORTHWHILE CRITERIA . DID THIS APPROACH ACTUALLY SUGGEST THE CRITERIA THAT WERE USED ?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?
2	DEFINING THE MARKET SEGMENTS.	DID THE APPROACH SUGGEST SEGMENTS THAT WERE FOUND TO BE USEFUL. DID THIS APPROACH ACTUALLY SUGGEST THE SEGMENTS THAT WERE USED?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?
3	IDENTIFYING THE NEED FOR COORDINATION BETWEEN THE DIFFERENT SERVICE RESPONSES INSIDE THE PD SYSTEM .	HOW MANY NEEDS FOR COORDINATION DID THIS APPROACH ACTUALLY IDENTIFY?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?
4	IDENTIFYING THE NEED FOR COORDINATION BETWEEN PD AND OTHER DEPARTMENTS.	HOW MANY NEEDS FOR COORDINATION DID THIS APPROACH ACTUALLY IDENTIFY?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?
5	IDENTIFYING WHAT THE DISTURBANCES ARE FOR EACH SERVICE MEASURE.	DID THE APPROACH ACTUALLY IDENTIFY THE DISTURBANCES FOR EACH SERVICE MEASURE?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?
6	DEFINING WHAT THE TRANSITIONAL COSTS ARE FOR A PARTICULAR SERVICE RESPONSE.	FOR HOW MANY OF THE SERVICE RESPONSES INVESTIGATED WAS IT POSSIBLE TO IDENTIFY THE TRANSITIONAL COSTS ?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?
7	DEFINING HOW QUICKLY EACH RESPONSE CAN BE CHANGED.	FOR HOW MANY, OF THE SERVICE RESPONSES INVESTIGATED, WAS IT POSSIBLE TO IDENTIFY THE SERVICE REPONSE TRANSITIONAL TIMES ?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?
8	DEFINING THE MEASURES THAT CAN BE LINKED TOGETHER.	HOW MANY GROUPINGS OF MEASURES WERE IDENTIFIED AS BEING ABLE TO BE LINKED TOGETHER ?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?
9	DEFINING THE CUSTOMERS OPERATIONS WHICH ARE EFFECTED BY THE SERVICE MEASURE.	HOW MANY CUSTOMER OPERATIONS WERE IDENTIFIED. WERE ATLEAST ONE OPERATION IDENTIFIED FOR EACH SERVICE MEASURE ?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?
10	DEFINING THE CUSTOMER REPONSES WHICH EFFECT THE OPERATIONS WHICH THE SERVICE MEASURE EFFECT.	HOW MANY CUSTOMER RESPONSES HAVE ACTUALLY BEEN IDENTIFIED ?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?
11	DETERMINING WHICH SERVICE MEASURES IT IS BENEFICIAL TO EVALUATE TOGETHER.	HOW MANY MEASURES DID THE APPROACH SUGGEST MAY BE WORTHWHILE TO CONSIDER TOGETHER ?	HOW MUCH TIME AND EFFORT DID IT TAKE TO ACTUALLY DO THE ANALYSIS ?	WAS IT ACTUALLY POSIBLE TO USE THE APPROACH ?

With **HAS 1**, determining what criteria should be used, the first three approaches shown in Table 7.1 were found to be feasible. It should be noted that, generally the mean value was suggested when a loose criteria was proposed and the mean plus variance was suggested when a tight criteria was proposed. Unfortunately it proved impractical, due to the problems it would have caused to the participating company to determine the financial feasibility of the different criteria.

For **HAS 2**, defining what market segments should be used, brainstorming sessions were held with the company to determine possible market segments for each set of customers. Questionnaires were then used to determine which of the suggested possible segmentations was best. The format of the questionnaires were such that service customers gave a value judgement to hypothetical service situation. These questionnaires and results are included in Appendix C.

For the stores it was considered by the company that there were two possible segmentations, these were

1) The size of the store.

2) The geographical location of the store.

Two geographical regions of the country were selected: - the North and the East. Also, two store sizes were used, using the company's classification:-Large and Small. 40 questionnaires were used in a crossed experimentally designed framework, ten being sent to the small and large stores in each of these specified regions. The following number of questionnaires were received back:

1) Small Stores in the North: 6

2) Small Stores in the East: 10

3) Large stores in the North: 9

4) Large stores in the East: 9

Regarding the Supply Managers it was proposed that which Business Centre a Supply Manager worked for, may influence the market segmentation required. Therefore, 40 questionnaires were sent to Supply Managers, five to each Business Centre. Unfortunately, only 11 valid answers were received back. (This small return rate is attributable to the role of Supply Managers being a relatively new one). Unfortunately as a result of this low return rate it was impossible to determine any market segments for Supply Managers by analysing the questionnaire results.

The questionnaire results were analysed by using K means clustering analysis to form 2 distinct groups. (The results of this analysis are shown in Appendix F). These results were then compared against the possible classifications suggested by the company. This indicated whether further investigation into the costs and benefit analysis of these possible segmentations was likely to be beneficial.

Unfortunately it proved impossible to determine the financial feasibility of the different segments due to the lack of data and the problems that would have been associated with 'experimenting' with the participating company to get this data.

Identifying the need for coordination between the different service responses (**HAS 3**) was carried out as shown in Table 7.1.

HAS 3, defining when there is a need for coordination between different departments, was carried out as described in Table 7.1.

HAS 4, defining the disturbances for a service measure, was also carried out as described in Table 7.1.

For defining what each of the service response transitional costs are (**HAS 5**) the experts in the company were consulted. Unfortunately this information cannot be included here because of its confidential nature. However, it should be stressed that for the service responses that were actually investigated it was generally feasible to determine an estimate of these transitional costs. Unfortunately, consulting the literature did not prove very successful.

HAS 6, defining how quickly each response can be changed, was carried out by consulting with the company, and the responses were classified as being either slow, medium or fast changing.

Defining which measures can be linked together (**HAS 7**) was carried out as proposed in Table 7.1.

HAS 8 defining the priorities of the linked measures was carried out as was proposed in Table 7.1.

Defining which of the customer's operations are affected by the service measure (**HAS 9**) was carried out by identifying the areas of the customer's system affected by each service measure. This was done by consulting with the customers and also by gaining first hand experience of the customer's system. These effects were represented by cognitive maps. Some indication of the relative benefits of different service levels were generated by using the questionnaire results.

HAS 10, defining the customer responses affecting the same customer operations as a service measure affects, was carried out as was proposed in Table 7.1.

Determining which customer measures can be evaluated together (**HAS 11**) was also carried out as was proposed in Table 7.1.

7.4 The case study results.

Included below is a summary of the information that was generated when the above HASs were used with the participating company. Although this information is strictly only applicable to the participating company it is felt that, due to the general nature of this PD system, the information generated is also applicable to other companies. Consequently, the information is felt to be of general interest and use. The description of the information has been divided into two sections: The first deals with the information relating to the store's service measures. The second is concerned with the information dealing with the Supply Manager's service measures. Each of these 2 sections are in turn subdivided into 2 sections, indicated as below:

1) The summary of the information relating to each of the service measures individually (a full description can be found in Appendixes D and E respectively for the stores and the Supply Managers).

2) The information that looks at the interaction of the different service measures (such as whether it is beneficial to link service measures together).

7.4.1. The store's service measures.

1) A summary of the results of the complete analysis for the store's service measures, included as Appendix D, is shown in Table 7.3.

Several interesting points are highlighted in this summary:

I) The variation in the workload (as well as the actual workload level) affects a large number of service measures' service levels. This indicates a need to match this variation by either changing the response level or by having a higher constant response level.

II) There are quite a few service measures that have common disturbances such as the workload. Thus there a large number of measures with common responses. (This indicates the possibility of linking several service measures together).

III) Very few of the measures have been identified as being possible to combine together. The exception to this is the combining together of service measures 6 and

IV) For only a few measures has a need for coordination with other departments inside the company been highlighted. Where there was present it usually indicated a need to coordinate with the data processing centre for the lead time service measures. This indicates the whole process ordering, processing and delivery has to be taken into consideration when dealing with lead time service measures.

TABLE 7.3: SUMMARY OF THE RESULTS FOR THE STORE MANAGER'S SERVICE MEASURES.

MEASURE NUMBER.	SERVICE MEASURE.	SEGMENTS.		DISTURBANCES.	RESPONSES.	EFFECTS.	CRITERIA.	COORDINATION WITH OTHER DEP'TS.
		REGION ?	SIZE ?					
1	THE NUMBER OF MINUTES LATE THAT A RDC VAN ARRIVES.	NO.	NO.	THE RDC'S WORKLOAD AND VARIATION.	THE LEVEL OF RDC STAFF.	PRODUCTIVITY OF THE STORE STAFF. THE LEVEL OF LOST SALES.	VARIANCE.	-
2	THE NUMBER OF MINUTES LATE THAT A CSR VAN ARRIVES.	NO.	NO.	THE CSR'S WORKLOAD AND VARIATION.	THE LEVEL OF CSR STAFF.	PRODUCTIVITY OF THE STORE STAFF. THE LEVEL OF LOST SALES.	VARIANCE.	-
1+2 ? COMBINED	CAN NOT BE COMBINED			CAN NOT BE COMBINED		CAN NOT BE COMBINED		
3	THE NUMBER OF MINUTES TAKEN TO UNLOAD A RDC DELIVERY VAN.	NO.	YES.	THE RDC'S WORKLOAD AND VARIATION IN WORKLOAD.	THE LEVEL OF RDC STAFF. THE LEVEL OF WAREHOUSE STAFF.	THE LEVEL OF BREAKAGES. THE LEVEL OF MANPOWER AT THE STORE. THE LEVEL OF LOST SALES.	MEAN.	-
4	THE NUMBER OF MINUTES TAKEN TO UNLOAD A CSR DELIVERY VAN.	NO.	YES.	THE CSR'S WORKLOAD.	THE LEVEL OF CSR STAFF. THE LEVEL OF WAREHOUSE STAFF.	THE LEVEL OF BREAKAGES. THE LEVEL OF MANPOWER AT THE STORE. THE LEVEL OF LOST SALES.	MEAN.	-
3+4 ? COMBINED	CAN NOT BE COMBINED			CAN NOT BE COMBINED		CAN NOT BE COMBINED		
5	THE NUMBER OF WORKING DAYS WARNING GIVEN OF CHANGE IN THE DELIVERY TIMES.	NO.	NO.	THE VARIATION IN THE AMOUNT OF STOCK BEING SENT TO EACH STORE.	REDUCE THE VAN FILL. INCREASE THE LEAD TIME .	THE STORE'S STAFF LEVELS .	MINIMUM NUMBER OF DAYS + MEAN VALUE	-
6+7+8	THE NUMBER OF WORKING DAYS LATE THAT 1ST CLASS/ 2ND CLASS/ FOCUS STOCK IS LATE.	NO.	NO.	THE LEVEL AND WORKLOAD VARIATION ON THE WAREHOUSES. THE LEVEL AND WORKLOAD VARIATION I ON THE RDC. VOLUME OF CONTAINERS GOING TO RDC. THE VOLUME OF CONTAINERS GOING TO THE STORES.	THE LEVEL OF WAREHOUSE STAFF. THE LEVEL OF RDC STAFF. THE NUMBER OF LORRIES. THE NUMBER OF VANS.	THE SERVICE LEVEL TO THE GENERAL PUBLIC. THE STORE'S SAFETY STOCK LEVELS.	MEAN (FOR 2ND CLASS) % ON TIME (FOR OTHER CLASSES.)	DATA PROCESSING CENTRE.

TABLE 7.3 (CONTINUED) SUMMARY OF THE RESULTS FOR THE STORE MANAGER'S SERVICE MEASURES.

MEASURE NUMBER.	SERVICE MEASURE	SEGMENTS. REGION ?	SEGMENTS. SIZE ?	DISTURBANCES.	RESPONSES.	EFFECTS.	CRITERIA.	COORDINATION WITH OTHER DEPTS.
6+7 ? COMBINED.	CANNOT BE COMBINED	CANNOT BE COMBINED				CAN NOT BE COMBINED		
6+8 ? COMBINED.	CAN BE COMBINED	CAN BE COMBINED				CAN BE COMBINED		
7+8 ? COMBINED.	CANNOT BE COMBINED	CANNOT BE COMBINED				CAN NOT BE COMBINED		
9	THE NUMBER OF DAYS IT TAKES FOR HOTLINE ORDERS TO ARRIVE, FROM THE TIME THE ORDER WAS PLACED.	NO.	NO.	VARIATION IN THE RDC'S WORKLOAD. VARIATION IN THE WAREHOUSE'S WORKLOAD. THE VOLUME OF STOCK GOING TO THE RDC. THE VOLUME OF STOCK GOING TO THE STORE.	THE LEVEL OF WAREHOUSE STAFF. THE LEVEL OF RDC STAFF. THE NUMBER OF LORRIES BEING USED. THE NUMBER OF VANS BEING USED	THE SERVICE LEVEL TO THE GENERAL PUBLIC. THE STORE'S SAFETY STOCK LEVELS.	MEAN + VARIANCE.	-
10	THE NUMBER OF WORKING DAYS IT TAKES FOR THE STOCK ORDERED, ON A SPECIAL REQUEST FORM ,TO ARRIVE AT THE STORE FROM THE TIME, THE FORM LEFT THE STORE.	NO.	YES.	VARIATION IN THE RDC'S WORKLOAD. VARIATION IN THE WAREHOUSE'S WORKLOAD. THE VOLUME OF STOCK GOING TOTHE RDC. THE VOLUME OF STOCK GOING TOTHE STORE.	THE LEVEL OF WAREHOUSE STAFF. THE LEVEL OF RDC STAFF. THE NUMBER OF LORRIES BEING USED. THE NUMBER OF VANS BEING USED	THE SERVICE LEVEL TO THE GENERAL PUBLIC. THE STORE'S SAFETY STOCK LEVELS.	MEAN + VARIANCE.	DATA PROCESSING CENTRE.
11	THE NUMBER OF DAYS IT TAKES FOR A INTER-STORE TRANSFER TO BE COMPLETED,FOR: A)THE SAME REGION.	NO.	NO.	THE DONOR STORE'S RDC WORKLOAD. THE AMOUNT OF STOCK GOING TOTHE STORE. AS ABOVE PLUS	THE LEVEL OF RDC STAFF. THE NUMBER OF VANS. AS ABOVE PLUS	THE SERVICE LEVEL TO THE GENERAL PUBLIC. THE STORE'S SAFETY STOCK LEVELS. AS ABOVE	MEAN + VARIANCE.	-
	B) DIFFERENT REGIONS.	NO.	NO.	D42 WORKLOAD. STOCK VOLUME GOING TO RECIPIENT RDC. AMOUNT OF WORKLOAD ON THE RECIPIENT RDC.	D42 STAFF LEVELS THE NUMBER OF LORRIES. THE LEVEL OF RDC STAFF.		MEAN + VARIANCE.	-

TABLE 7.3 (CONTINUED): SUMMARY OF THE RESULTS FOR THE STORE MANAGER'S SERVICE MEASURES.

MEASURE NUMBER.	SERVICE MEASURE.	SEGMENTS.		DISTURBANCES.	RESPONSES.	EFFECTS.	CRITERIA.	COORDINATION WITH OTHER DEPTS
		REGION ?	SIZE ?					
12	THE NUMBER OF WORKING DAYS NOTICE GIVEN OF A EXTRA VAN ARRIVING.	NO.	YES.	VARIATION IN THE STOCK LEVELS GOING TO THE STORES.	INCREASE IN THE LEAD TIME.	THE STAFFING POLICIES AT THE STORE.	MINIMUM NUMBER OF DAYS.	–
13	THE NUMBER OF MINUTES SPENT FILLING OUT M AND E FORMS.	NO.	YES.	THE LEVEL OF WORKLOAD ON THE WAREHOUSES.	INCREASE THE WAREHOUSE'S STAFF LEVELS.	THE TIME SPENT FILLING OUT M AND E FORMS. THE STORE'S STAFFING LEVELS	MEAN.	–
14	THE PERCENTAGE VOLUME OF EXCESS RDC STOCK.	YES.	NO.	THE DISTANCE APART OF SIMILAR LINES. THE WAREHOUSE'S WORKLOAD.	MOVE STOCK FURTHER APART (INCREASE IN SIZE OF WAREHOUSES) INCREASE THE STAFFING LEVELS.	SPACE IN THE STORE'S BACK STORE. THE ACCURACY OF THE COMPUTER STOCK LEVELS.	MEAN.	–
15	THE PERCENTAGE VOLUME OF EXCESS CSR STOCK.	YES.	YES.	DISTANCE APART OF SIMILAR LINES. THE CSR'S WORK LOAD.	MOVE STOCK FURTHER APART (INCREASE SIZE OF CSR). INCREASE IN THE CSR'S STAFFING LEVELS.	AN INCREASEIN THE SPACE NEEDED IN THE STORE'S BACK STORE. THE ACCURACY OF THE COMPUTER STOCK LEVELS.	MEAN.	–
16	THE PERCENTAGE OF RDC STOCK THAT DID NOT ARRIVE OR WAS NOT FIT FOR USE.	NO.	NO.	DISTANCE APART OF SIMILAR LINES. THE WAREHOUSE'S WOKLOAD. THE RDC'S WORKLOAD.	MOVE STOCK FURTHER APART. THE LEVEL OF WAREHOUSE STAFF. THE LEVEL OF RDC STAFF.	THE LEVEL OF LOST SALES THE LEVEL OF BREAKAGES. THE ACCURACY OF THE COMPUTER STOCK LEVELS.	MEAN.	–
17	THE PERCENTAGE OF CSR STOCK THAT DID NOT ARRIVE OR WAS NOT FIT FOR USE.	NO.	NO.	DISTANCE APART OF SIMILAR LINES. THE CSR'S WORKLOAD.	MOVE STOCK FURTHER APART. THE LEVEL OF CSR STAFF.	THE LEVEL OF LOST SALES THE LEVEL OF BREAKAGES. THE ACCURACY OF THE COMPUTER STOCK LEVELS.	MEAN.	–
18	THE PERCENATAGE OF CSR STOCK MISPRICED.	NO.	NO.	THE CSR'S WORKLOAD. THE DISTANCE APART OF DIFFERENT PRICED STOCK.	THE CSR'S STAFF LEVELS. PLANOUT CSR BETTER/ INCREASE SIZE OF CSR.	TIME SPENT REPRICING STOCK IN THE STORE.	MEAN.	–

TABLE 7.3 (CONTINUED): SUMMARY OF THE RESULTS FOR THE STORE MANAGER'S SERVICE MEASURES.

MEASURE NUMBER.	SERVICE MEASURE.	SEGMENTS.		DISTURBANCES.	RESPONSES.	EFFECTS.	CRITERIA.	COORDINATION WITH OTHER DEPTS.
		REGION.	SIZE.					
19	THE NUMBER OF WORKING DAYS, AFTER THE STOCK, THAT THE INVOICES ARRIVE.	NO.	NO.	THE WAREHOUSE'S WORKLOAD. THE RDC'S WORKLOAD. THE LEVEL OF STOCK GOING TO THE RDC. THE LEVEL OF STOCK GOING TO THE STORE. THE NUMBER OF INVOICES GOING TO THE STORES.	THE LEVEL OF WAREHOUSE STAFF. THE LEVEL OF RDC STAFF. THE NUMBER OF LORRIES GOING TO THE RDC. THE NUMBER OF VANS GOING TO THE STORES. THE LEVEL OF MOVEMENT CONTROL STAFF.	AMOUNT OF STORAGE SPACE REQUIRED IN THE STORE. AMOUNT OF TIME WASTED CHECKING OFF STOCK TWICE.	% FOR EACH NUMBER OF DAYS (EG% OF STOCK ARRIVING WITH INVOICES, % OF STOCK ARRIVING A DAY AFTER THE INVOICES).	-
20	THE 'ASCOT' SERVICE LEVEL.	NO.	NO.	THE AMOUNT OF STOCK REQUIRED BY THE GENERAL PUBLIC. (ALSO AS 6-8)	AS FOR STOCK LEAD TIMES (SEE MEASURES 6-8). LEVEL OF SAFETY STOCK IN STORE.	THE LEVEL OF LOST SALES.	MEAN.	SUPPLY MANAGERS AND THE STORES.
21	THE COMPATIBILITY OF THE DELIVERY TIMES TO THE STORE'S PREFERED DELIVERY TIMES.	NO.	NO.	THE LACK OF SPREAD IN THE STORE'S PREFERED DELIVERY TIMES.	THE NUMBER OF DELIVERY VANS.	THE PRODUCTIVITY OF THE STORE'S STAFF.	?	-

V) With only a small number of measures has it been indicated that it may be beneficial to use market segmentation. Of these the segmentation generally occurs along the lines of the store's size rather than its geographical location. This is probably due to a number of service measures being affected by the amount of stock being delivered (and hence affected more by the store's size rather than its geographical location).

VI) Several different types of effect on the stores have been highlighted. However there are broadly two types of effect. The first is concerned with the store's output (such as the level of lost sales). The second is concerned with the store's operating costs (such as the level of manpower). It should be noted that many of the service measures produce both of these types of effects on the stores. For example service measures 1 and 2 affect both the level of lost sales (the store's output) and the productivity of the store's staff (the store's operating costs).

2) Considering all the store's service measures collectively. All the cognitive maps for the service measures (included in Appendix D) were combined together to form a complete cognitive map of the system. A simplified version of this map is shown in Fig 7.1.

This diagram was then used to indicate the service measures which can be linked together and the service measures which may be beneficial to evaluate together. A indication of how this was done and the results of the analysis are included below:

A) Identifying the service measures that can be linked together. By looking at Fig7.1 it was possible to identify the service responses, which affected more than one service measure. These common service responses and the identified service measures are shown in Table 7.4 along with where appropriate the relative priority of the linked service measures.

Fig 7.1: A diagram showing the service factors which effect each of the service measures and the parts of the customer system affected by these service measures. This represents how the service measures couple the PD and store's system together.

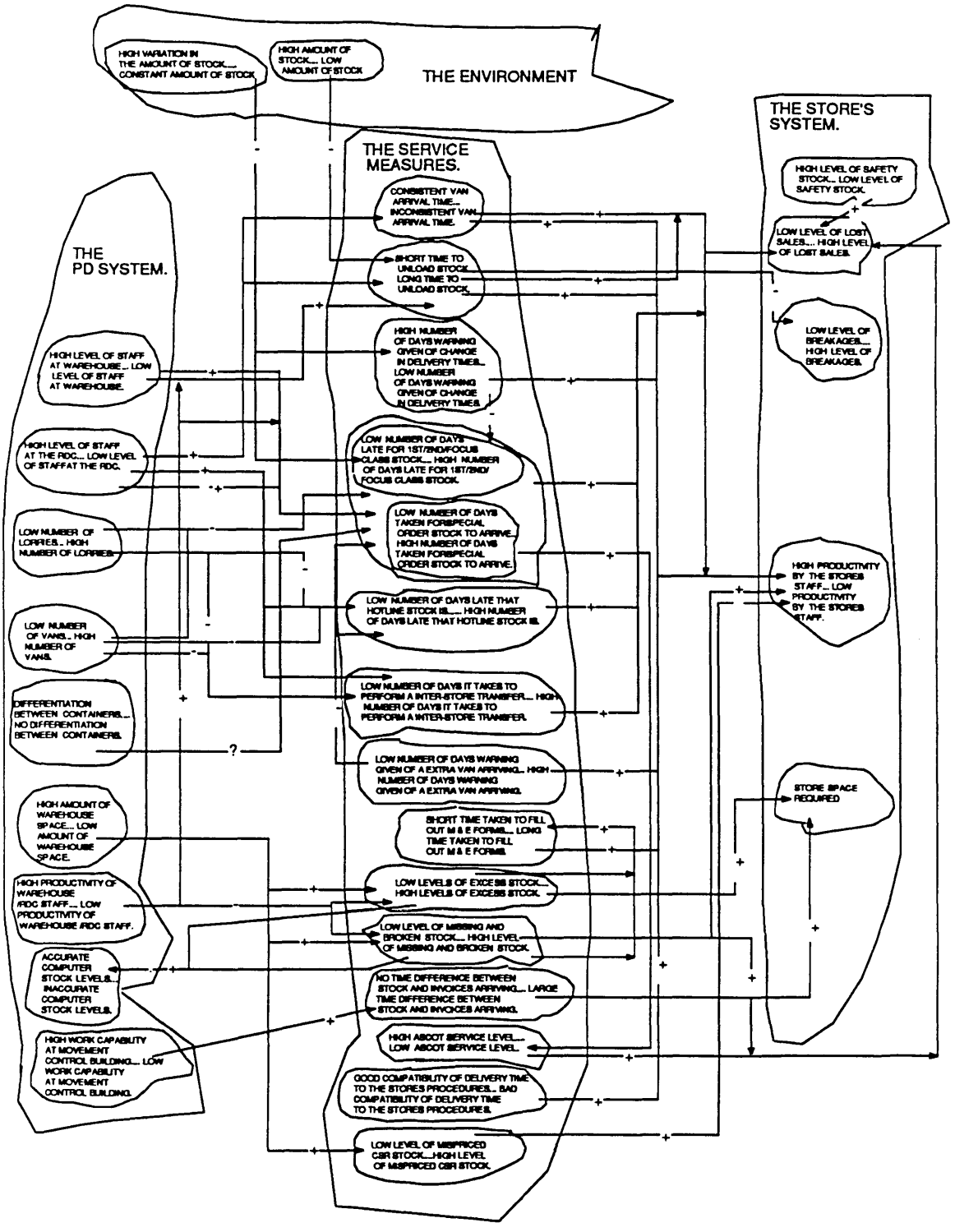


Table 7.4. The store service measures that can be linked together.

Service measures linked together.	Common service response(s).	Priority rating.
6+7+8+9+10 .	The number of warehouse staff + The number of lorries.	9>> 10>8=6>7.
6+7+8+9+10+11.	The level of RDC Staff + The number of RDC vans. *	9>>10>11>8=6>7.
1+3.	The level Of RDC staff.	1=3.
2+4.	The level of CSR staff.	2=4.
1+2+3+4.	The level of RDC/CSR staff (If RDC and CSR are twinlocated.)	1=2=3=4.

*There are problems with notifying the stores of extra vans or changes in deliver times.

Several interesting points are illuminated in this analysis:

I) It is possible to link together a high number of measures. Thus seeming to indicate that linking together of measures can have a high effect on the organisation's performance.

II) The majority of measures that are identified as being possible to link together are lead time service measures.

III) By twin-locating CSR and RDCs it became possible for several otherwise unlinked measures to become linked together. Thus indicating that there are advantages with twin locating CSRs and RDCs. However there will be disadvantages, costs, in having to differentiate between CSR and RDC stock.

IV) Several of the service measures can be linked together by the level of warehouse staff and the number of lorries. Generally the possibilities and advantages of this are increased when the warehouses are on the same site

as each other (thus allowing responses to be transferred between operations easier- For example moving pickers from one warehouse to another).

V) Linking together of service measures can affect other service measures. This is demonstrated by the situation of linking measures 6,7,8,9,10 and 11 together which affects the amount of warning given to a store manager of a change in the delivery times.

B) Identifying the service measures that were beneficial to evaluate together. By looking at Fig 7.1 it was possible to identify the service measures which either had a common effect on the customer's system or were affected by the same service response. From this it was possible to identify the service measures which may be beneficial to evaluate together. The results of this analysis are shown in Table 7.5 which shows that there are a large number of the measures which may have benefits associated with evaluating them together.

Table 7.5: The store service measures which may be beneficial to evaluate together.

Service measures that could be evaluated together.	The common service response or effect.
6+7+8+9+10+11+16+17+19+20.	The level of lost sales.
1+2+3+4+5+12+13+19.	Productivity of the workers at the store.
14+15.	Stores storage space required.
6+7+8+9+10+13+14+15+16+19.	Number of warehouse staff.
1+3+6+7+8+9+10+11+16+19.	Number of RDC staff.
17+18.	Number of CSR staff.
14+16.	Size of warehouse.
15+17+18.	Size of CSR.

7.4.2 The Supply Managers' results.

1) A summary of the results (which are included in more detail in Appendix E) for the Supply Manager's service measures can be found in Table 7.6. This also analysis identifies several interesting points:

I) Not many segments have been identified. However this may be partly due to the lack of questionnaire results.

II) No measures can be combined together. This may indicate that all the measures are pretty well distinct and there is no overlapping.

III) Both types of service effect are represented (the output of the whole organisation and reducing the system's operating costs). However generally they are more concerned with reducing the system's operating costs. This is probably a reflection of the Supply Manager's role in the company.

2) Considering the Supply Managers service measures collectively. All the cognitive maps that were generated for the above Supply Manager's service measures were combined together to form one large cognitive map. A simplified version of this map is shown in Fig7.2. From this map service measures that could be linked together were identified. These linked service measures and the common service responses are shown in Table 7.7. This analysis brings out the following points:

I) There are not many measures that can be linked together. This is a reflection of the diversity in the types of measures for the Supply Manager.

II) The advantages of twin locating a RDC and a CSR enabling service measures to be linked are again highlighted.

TABLE 7.6: SUMMARY OF THE RESULTS FOR THE SUPPLY MANAGER'S SERVICE MEASURES.

MEASURE NUMBER.	SERVICE MEASURE.	SEGMENTS.	DISTURBANCES.	RESPONSES.	EFFECTS.	CRITERIA.	COORDINATION WITH OTHER DEPTS.
1	THE AMOUNT OF WAREHOUSE SPACE THAT IS AVAILABLE FOR A SUPPLY MANAGER TO USE, COMPARED TO THE AMOUNT OF SPACE THAT IS NEEDED FOR HIS STOCK.	PER BUSINES CENTRE.	UNEXPECTED DEMAND NOT REPRESENTED IN THE STOCK FLOW PROPOSALS.	INCREASE THE WAREHOUSE SPACE AVAILABLE. MORE ACCURATE STOCK FLOW PROPOSALS.	THE LEVEL OF STOCK THAT CAN NOT BE ACCEPTED RESULTING IN WASTED OPPORTUNITIES.	MEAN +VARIANCE	-
2	THE ACCURACY OF THE WAREHOUSE'S COMPUTER STOCK LEVELS.	BY THE TYPE OF STOCK.	THE LEVEL OF STOCK FLOW.	THE LEVEL OF CHECKING OFF STAFF. THE LEVEL OF PICKING STAFF. THE LEVEL OF COUNTING STAFF.	THE LEVEL OF STOCKOUTS OCCURRING IN THE WAREHOUSE. THE LEVEL OF STOCK IN THE WAREHOUSE.	MEAN + VARIANCE.	-
3	THE ACCURACY OF THE COSTING, OF STORING STOCK IN THE WAREHOUSE.	NONE.	?	MORE ACCURATE ACCOUNTING PROCEDURES.	THE PENALTIES OF MAKING A WRONG DECISION. I.E. NON PROFITABLE STOCK BEING ACCEPTED OR STOCK BEING SENT THE WRONG WAY. THIS INCREASES THE COST OF THE STOCK IN THE STORE.	MEAN + VARIANCE.	-
4	FOR NEW MERCHANDISE LINES: THE NUMBER OF WORKING DAYS IT TAKES FOR STOCK TO GET TO THE STORE, FROM THE DATE THAT, THE SUPPLY MANAGER REQUESTED THAT THE STOCK SHOULD BE DELIVERED TO THE WAREHOUSE.	NONE.	THE AMOUNT OF STOCK THAT IS TRYNG TO GET INTO THE WAREHOUSE. THE WAREHOUSE'S PICKING WORKLOAD. THE AMOUNT OF STOCK GOING TO THE RDC. THE RDC'S WORKLOAD. THE AMOUNT OF STOCK GOING TO THE STORES.	THE LEVEL OF UNLOADING STAFF. THE LEVEL OF CHECKING OFF STAFF. THE LEVEL OF PICKING STAFF. THE NUMBER OF LORRIES. THE NUMBER OF RDC STAFF. THE NUMBER OF VANS BEING USED.	THE LEVEL OF LOST SALES.	MEAN+ VARIANCE.	DATA PROCESSING CENTRE.

TABLE 7.6 (CONTINUED): SUMMARY OF THE RESULTS FOR THE SUPPLY MANAGER'S SERVICE MEASURES.

MEASURE NUMBER.	SERVICE MEASURE.	SEGMENTS.	DISTURBANCES.	RESPONSES.	EFFECTS.	CRITERIA.	COORDINATION WITH OTHER DEPTS.
5	THE NUMBER OF DAYS IT TAKES FOR A INTER-STORE TRANSFER TO BE COMPLETED, FOR: A)THE SAME REGION.	NONE.	THE WORKLOAD ON THE DONOR STORE'S RDC. THE AMOUNT OF STOCK GOING TO THE STORE.	THE LEVEL OF RDC STAFF. THE NUMBER OF VANS.	THE LEVEL OF LOST SALES. THE SAFETY STOCK LEVELS.	MEAN + VARIANCE.	–
	B) DIFFERENT REGIONS.	NONE.	AS ABOVE PLUS: D42 WORKLOAD. THE VOLUME OF STOCK GOING TOTHE RECIPIENT STORE'S RDC. AMOUNT OF WORKLOAD ON THE RECIPIENT RDC.	AS ABOVE PLUS: D42 STAFF LEVELS THE NUMBER OF LORRIES. THE LEVEL OF RDC STAFF.	AS ABOVE.	MEAN + VARIANCE.	–
6	THE NUMBER OF DAYS A STORE WAS OUT OF STOCK WHILST STOCK WAS AVAILABLE IN THE PHYSICAL DISTRIBUTION SYSTEM.	NONE.	THE LEVEL OF STOCK BEING PICKED. THE LEVEL OF STOCK GOING TO THE RDC. THE RDC'S WORKLOAD. THE LEVEL OF STOCK GOING TO THE STORE. THE AMOUNT OF STOCK TO BE TRANSFERRED FROM THE REPOSITORY WAREHOUSE TO THE PARENT WAREHOUSE.	THE WAREHOUSE'S STAFF LEVELS. THE RDC'S STAFF LEVELS. THE NUMBER OF LORRIES GOING TO THE RDC. THE NUMER OF VANS GOING TO THE STORES. THE NUMBER OF LORRIES TRANSFERRING STOCK BETWEEN THE WAREHOUSES.	THE LEVEL OF LOST SALES.	MEAN + VARIANCE + NUMBER OF TIMES IT HAPPENS.	DATA PROCESSING CENTRE.
7	THE NUMBER OF WORKING DAYS IT TAKES FOR RETURNING STOCK TO BE READY FOR DISPATCH IN THE WAREHOUSE, FROM THE TIME IT LEFT THE STORE.	NONE.	THE RDC'S WORKLOAD. D6'S WORKLOAD. THE WAREHOUSE'S WORKLOAD.	THE RDC'S STAFF LEVELS. D6'S STAFF LEVELS. THE WAREHOUSE'S STAFF LEVELS.	THE COST OF STORING STOCK. THE STOCK TURNOVER RATE.	MEAN.	–

TABLE 7.6 (CONTINUED): SUMMARY OF THE RESULTS FOR THE SUPPLY MANAGER'S SERVICE MEASURES.

MEASURE NUMBER.	SERVICE MEASURE.	SEGMENTS.	DISTURBANCES.	RESPONSES.	EFFECTS.	CRITERIA.	COORDINATION WITH OTHER DEPTS.
8	FOR ALLOCATION STOCK, THE NUMBER OF WORKING DAYS AFTER THE EXPECTED DELIVERY DAY THAT IT TAKES FOR STOCK TO ARRIVE AT THE STORE.	NONE.	THE WAREHOUSE'S WORKLOAD. THE RDC'S WORKLOAD. THE LEVEL OF STOCK GOING TO THE RDC. THE LEVEL OF STOCK GOING TO THE STORES.	THE WAREHOUSE'S STAFF LEVELS. THE RDC'S STAFF LEVELS. THE NUMBER OF LORRIES. THE NUMBER OF VANS.	THE SERVICE TO THE GENERAL PUBLIC/ THE LEVEL OF SAFETY STOCK.	MEAN.	DATA PROCESSING CENTRE

Fig 7.2: Diagram showing how the service measures couple the Physical Distribution System to the Supply Manager's system.

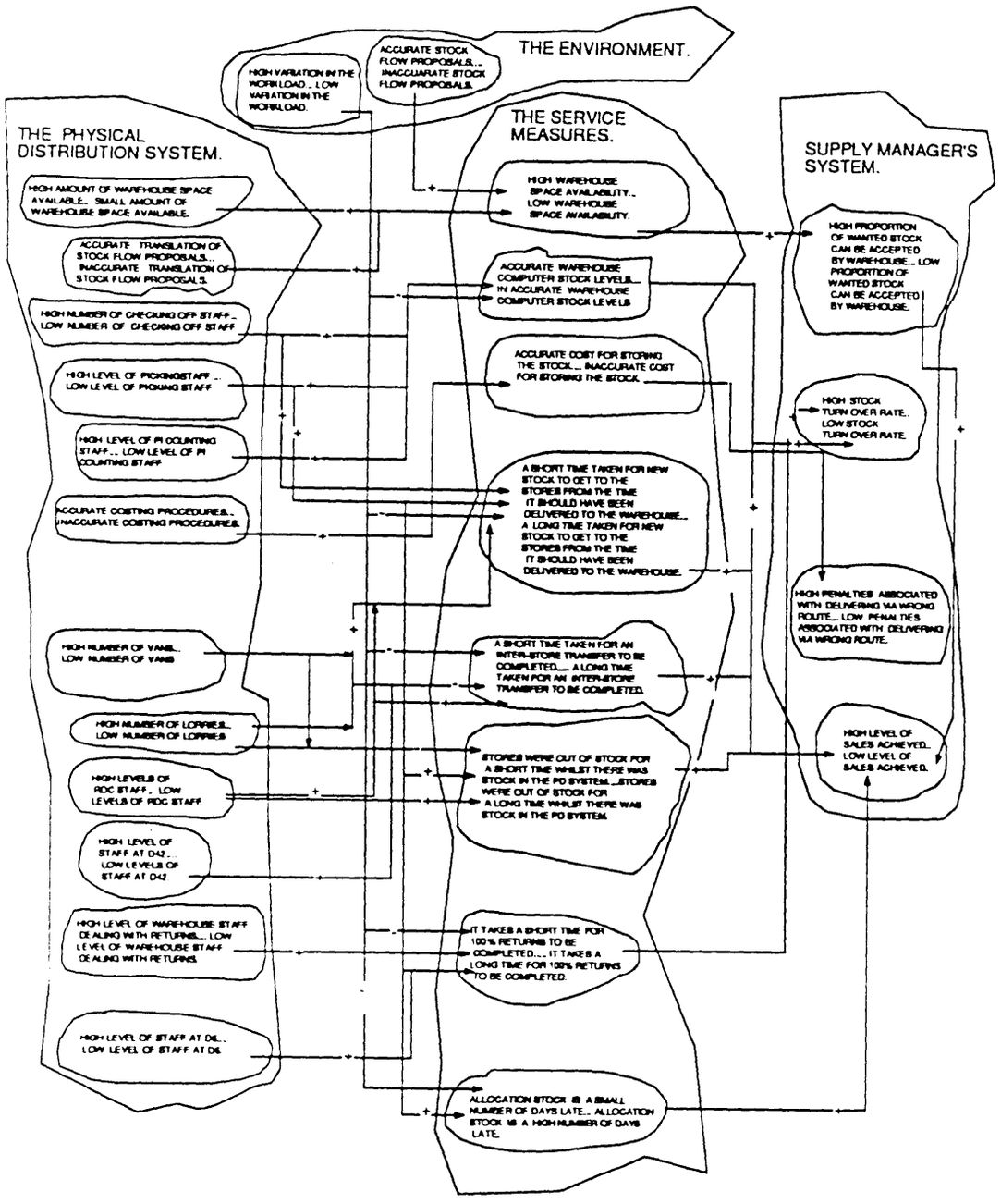


Table 7.7: The Supply Manager's service measures that can be linked together.

Service measures linked together.	Common service response(s).	Priority rating
4+6+8.	The number of RDC/CSR vans.	6>4>8.
4+6+7+8.	The number of RDC Workers.	6>4>8>7.

Fig 7.2 was also used to identify the service measures which had common effects on the customer's system and those that were affected by the same service response. This enabled the service measures to be identified which it may be beneficial to evaluate together. These service measures are shown in Table 7.8, along with the common service responses and effects.

Table 7.8: The Supply Manager's service measures that may be beneficial to evaluate together.

Service measures that could be evaluated together.	The common service response or effect.
3+7.	Stock turn over rate.
6+8.	Sales levels achieved.
4+6+8.	Number of RDC/CSR vans.
4+6+7+8.	Number of RDC workers.

7.5 Testing which approach is the best for carrying out the HASs.

The above discussion, in section 7.4, has indicated a summary of the results that were obtained by using the various approaches (proposed in Table 7.1) for carrying out the HASs which are more likely to be cost effective when performed infrequently. This section looks at which of these identified approaches were most successful in carrying out each of the HASs (listed in section 7.2).This will be done by looking at how well each approach performed against the 3 E criterion (see Table 7.1).

For **HAS 1.**the use of the loose and tight criteria approach proved to be a highly effective approach for defining the criteria. Also, this approach had the advantage of being relatively efficient, due to the ease of using the questionnaires. Unfortunately, one of the drawbacks with this approach was that the results produced were rather subjective in nature.

The use of brainstorming sessions proved relatively effective in producing criteria. This approach mainly identified whether or not the mean or variance was the most important criteria. This approach was very simple and efficient to use.

As determining whether a criterion has the desired effect on the customer's system only helped in determining the criteria for two measures, it can be concluded that this approach was not very effective.

Unfortunately, it was found impossible to determine the financial feasibility of the different criteria by looking at the differences in the optimum profit levels. This was due to the problems associated with experimenting with the participating company's PD system. In the general case it may be possible to gain an estimation of this by consulting with experienced staff. However when this was attempted with the participating company it failed to produce accurate enough data to make a reliable decision.

Overall, it is suggested that probably the best tactic to adopt is to use both the loose and tight criteria approach and the use of brainstorming sessions, and then compare the criteria produced by these two approaches. If there is agreement in the suggested criteria, the use this criteria; otherwise a more in depth analysis should be carried out. This approach was found to be very successful when used in the analysis to define the service criteria.

For **HAS 2** the use of brainstorming sessions was quite effective and efficient in producing possible segments. The use of a questionnaire was also highly effective in determining whether the segments suggested by the company should be used.

However, the comparison of the K mean cluster analysis results against the segments did not often indicate any possible need to change the segments. Thus, this approach did not really add much to the HAS's effectiveness.

Unfortunately, it was not possible to test the financial feasibility of the segments. This was due to the problem of experimenting with the Company's PD system to determine the results.

From the above discussion, it is suggested that the use of questionnaire results to test the segments suggested by the company is probably the best approach to use.

For **HAS 3** the use of cognitive maps to represent PD's thoughts on what affects the service level and from these identify the service responses which are inside of PD, proved to be both highly effective and efficient. Thus, it is proposed that this technique should be used to identify the need for coordination between different service responses in the same department.

For **HAS 4** the use of cognitive maps to represent PD's thoughts on what affects the service level and from these maps identifying the service factors which are outside of PD but still inside the company, proved to be both highly effective and efficient. Thus, it is suggested that this technique should be used to define the need for coordination between different departments.

For **HAS 5** the use of cognitive maps to represent PD's thoughts on what affects the service level and from these maps identify the service factors which are outside of the company proved to be both highly effective and efficient. Thus, it is felt that this technique should be used to define what the disturbances are.

For **HAS 6** it was generally found possible to determine an estimation of the service responses transitional costs by consulting the experts in the company. Thus, this approach is considered to be a good way of defining what the transitional costs are.

For **HAS 7** it was generally possible by consulting with the company's experts to

determine a figure for each of the service responses investigated. Thus it is considered that this approach can be used to define how quickly each response can be changed.

For **HAS 8** holding discussions with PD concerning what affected the service measures and then combining the resultant cognitive maps to identify the service measures which had the same service responses proved to be both very effective and efficient. Consequently it is proposed that this approach should be used when defining which measures can be linked together.

For **HAS 9** consulting with the company to determine the priorities of the different measures was both effective and efficient. Thus it is felt that this approach should be used to define which of the service measures, if any, should be given priority when linked together.

For **HAS 10** a highly effective and efficient approach was the use of cognitive maps to represent the service customer's thoughts on what effect the service level had on his operations and from this identifying the areas affected. Thus, it is proposed that this technique should be used in defining the customer's operations affected by the service measure.

For **HAS 11** the use of cognitive maps to represent the service customer's thoughts on which of his operations (customer responses) affect the areas that the service measures also affect was found to be both effective and efficient. Thus, it is suggested that this technique should be used to define the customer responses which affect the customer operations which are in turn affected by a service measure.

For **HAS 12** combining the cognitive maps generated when holding discussing with PD and the service customers to determine what affects the service level and what effect the

service level has on the customer's system was found to be both effective and efficient. Thus, it is felt that this approach is a good one to determine which service measures are beneficial to evaluate together.

7.6 Summary.

This chapter has looked at the carrying out the HASs that are involved in defining and ensuring the best policy is achieved and also are defined as being more cost effective/productive when used infrequently. This broadly involved defining the disturbances, service responses, service effects and segments for each service measure. Also it involved determining which measures can be linked and/or evaluated together.

Various approaches were proposed for carrying out these HASs. The relative merits of these approaches were then tested out by using them with the participating company. It proved possible to carry out all the HASs, with varying degrees of success. Overall the use of cognitive maps to represent what was considered, by the company's personnel, to be the factors influencing and the influences of each service measure proved to be highly successful approach for helping in carrying out the HAS. The output of each HAS were summarised and with the following general conclusions being derived:

1) Workload variation in the workload (as well as the actual workload level) affects the service level in a large number of service measures. This indicated the need to match this variation by either changing the response level or by having a higher constant response level.

2) Very few measures were identified as being possible to combine together.

3) For only a small proportion of measures was it indicated that it may be beneficial

to use market segmentations.

4) There was very little indication of the need for coordination between PD and the other departments. There is a need for coordination between the PD system and the data processing centre..

5) Several different types of effect on the customers were highlighted. However there were broadly classified into two types of effect. The first was concerned with the organisation's output. The second was concerned with reducing the organisation's operating costs. Many of the service measures produced both of these types of effects on the customers. Generally the stores service measures effect the organisation's output more than the Supply Managers service measures do.

6) It was possible to link together a high number of the measures. This would seem to indicate that this may be a valuable way of reducing service costs.

7) The majority of measures that were identified as being possible to link together were lead time service measures.

8) By twin-locating CSR and RDCs it became possible for many measures to be linked together. Thus indicating that there are advantages associated with twin locating CSRs and RDCs.

9) Several of the service measures, such as the delivery of the different categories of stock, were linked together by the service responses: The level of warehouse staff and the number of lorries. Generally the possibilities and advantages of this are increased when the warehouses are on the same site as each other.

10) Linking together of service measures can affect other service measures.

CHAPTER 8
HUMAN ACTIVITY SYSTEMS USED FREQUENTLY IN DEFINING AND ACHIEVING THE BEST SERVICE STRATEGY.

8.1 Introduction.

This chapter looks at the human activity systems (HASs) involved in defining and achieving the service strategy and were shown in chapter 6, as being probably more productive/cost effective when used frequently The HASs that fall into this category are highlighted. The constraints operating on the design of such HASs are then indicated. The merits of different feasible designs for carrying out these HASs are discussed in terms of how they influence the HAS's productivity- efficiency and effectiveness. The chapter finishes by looking at the differences between the HASs required when service customers are external and when they are internal.

8.2 What HASs are required to be performed?

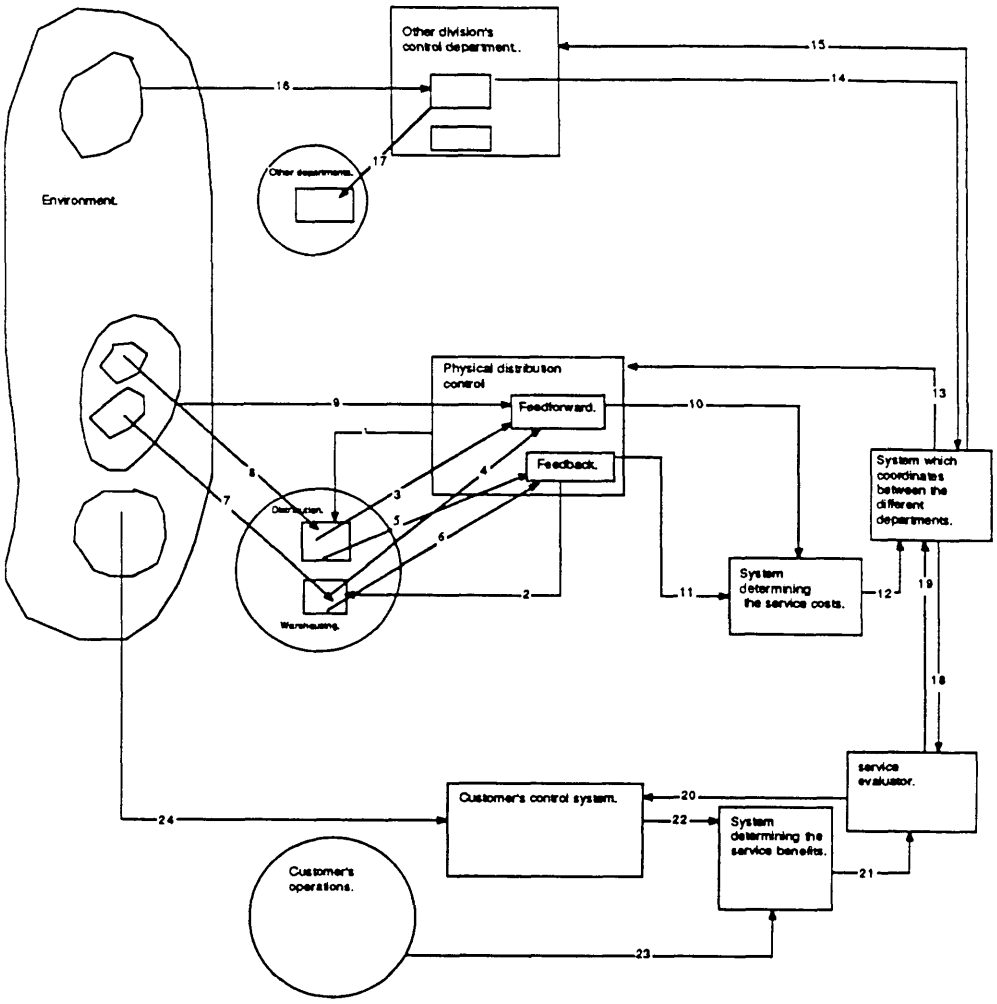
In chapter 6 two general classes of HASs were identified as being more cost effective when used frequently. These were:

1) The information reporting systems.

2) The decision making systems (DMS) which make the day to day decisions.

Shown in Fig 8.1 is the full interaction of all the HASs, identified in chapter 6 as belonging

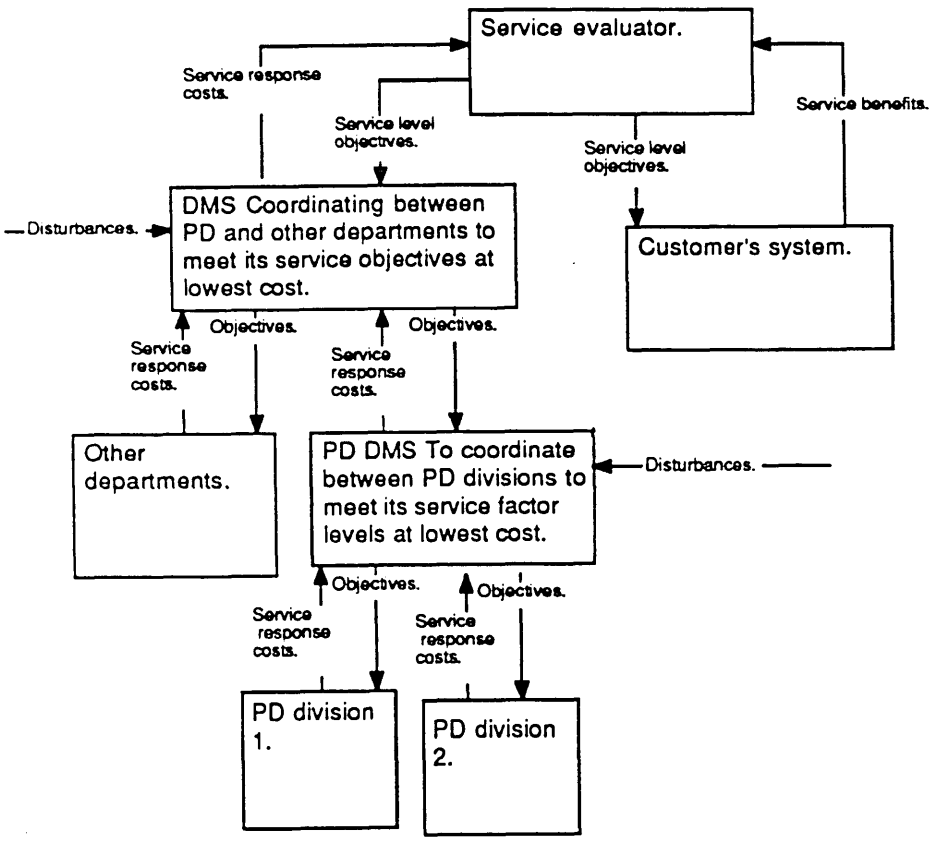
Fig 8.1: A diagram showing the information flows required to maximise the profits associated with PD's service.



Where
1 is the performance objectives being relayed to the Warehousing division.
2 is the performance objectives being relayed to the Distribution division.
3 is the feedforward of the service factor costs from Distribution to the system coordinating the trade-off between the warehousing and Distribution.
4 is the feedforward of the service factor costs from the warehouses to the system coordinating the trade-off between the warehouses and Distribution .
5 is the feedback of Distribution's performance to PD.
6 is the feedback of the Warehouse's performance to PD.
7 is the environmental disturbances being relayed to the Warehousing division.
8 is the environmental disturbances being relayed to the Distribution divisions.
9 is the environmental disturbances being relayed to the PD division.
10 is the feedforward of PD's service factor costs to the system determing the service costs.
11 is the feedback of PD's service costs to the system determing the service costs.
12 is the reporting of PD's service factor costs to the coordinator between PD and other departments.
13 is the service objectives being reported to the PD division.
14 is the reporting the other departments service factor costs to the coordinating system.
15 is the performance objectives being reported to other departments.
16 is the reporting the disturbances affecting the other departments.
17 is the reporting the performance objectives for other departments.
18 is the information concerning the service costs being sent to the service evaluator.
19 is the service objectives being reported to system coordinating between PD and other departments.
20 is the service objectives being reported to the customer's system.
21 is the service benefits being relayed to the service evaluator.
22 is the feedforward of information about the service benefits being relayed to the system determining the service benefits.
23 is the feedback of information about the service benefits being relayed to the system determining the service benefits.
24 is the disturbances being reported to the customer's system so that they can feedforward the service benefits.

to the above classifications. Fig 8.2 shows a summary of all these systems. It is assumed that all the HASs belonging to a particular classification have the same basic properties. Therefore, it is proposed to formulate a general design for each HAS belonging to a particular classification, which when slightly modified can be used for all the HASs belonging to that classification.

Fig 8.2: A diagram summarising the information systems required to control service to internal customers.



When designing these 2 general HASs, the 3 E criteria will be used as a yardstick to gauge the best design. The efficiency and effectiveness of a particular approach is discussed later in the sections directly dealing with the HASs designs. As both of the identified HASs are information handling systems what determines a particular HAS's efficacy is common to both HASs. It has been pointed out by both Beer(1979,1982,1985) and Espejo(1980,1983a,1983b) that there is a need for such systems to have requisite variety. This means that the HAS must have at least the variety handling capacity to cope with the

variety of the information it has to handle in a given time. This condition is derived from Ashby's law of requisite variety, which states that:

> "Only variety can absorb variety". (Ashby 1965).

It should be noted that variety is defined as: The possible number of system states. Thus there is a need to increase the productivity, efficiency and effectiveness, of the HAS whilst having requisite variety (efficacious). This corresponds to Beer's 1st principle of an organisation which states that:

> "Managerial, operational and environmental varieties, diffusing through an institutional system, tend to equate (the system has requisite variety). They should be designed to do so with minimal damage to people and to cost (increase in productivity)." Beer (1985).

The design of the 2 HASs will now be discussed.

8.3 Design of the monitoring systems.

8.3.1 Introduction.

Information is only monitored to aid the DMS's decision making processes. Thus a monitoring system's effectiveness can been seen as the amount of influence the monitored information has on the decisions being made. A monitoring system's efficiency is determined by the costs of using the monitoring system.

From the literature on monitoring systems (for example Beer(1985)) it can be seen that there are principally three parts to any monitoring system. The first part is concerned with monitoring the required information. The second part with transmitting the data to the recipient. The third part with translating the information into a form, that the recipient

understands. The design of these three parts is discussed below.

8.3.2 Monitoring the information required.

Usually there exists more than one possible information source that can be used to monitor the required information. Churchman(1962) points out that, whatever monitor information source is used there exists a trade-off between its cost (efficiency) and its potential return (effectiveness). In most cases it is possible to use cheaper surrogate information instead of the actual information required.

Consequently, there is a need to develop criteria, which can be used to determine the relative merits, the efficiency and effectiveness, of different possible information sources. The efficiency of using a particular information source is determined by its monitoring costs. A particular information source's effectiveness is determined by its influence on the decisions made by the DMSs. This is reflected by its motivating force on the DMSs to make a decision. Shown below are various factors identified in the literature, which affect this motivation level:

I) The completeness of the monitored information: This is concerned with the degree to which the measured information captures the essence of the required information. Does it give all the information that the recipient needs? (For example, does the information only relate to part of the organisation). Lawler and Rhode (1976) argue that this is important as people often ignore unmeasured attributes, resulting in bureaucratic behaviour.

II) The objectivity of the monitored information. This involves looking at whether the information is impartial and cannot be manipulated by someone to make themselves look good. This point especially relates to reporting the service level achieved. This point is identified by Lawler and Rhode (1976).

III) Lawler and Rhode (1976) suggest that the speed of monitoring affects the motivation level. Generally, the older the information, the less motivating force it has.

IV) The meaningfulness of the information. Euske(1984) argues that data being monitored can only have a certain level of information contained in it. (For example, how much information does the recording of a mean value actually give us. If the critical thing about the information is its spread then it is more worthwhile to give the variance). The idea here is to ensure that the right statistical form for the data is monitored.

Due to the cost reductions (efficiency increase) it is felt better, wherever possible, to use existing information sources to monitor the information. The above effectiveness criteria were used with the participating company, to identify which of the existing possible information sources were felt to be the best for monitoring the required information as identified in chapter 7. The existing information sources were identified by using the information and material flow audit results (see chapter 4). However, no indication is included here of the proposed information sources for the participating company. This is because they are very specific to the participating company. This will generally be the case due to the information differences in different companies.

It should be noted that the ease with which information can be monitored is a further difference between the cases of external and internal customers. Generally with internal customers it is easier to get information than with external customers.

8.3.3. Transmitting the information.

Probably the most important factor influencing transmitting system design is their need to have requisite variety. This point is derived from Beer's (1985) 2nd principle of an organisation which, when slightly modified, states that:

> "The channels carrying data between the management unit, the operation, and the environment must each have a higher variety transmitting capacity in a given time than the originate subsystem has to generate in that time." (Beer(1985)).

If a transmitting channel does not have requisite variety, then according to Galbraith (1973), there are two tactics which can be adopted to give it requisite variety:

1) Attenuate, decrease the data's variety level.

2) Amplify, increase the channel's variety capacity.

Both of these approaches are now discussed in more detail.

1) Attenuating the variety level: There are broadly two possible approaches that can be used to decrease the variety of the data being reported, these are:

I) Decrease the information level being reported.

II) Improve the way in which the information is transmitted. This means transmitting the information in a more concise, productive, format (i.e. transmit less data).

The first approach is not very desirable as it results in a decrease in the monitoring system's effectiveness. This is because the information level reported affects the quality of the decisions made by the DMSs.

There are various approaches that can be adopted to improve the way information is transmitted. A popular approach is to report information in a summary form, usually in a statistical format. When using this approach, a decision has to be made of which statistical format is going to be used. It is felt that this should be dependent on what statistical format influences the DMS's decisions most. An idea of this can be discerned, wherever possible, by consulting with existing information recipients. (If the required information is the service level then it would be sensible to report it by using the criteria identified in chapter 7, as being the most profitable to use). Another popular approach, especially in Physical Distribution, is to report the information by using performance ratios. This means that data is only reported when there has been an actual change in the performance levels. (Examples of using such ratios can be found in numerous studies including the National Council of Physical Distribution Management (1984)).

Another approach, for improving data reporting, is to only report data which changes the DMS's decisions. Thus, when there has been little, or no, change in the data it is pointless reporting it. It should be stressed that this approach reduces the data's variety whilst minimising the information loss. This is due to the DMS assuming that the information has not changed. It should be noted that this forms the basis of an exception reporting system (i.e. data is only transmitted when it contains new information to its recipient). Also, it is not worthwhile (cost effective) to report short term changes in the data as it is unlikely to be beneficial for the DMS to react to theses changes. Beer (1981) uses Kalman filters, alongside of Bayesian forecasting (see Stephens and Harrison(1971)), to perform both of these tasks.

However, there is a limit to how well information can be formulated. Consequently, there is an upper limit to the information level (effectiveness) that a channel, of a specified data variety handling capacity, can actually transmit. To reduce the data level any further will result in information loss and hence effectiveness reduction.

2) Amplifying the channel's capacity. There are two ways the channel capacity can be amplified:

I) Increase the amount of data that can be transmitted, per transmission.

II) Increase the transmission frequency.

To prevent the data becoming out of date, it is usually better to increase the transmission frequency.

The efficiency of a transmitting channel can also be increased by using different approaches (actors) for transmitting the information. For example, there are differences in the variety capacity of a written report and sending information via a computer terminal screen.

The issues identified above influencing transmitting system designs are summarised in Fig8.3.

8.3.4 The format of the information.

If information recipients receive data formatted in a style which they do not comprehend it is of no practical use to them. Consequently there is a need to translate data entering a recipient system into the format which the system's actor wants. The required format can be identified by consulting these actors. It is felt best to carry out this translation process before transmitting the information to the recipient. This is because this translation process determines the statistical format that the data should have and consequently the format it should be transmitted in.

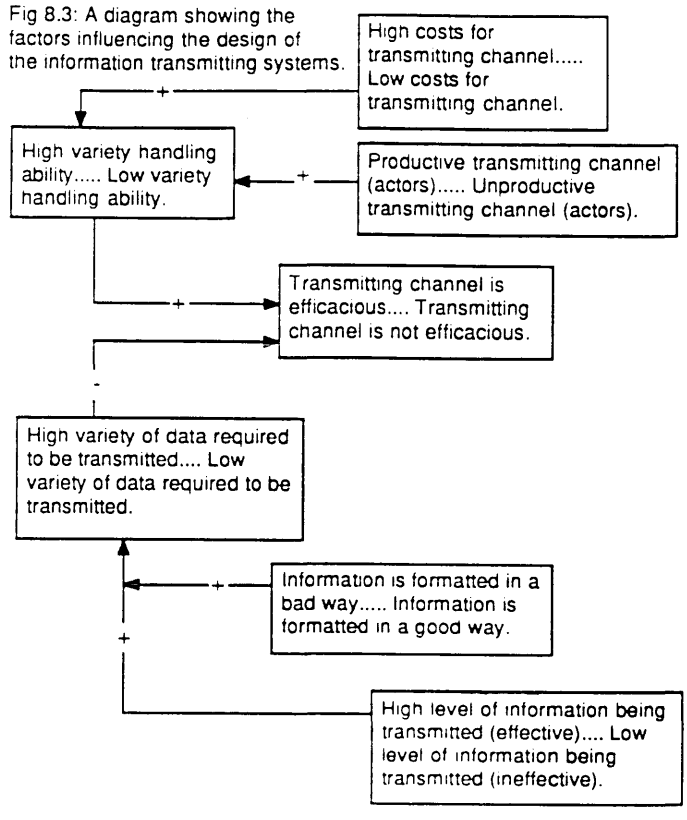


Fig 8.3: A diagram showing the factors influencing the design of the information transmitting systems.

8.4 The design of the DMS.

8.4.1 Introduction.

From Fig 8.2 it can been seen that each divisional DMS set objectives for the divisions under its control to meet its own divisional objectives at the lowest cost subject to the environmental disturbances. To make this decision there is a need for the DMS to have:

1) Some model which defines the divisional performance as a function of the subdivision performance levels and disturbance levels.

2) Knowledge of the disturbance levels.

3) Knowledge of what the subdivisional performance costs are.

As the disturbances hitting a system change,so will the objectives being set for its subdivisions along with its own divisional performance costs. This creates a dilemma to the

DMS of where to draw the balance between setting objectives meeting the present situation and setting objectives to meet the future situation. It should be noted that this is partly the dilemma of whether to react to the disturbances changes or not (see chapter 6). Information relevant to the decision of where to draw the balance are:

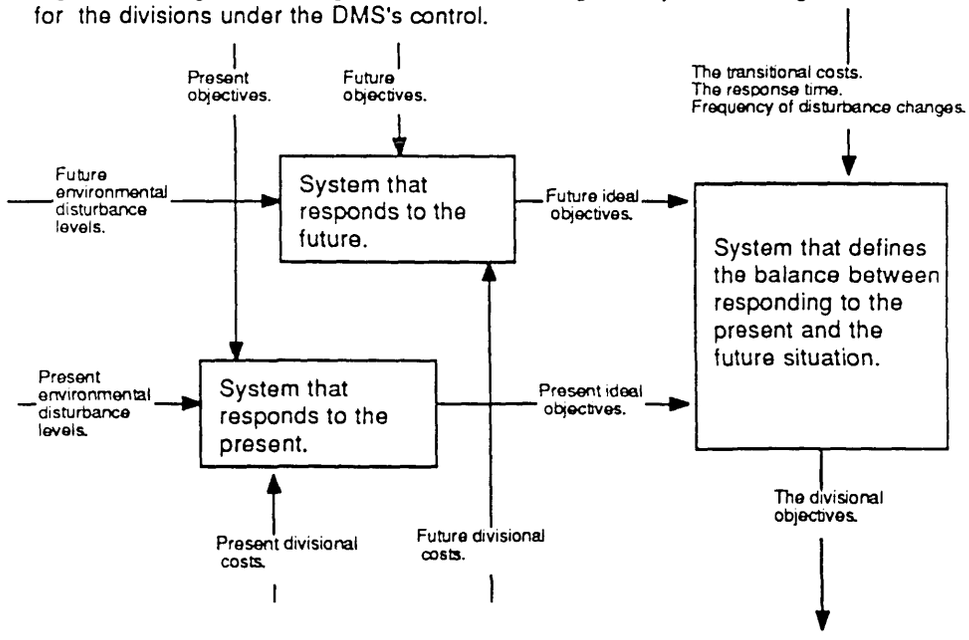
1) How quickly the responses change.

2) What the transitional costs are.

3) How often changes take place.

Fig 8.4 summarises the above arguments concerning whether to react to the present or future situation.

Fig 8.4: A diagram showing the factors influencing the objective setting for the divisions under the DMS's control.



It should be stressed that to generate the model required by the DMS both the service factors and service level have to be reported to the DMS. (The model generation is discussed later in section 8.4.2.)

It can be seen from Fig 8.4 that the DMS consists of three main parts:

1) The part of the DMS which determines objectives (service response levels) for

the present moment.

2) The part of the DMS which determines objectives (service response levels) for the future.

3) The part of the DMS which determines what balance there should be between responding to the present and future situations.

It should be noted that these correspond to systems 3 to 5 respectively of Beer's model of a viable system (Beer(1981)).

For a DMS to be viable (efficacious) the actor needs to have requisite variety. This means that the actor's data processing (variety handling) capacity has to be greater or equal to the variety entering the DMS's domain. Unfortunately, the situation's variety under the DMS's control is usually greater than the DMS's variety handling capacity- Espejo and Watt(1988). This point is demonstrated here by looking at the DMS determining the best combination of service responses to achieve a specified service level given the disturbance levels. The factors relevant to this decision are all the service factors, the service responses and disturbances. For the DMS to be totally effective it has to cope with all the possible permutations of the service factors. Consequently, the variety required to be handled is the product of the varieties of all the service factors affecting the service level. This is usually far greater than the variety handling capacity of any human actor.

It should be noted that whenever any of the profit increasing approaches, suggested in chapter 6, are used then the variety entering the DMS's domain is increased. This is because more of the environment (disturbances) and the organisation (service responses) are relevant to the decision making process. For example, when reacting to disturbance level changes the disturbance level becomes a relevant factor whereas before it was not. Another example is the use of market segmentation. This is because information has to be reported from each segment and can not be combined into one piece of information. Thus

there is an increase in the variety of the information.

The above argument ties in with what Espejo (1983a) says: "That in general, a more ambitious performance level implies a larger relevant environment." Espejo (1983b) also argues that: "Organisational redundancies and slack resources make it possible to maintain viability in enterprises despite their ineffective use of information." Thus if some of the slack resources are eliminated, by using the approaches proposed in chapter 6, then there is a need to design a more effective information handling system. This implies that a trade-off exists between the increase in the organisation's gross profits, by having a better service policy, and the control (information handling) costs.

This indicates that it is advantageous to have a highly productive service policy (service measures and service segments). That is one that is highly effective, increases the gross profits, but which is also highly efficient in minimising the environmental variety relevant to ensuring that the service policy is achieved. Thus any service measures or segmentations that does not increase the systems profits greatly and substantially increases the relevant environmental variety should not be used. Whereas any service measures or segmentations which increase the systems profits considerably and does not greatly increase the relevant environmental variety should be used. (This means trying to ensure each part of the service policy is highly productive, economically viable).

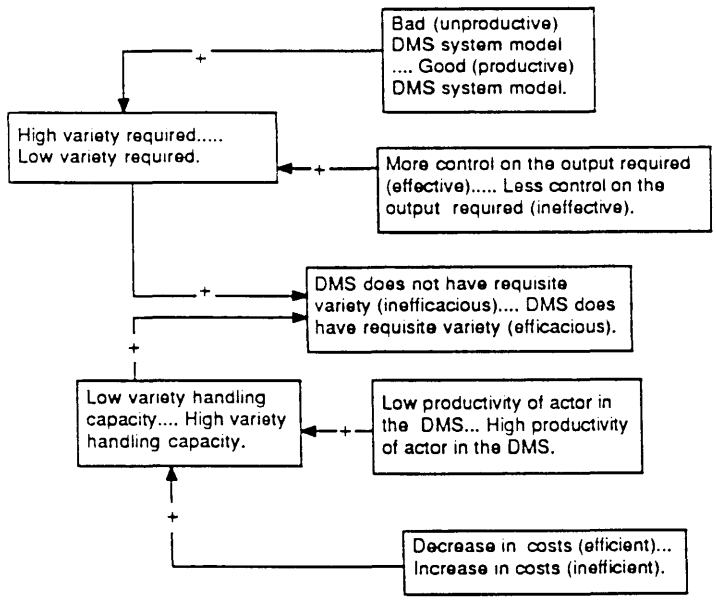
When a system does not have requisite variety there are broadly two ways as proposed by Galbraith(1973), that can be used to eliminate this so called variety gap:

1) Decrease, attenuate, the variety that has to be handled. This can either be done by decreasing the system's effectiveness or by increasing the system's/model's productivity (increase the effectiveness for a particular variety level handled).

2) Increase, amplify, the actor's variety handling capacity. This can either be done by increasing the costs (consequently decreasing the efficiency) or by increasing the actor's productivity.

The interaction of these above principles to ensure a DMS has requisite variety are shown in Fig 8.5. The above two ways for eliminating the variety gap are discussed below.

Fig 8.5: A diagram showing the factors influencing the design of a Decision Making System to ensure it has requisite variety.



8.4.2 Way 1: Decrease the variety needed to be handled.

Several approaches are suggested in the literature (for example see Espejo and Watt(1988)), for doing this. These approaches are investigated below:

Approach 1, the actor ignores part of the information. Usually, this is done rather haphazardly by the actor ignoring the influence of particular variables. Consequently, a decrease in the DMS's effectiveness occurs rather than an increase in its productivity. It should be noted that this is often the situation that happens due to the lack of planning of how to handle the information's variety. Espejo and Watt(1988) says that the actor's filtering process can be improved in several ways.

This includes using cognitive mapping techniques (Eden et al(1983)) to discuss the issues or factors most relevant to a decision as was done in chapter 7. When this technique is used, the DMS's productivity is increased.

Approach 2, defining the inputs of the DMS's models appropriately. The size/variety of the models required to be handled is determined by the number of inputs, disturbances and service responses entering the DMS's domain. Thus, by defining the inputs which most influence the output or the service level, it is possible to reduce the models size by disregarding other possible inputs, at the same time minimising the loss ineffectiveness. Thus, this approach increases the model's productivity. Another way of limiting the number of inputs is to limit the number of outputs in the models, that is the number of service measures and segments. This argument is supported by Espejo(1983b) who says that: "The criteria of performance should be defined where ever possible." When the system is hard, well defined, this matter is relatively easy. However when the system is soft/ill-defined, like in this situation, then this is harder to do. Espejo and Watt(1988) suggests that Checkland's soft system methodology (Checkland(1981)) can be used to determine the performance criteria in these situations

This process of defining the inputs can be done by using cognitive mapping techniques with PD to determine what are considered to be the inputs. This was carried out in chapter 7 for defining the service factors for the service measures. Also by defining what the service measures are, the number of model outputs has been limited consequently restricting the number of inputs required.

Approach 3, filtering the data by the use of management information systems. The level of data entering a DMS's domain is dependent on the level of data being reported by the information systems (both formal and informal). It has already been

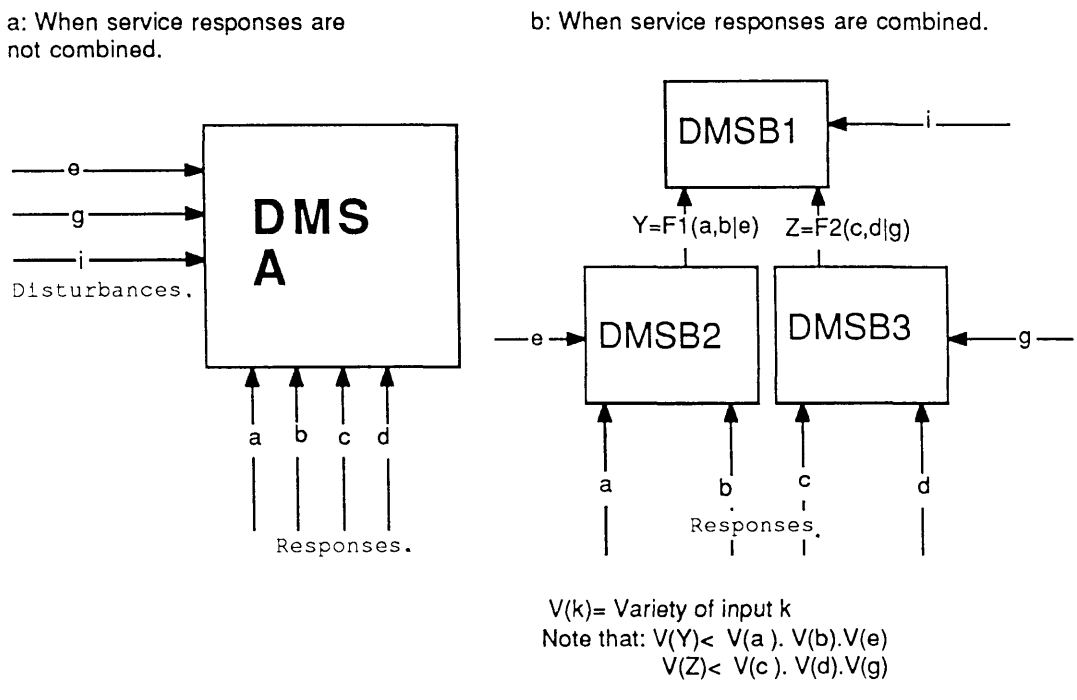
argued, in section 8.3.2, that it is more productive to only report information to DMSs when it affects the decisions being made. This reduces the number of times a DMS makes a decision, resulting in a variety reduction. However, this does not adversely affect the DMS's effectiveness as the same decision would still hold true. Thus there is a need for a way of determining whether a system change has occurred. Beer(1981) uses Kalman filters alongside the use of Bayesian forecasting to perform this task. It should be noted that the above principles also hold for reporting information (objectives) to the lower company divisions.

Approach 4, filtering done by the organisational structure: It has already been argued that the product of the variety of the inputs, (such as the disturbances and the service responses) determines the variety level that has to be handled by the DMS. This approach combines two or more service responses together to form a more general service response (having a lower variety than the combined variety of the original service responses). This more general service response is a function of these other service responses. This means that, there is a need for a further DMS to coordinate between the service responses to generate this more general service response level at the lowest cost. This principle is illustrated in Fig 8.6. The advantage of doing this is that the variety level which any one particular DMS has to handle is reduced. From the example shown in Fig 8.6 the DMSs when the service responses are not combined, have to handle variety equal to V(a).V(b).V(c).V(d).V(e).V(g).V(i). Whereas the variety that the other DMSs have to handle is always less than this when the service responses are combined.

As well, as reducing the service responses variety this approach reduces the disturbance variety. It can be seen from Fig 8.6 that DMSB1 only coordinates between service responses Y and Z. Thus, only the disturbances which affect the coordination between these two service responses should be reported to DMSB1.

Whereas, any disturbances which affect the coordination between a,b,c,d should be reported to DMSA. The disturbances reported to DMSB1 generally form a subset of the disturbances reported to DMSA. This point has been expressed by Beer(1985).

Fig 8.6: Diagrams showing how combining two or more service responses together to form a more general service response reduces the variety required to be handled by any one DMS.



Unfortunately even DMS's DMSB1, DMSB2 and DMSB3 in Fig 8.6 generally do not have requisite variety. Thus their service responses have to be combined together to form more general ones. From this it should be apparent that by using this approach a recursive structure, such as shown in Fig 8.7, is generated.

If level N, in Fig 8.7, is seen as the PD's DMS controlling the PD's service then level N-1 can be seen as the divisions inside PD. What these divisions are will be dependent on the individual company. However, usually these divisions are the company's warehousing and distribution functions. Thus, PD's DMS generally has to coordinate the distribution and the warehouse divisions output to generate PD's

performance at the lowest cost. In turn the warehouse division DMS has to coordinate between the warehousing subdivisions and so on. This principle is shown in Fig 8.8.

Fig 8.7: A diagram showing the recursive structures of DMSs that is produced as a result of the need for each DMS to have requisite variety.

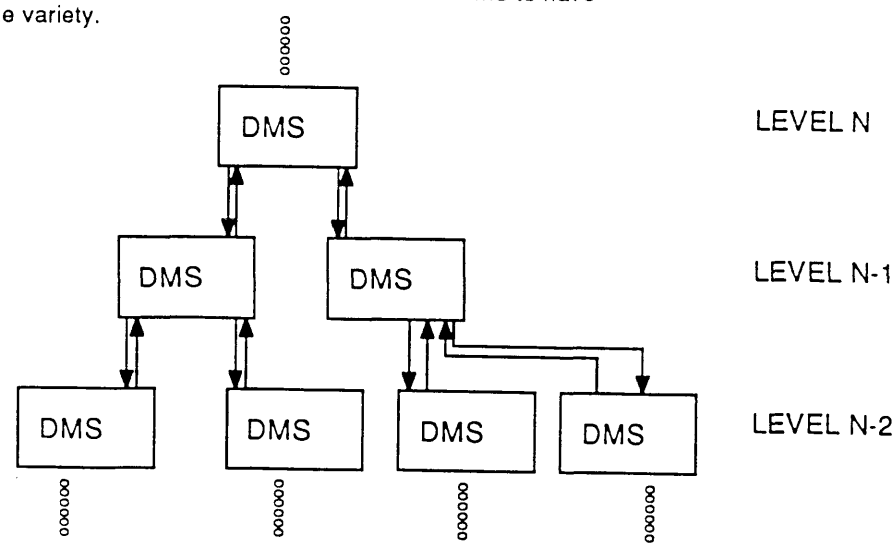
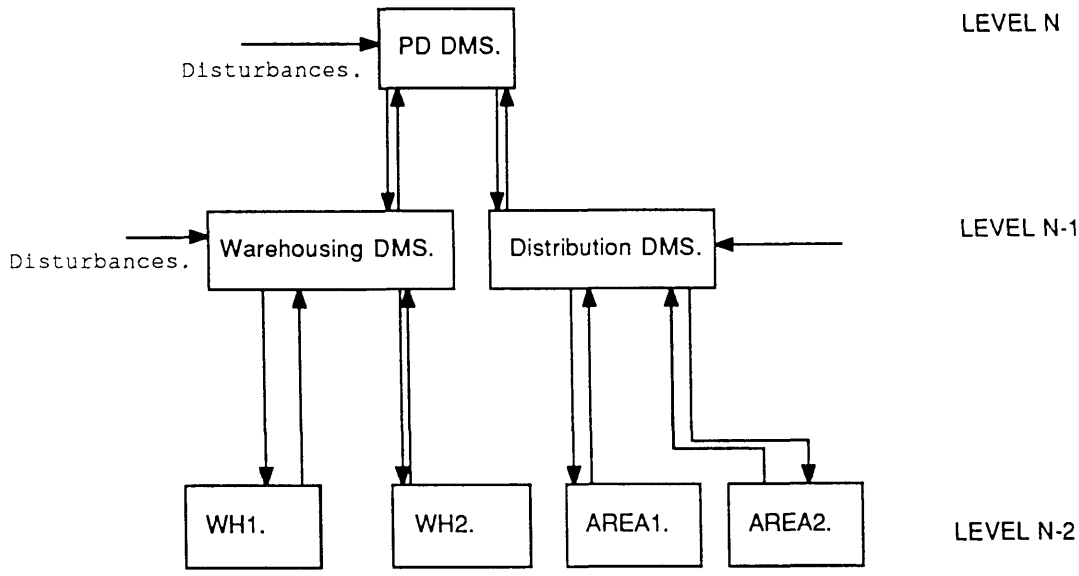


Fig 8.8: A diagram showing a typical recursive DMS structure when PD has to coordinate between the warehousing and distribution divisions.

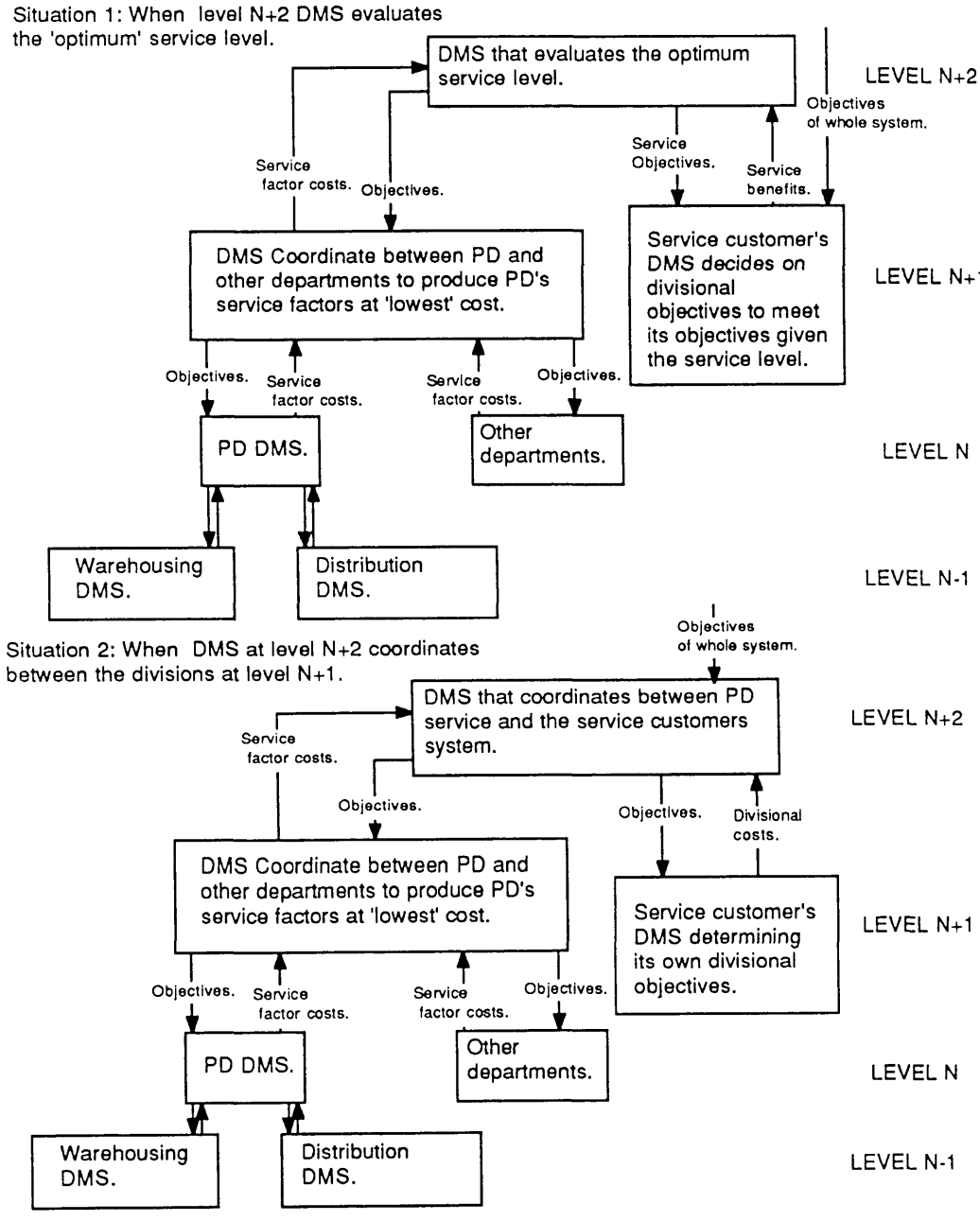


When the next 2 higher recursion levels of the company are included, then the situation is as shown in Fig 8.9. Several interesting and important points concerning the control of PD service come out this diagram.

Point 1: Defining the optimum service level has the same effect as

coordinating between PD's output and the service customer's output. When defining the optimum service level (where the service affects the output of the customer's system) the system identifies the service level which generates the customer's system output at the lowest total cost. However this output is the output of the whole system- the PD and customer's systems combined, that is the same output as in situation 2. Consequently,

Fig 8.9: Diagrams showing the 2 alternative situations for when levels N+1 and N+2 are included in the system.



when the DMS at level N+2, as shown in Fig 8.9 (situation 1), determines PD's required service level it decides on the same service level as that which is decided by using the approach, shown in situation 2, that coordinates between the systems to produce the total system's output at the lowest cost. From now on, for parts of service which affect the output level of the combined systems, the idea of coordinating between the 2 divisions will be used instead of evaluating the optimum service level. It should be stressed that, it is not being argued that the concept of service measures should be abandoned but this part of service should be seen and be dealt with as being:

> " The output of the PD system which contributes with the customer's system to meeting the whole system's objectives."

Point 2: In situation 1 the company objectives are 'feed' through the customer's system and then onto the service control system. Consequently there are time lags and resultant performance loss. However in situation 2 there are no such delays. Hence it is proposed that using situation 2 approach would probably be more productive.

Point 3: It is interesting to note that it is possible to argue that the customers also provide service to PD. For example, stores holding back store stock provide a service to PD, by allowing them to decrease their lead time.

Point 4: That the coordination between other departments and PD to provide a service level at the lowest cost does not necessarily have to be done independently of determining the best service level. There is no reason

why a DMS should not coordinate between the output of all three departments (PD, others and customers). It should be noted that the coordination between PD and the other departments, at level N+1 in Fig8.9, is only done to decrease the level of variety needing to be handled by the DMS at level N+2 in Fig 8.9.

Unfortunately, using this approach of attenuating the variety level does not guarantee that the whole system's output is actually achieved at the lowest cost. This is due to the performance of the different divisions, which the system has been split into, not being independent of each other. Although this may not affect the whole system's output level it may affect the 'fixed' operating costs of achieving this output. That is the costs of providing an output level are increased by a fixed amount. This can be counteracted by using a mechanism which stops this unbeneficial behaviour happening. This means controlling the output of one subsystem which affects another subsystem performance but does not directly affect the output of the two systems combined.An example of this would be the arrival of delivery vans. This output also constitutes part of the service to the other system. The optimum output level has to be evaluated in this case in terms of the costs and benefits of the service level. This control mechanism corresponds to system 2, the anti-oscillatory system, in Beer's model of a viable system (Beer(1981)). Thus, it can be seen that there are two types of service:

Type 1: PD's performance which combined with the service customer's performance produces the output of the whole system.

Type 2: PD's performance which affects the service customer's operating 'fixed' costs.

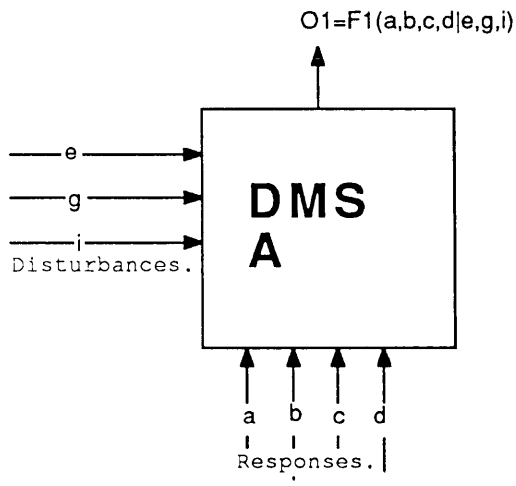
Thus from the above arguments it can be seen that type 1 measures should be controlled by using a coordinating approach (Fig 8.9 situation 1) and type 2 measures should be controlled by defining the optimum service level (Fig 8.9

situation 2).

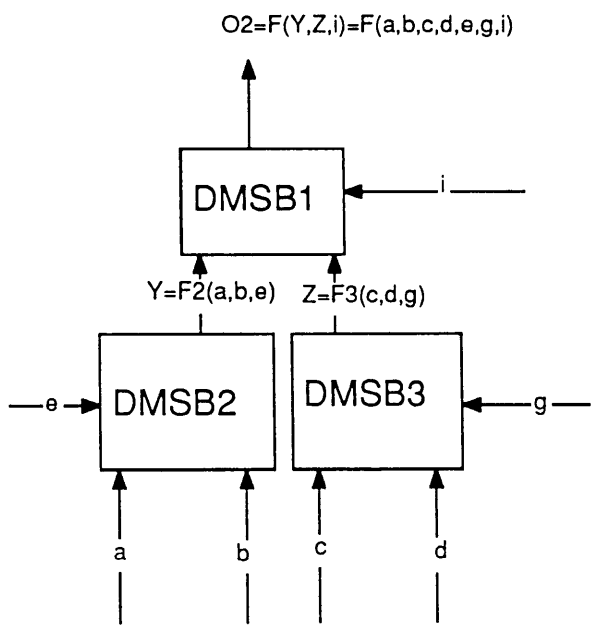
The effect that controlling these two types of service has on the total system's performance are illustrated with reference to Fig 8.10. When service responses are chosen in response to a known disturbance level the performance levels are greater

Fig 8.10: Diagrams showing the different effect on the system's output for the 4 different service control situations.

Situation 1: The DMS has requisite variety.



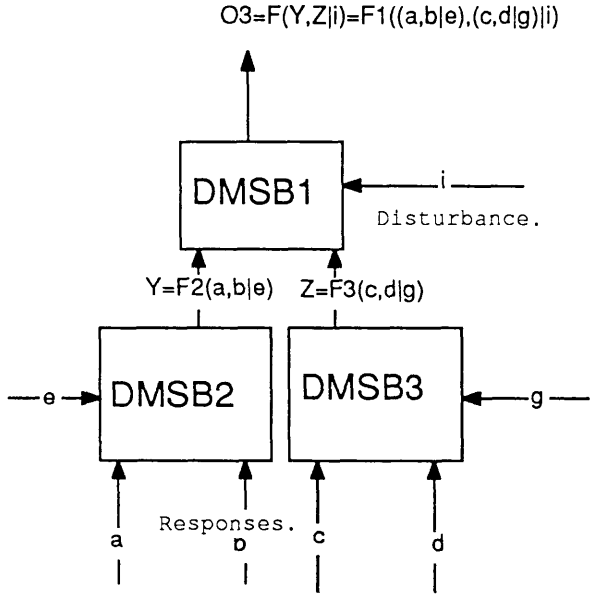
Situation 2: The DMS does not have requisite variety and there is no control of service.



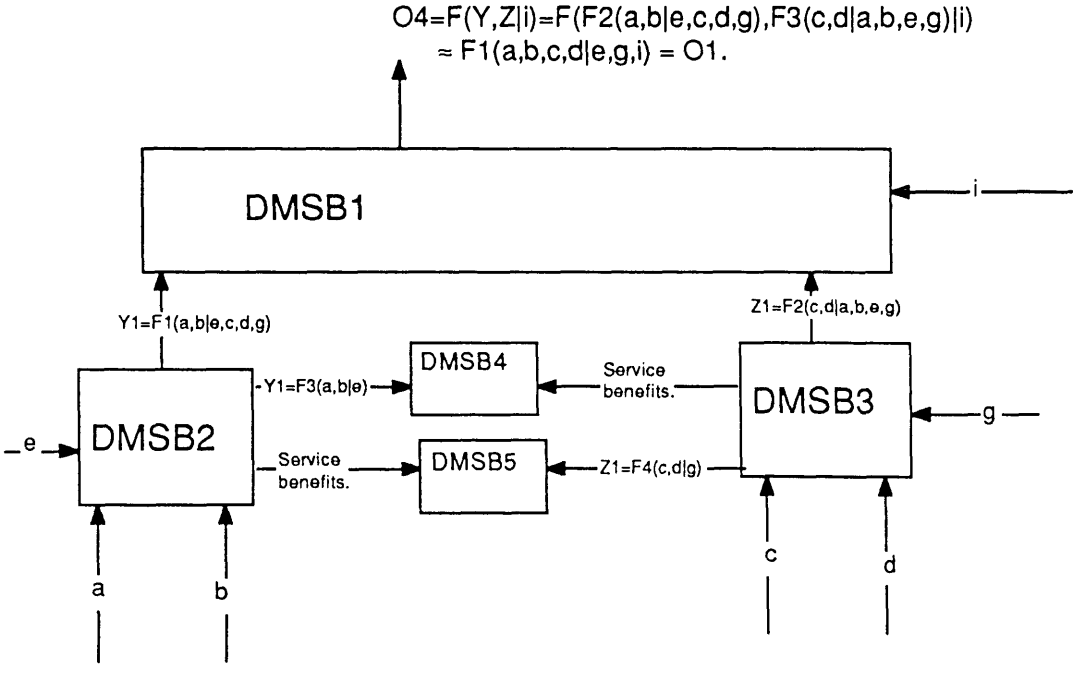
than when disturbance levels are not taken into consideration. Thus, situation 1 in Fig 8.10 generates the best performance level as all the service response levels are chosen together and the disturbances are taken into consideration . When no type of service is controlled, situation 2, the performance level is at its lowest. Controlling type 1 service, situation 3, improves the performance by taking some of the

Fig 8.10(cont): Diagrams showing the different effect on the system's output for the 4 different service control situations.

Situation 3: The DMS does not have requisite variety and type 1 service is controlled.



Situation 4: The DMS does not have requisite variety and both types of service are controlled.



disturbances into consideration when choosing service response levels. Unfortunately the service responses are often chosen independently (for example the level of service responses a and c are chosen independently in Fig 8.10). However when both types of service are controlled situation 4 the service responses are chosen together and consideration is taken of all the disturbance levels. It can be seen from this that when both types of the service are controlled-situation 4- the whole system's performance is very similar to the performance in situation 1, when the system is not split up into different parts. Consequently, the control of PD service can be seen as:

> "The retrieval of the system's performance (synergy) which is lost, due to the system being split into smaller parts. This is as a result of the decision making system of the whole organisation not having requisite variety to handle the relevant information."

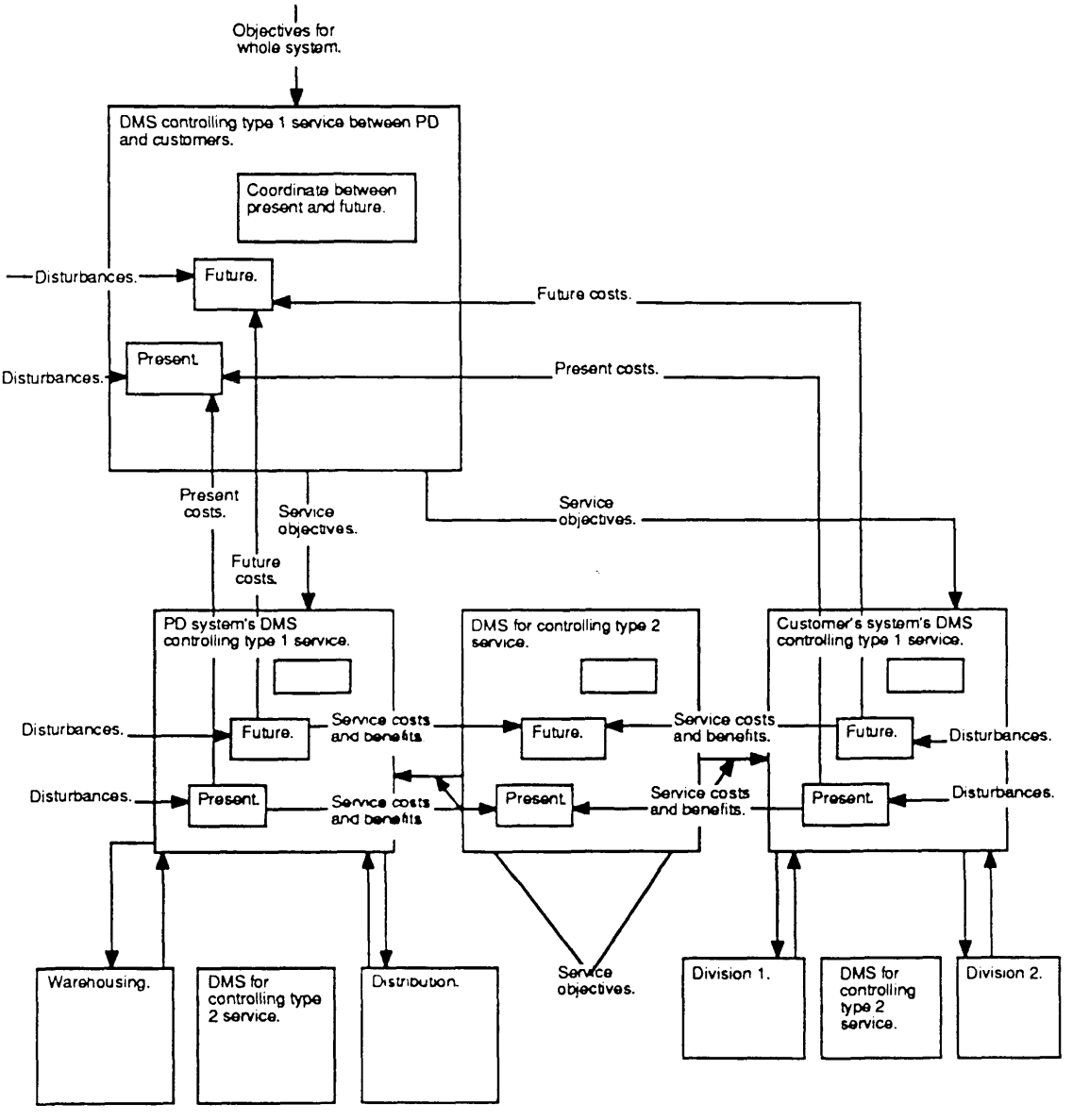
This means that controlling service enables a total system cost approach to be adopted. When a PD system is being considered it enables a total distribution cost approach to be adopted (see Christopher(1971)).

It is suggested that this work on the effect of controlling service to internal customers is similar in nature to the work that has been carried out on hierarchical control of large scale systems. (For example see Jamshidi(1983) and Mahmoud(1977)) Where the coordinating variables used in the model coordination method and goal coordination method are equivalent to the service measures. With these methods the coordinating variables are manipulated until the interaction error, of splitting the system into smaller parts, is reduced to zero. Thus these methods have similar effect to controlling service to internal customers.One advantage of using the approach of controlling service measures over using the hierarchical control approach is its ability to deal with fuzzy situations An investigation into the comparison of controlling service to internal customers and the hierarchical control

of large scale systems could be an area for further research.

Thus, the whole of the company can be seen in Fig 8.11. This diagram is similar to Beer's model of a viable system (Beer 1981). This is not surprising as the above arguments have been based on having a viable, efficacious, system.

Fig 8.11: A diagram showing all the DMSs for controlling PD service to internal customers.



It was argued above that controlling service between the divisions at a particular recursion level can retrieve the lost performance of considering the system in a piece-meal fashion. Unfortunately, some of the performance is still lost as a result of time lags involved in reporting from the different subsystems to each other in the organisation. This makes it harder to react to disturbance and other system changes. Therefore, there exists a trade-off between the performance decrease ,by reducing the effectiveness of a particular DMS, and the reduction in performance due to the time lags, as a result of there being many more subsystems. Unfortunately it is impossible to actually determine where the optimum position between these two poles is. The need for fast response from one DMS to another DMS broadly represents Beer's 4th principle of an organisation, which states that:

> "The operation of the first three principles must be cyclical maintained through time without hiatus or lags." (Beer(1985))

8.4.2 Way 2: Increase the actor's variety handling capacity.

It has just been shown that there are advantages associated with reducing the number of recursive levels in a system and hence reduce the time lag problems. One way of doing this is by increasing the variety that each level's DMS can handle.

So far it has not been specified who the actors for a DMS should be. Indeed it is not necessary for all the activities, HASs, contained within a DMS, as shown in Fig 8.4, to be carried out by the same actor. Unaided, any one actor is limited in the effect that he can have. However when one actor is coupled to another actor then there is a resultant amplification of the system's variety handling capacity.

The different activities contained in a particular DMS are often best carried out by different types of actors. For example determining the best service response combinations to produce a particular service level is a reasonably straight forward decision but requires an actor with

a high variety handling capacity. Therefore this activity lends itself to be carried out by a computing system. Where as the other parts of DMS (such as deciding what time horizon needs to be considered) due to their fuzzy and rather subjective nature are often best carried out by humans. It should be noted that if this approach was used it would form the basis of a Decision Support System (DSS). This is the situation where the human decision maker has access to a computer model of the systems dynamics, which due to its size has greater knowledge than his own brain can generate.

The computer models used in a DSS can be any mathematical or other model felt to be appropriate to the particular situation. (For example the Economic Order Quantity model may be appropriate in certain situations). However when no such nice known model exists there is a need to generate one. When attempting to generate these computer models of the system the model's basic shell (the inputs and outputs) can be formulated by using cognitive mapping techniques with the present decision makers. A series of such cognitive mappings were produced, in chapter 7, to represent the relationship between the service factors and the service measures in the organisation studied. Once these conceptualised models have been generated then the technique described below can be used to transform these cognitive maps into a highly productive model.

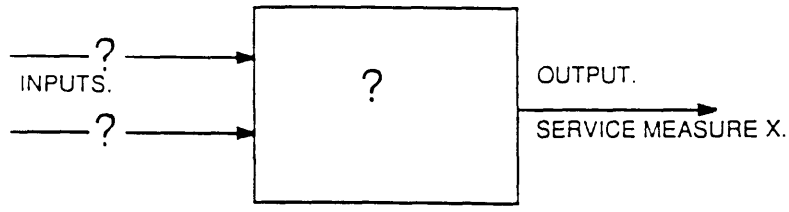
This technique tries to maximise the DMS's model's effectiveness for a particular model size (i.e. increase its productivity). It is suggested that the DMS's model effectiveness is measured by the certainty of knowing what effect (output level) a particular set of actions (inputs) will have. This certainty, or lack of it, can be measured by the output's entropy. This measurement will be used as the criterion for determining which of a selection of possible models is the most productive/ knowledgeable (Lewis (1936)).

Let the case of generating a model of the relationship between the service factors and a service measure be considered. The service measure level can be considered as the outputs

of a black box. This black box is the whole system under investigation (both the PD system and its environment). Each of these outputs, the service measures has several values.

The initial state of the knowledge of this black box is shown below, in Fig 8.12:

Fig 8.12: A diagram showing the initial state of the black box.



This model has an entropy value associated with it. The entropy of this model is measured by:

$$H(X)=\sum_{i=1}^{N} P_i \text{ Ln } P_i$$

Where Pi is the probability that the result will be i. for output X.

and N is the number of different output values.

What is interesting to know is: The effect knowing the level of any another event (service factor) has on the knowledge of the output (the service measure). Lets assume that this event is Y1.

If $Y_1=1$ then the entropy of the output X will be:

$$H(X|Y_1)=\sum_{i=1}^{N}(P_i|Y_1=1) \text{ Ln } (P_i|Y_1=1)$$

If Y_1=2 then the entropy of the output X will be:

$$H(X|Y_1)= \sum_{i=1}^{N}(P_i|Y_1=1)\ Ln\ (P_i|Y_1=2)$$

An average uncertainty in the result is given by multiplying the resultant entropy value for the output associated for a particular input value, by the probability that Y_1 is that input value. This, thus, gives the entropy as being:

$$H(X|Y_1)= \sum_{j=1}^{M}\sum_{i=1}^{N}(P_i|Y_1=j)\ Ln\ (P_i|Y_1=j).P(Y_1=j)$$

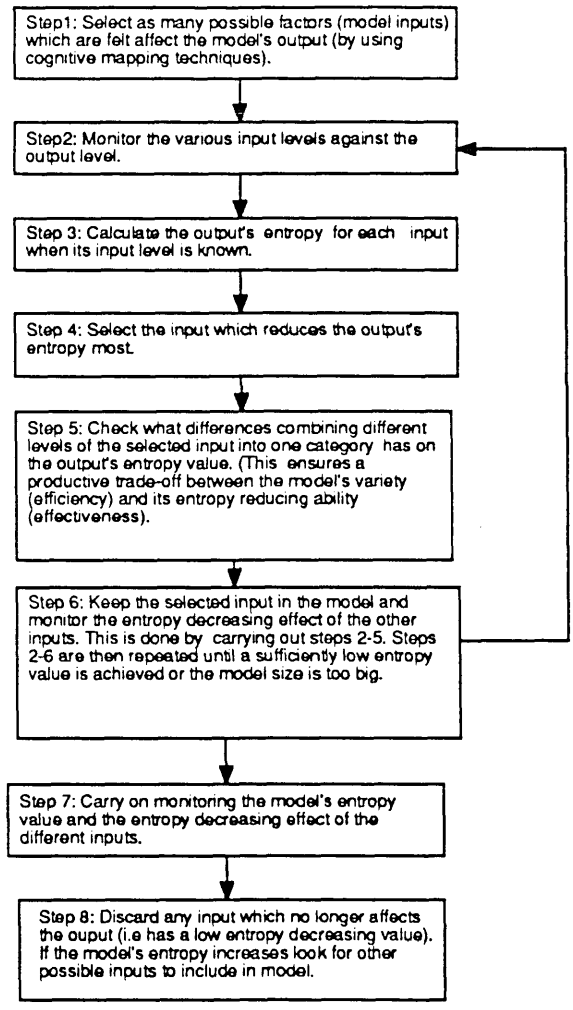
Where M is the number of different possible values for Y_1.

If there has been an entropy decrease then there has been a resultant increase in the model's knowledge- effectiveness. It should be noted that, it is impossible to have an increase in the entropy level when putting an extra input into the model (this can be proved by induction). When a further input is monitored the entropy is reduced even more. Gradually as more inputs (service factors) are used the system's behaviour becomes more predictable. However it is more productive to include the factors in the model which reduce the entropy value most. An outline of a possible approach for performing this is indicated in Fig 8.13.

If the system is monitored continuously then as the system changes so do the various outcome probabilities. When the model's entropy increases it indicates that there may be some other service factors (previously not included in the model) that need to be considered. Also a check can be made of the entropy decreasing effect of the inputs already contained in the model. From this the factors which no longer have a significant effect on

the output can be discerned and discarded. Thus, this entropy decreasing model technique is evolutionary in manner in that the models that survive are those which describe the system most productively.

Fig 8.13: A diagram showing the steps involved in using the entropy decreasing modelling technique.



It should also be noted that, this technique can also give an indication of the absolute effectiveness of the HASs, described in chapter 7, for determining the different service measure's service responses and disturbances. If the model has a high entropy value then these HASs have not been very effective.

8.5. The situation for external customers.

With external customers there is still a need for both DMSs and information reporting systems. However the decisions made by the DMSs are slightly different to those with internal customer. Instead of defining service objectives which minimise the total internal system costs, to meet the total system's objectives, the objectives are set to maximise the company's profits.

The basis of such systems has been outlined in chapter 2 when looking at previous customer service studies. Broadly it entails determining the service segments and evaluating the optimum service level (service level with highest profit level) for the identified service measures. The service costs reflect the company's internal performance. It should be noted that this is partly dependent on controlling service to internal customers. The service benefits are the sales levels resulting from a particular service level. Controlling service to external customer can be seen as:

> "Increasing in the organisation's performance, profit levels, by considering its interaction with its environment (customers)."

To make a decision the DMS most know the service benefits levels, sales levels. The sales level is determined by the customer's image of this particular supplier (company) compared to other suppliers. It was indicated in chapter 2 that there are several factors influencing the sales level, including:

1) The customer's service expectations and the relative importance of the different service measures. This is dependent on the effect that service has on the customer's operations.

2) The service levels being offered compared to the rival suppliers' service levels.

There is a need, as with internal customers, to have a productive service policy that increases the gross profit levels (effectiveness) but does not result in a high resultant relevant information variety level, costs, associated with the decision making (high efficiency). It was implied in chapter 2 that this can be done by determining the service measures which must influence the customer's image of the supplier and hence the sales. It should be noted that this point has been discussed in greater detail in chapter 5.

As with the internal customers the service costs change as the disturbances affecting the internal system's performance. The service benefit changes occur when:

1) The rival supplier's service levels change. If the rival supplier's service level increase then the customer's service expectations increase resulting in a decrease in the service benefits.

2) Environmental factors affecting the customer's system change. For example, if interest rates increase, leading to a customer's desire to reduce his stock levels, then customers place a higher emphasis on shorter lead times. This means the relative emphasis placed on different service measures changes.

As neither the service costs nor the service benefits are static there is still a need for the DMS to strike a balance between responding to present and future circumstances.

From the above arguments it can be seen that there are 3 basic needs for a DMS with an external customer:

1) A model relating the service benefits and service costs to the profit level.
2) Knowledge of the service costs.
3) Knowledge of the service benefits. This can be done in several ways.

Questionnaires etc can be used to determine the influence of service on the company's image. The effect of service on sales can also be monitored. It might also be beneficial to monitor key factors, such as environmental factors, influencing the customer's system and rivals service levels.

The differences in the DMS required for controlling service to external customers and to internal customers are shown in Fig 8.14. The main differences in the two DMS result from their different roles in the company. The role for DMS for internal customers can be seen as: "Coordinating the divisional performances under its control so as to meet its own divisional performance at the lowest cost."

Whereas the role of the DMS for external customers can be seen as: "Managing the interface between company and its customers so as to maximise the profits."

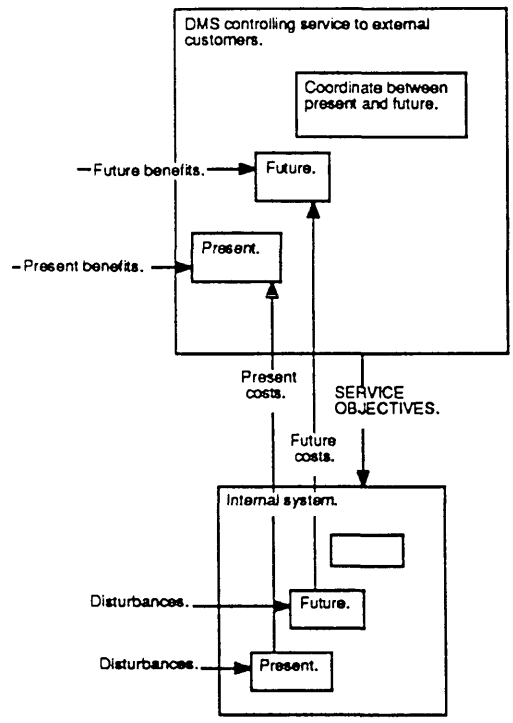
The same basic principles hold for internal and external customers when it is what information reporting systems are required is being considered. However the information required will be different. Also the information that is available for use may differ. Unfortunately there may be greater problems with collecting information with external customers as the information required is often from an outside source.

8.6 Controlling service in the whole company.

It can be seen from Fig 8.14 that controlling service to external customers sets the performance objectives for the whole internal system which are then met by controlling the service to internal customers. This means that by controlling service (both internally and externally) a control system for a whole system, the company and its interaction with its environment, has been developed. This system is shown in Fig 8.15.

Fig 8.14: the differences in the DMS for the two types of customers external and internal,:

a) External customers.



b) Internal customers.

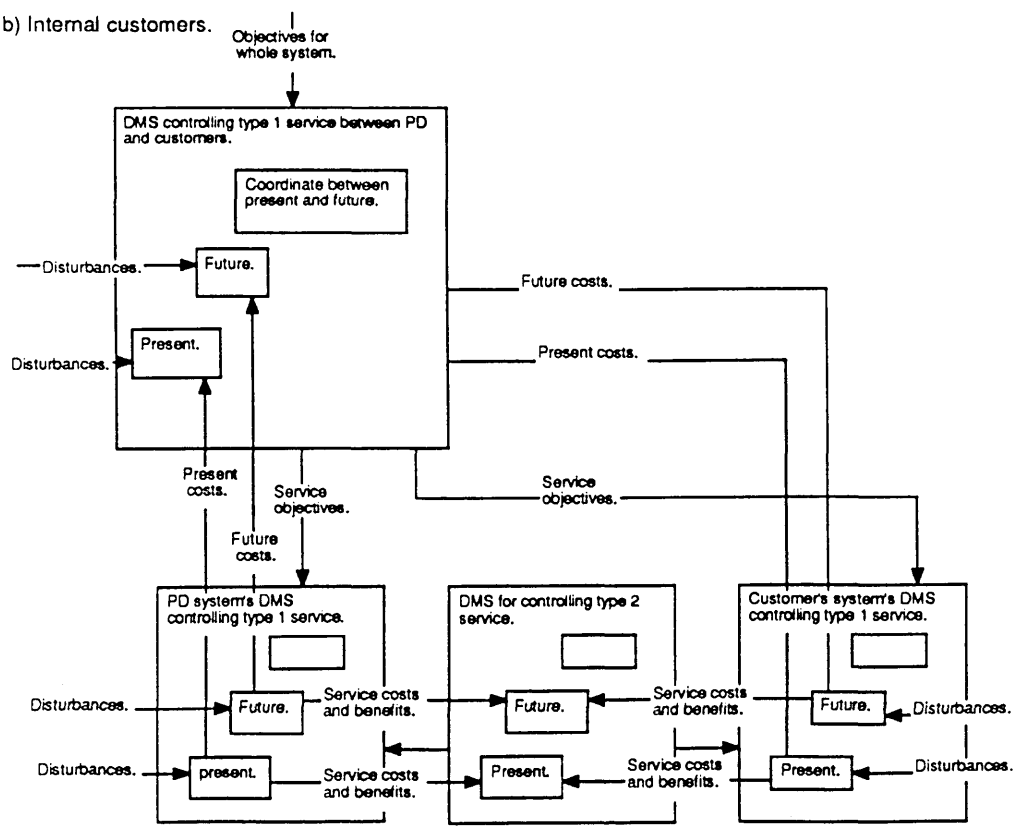
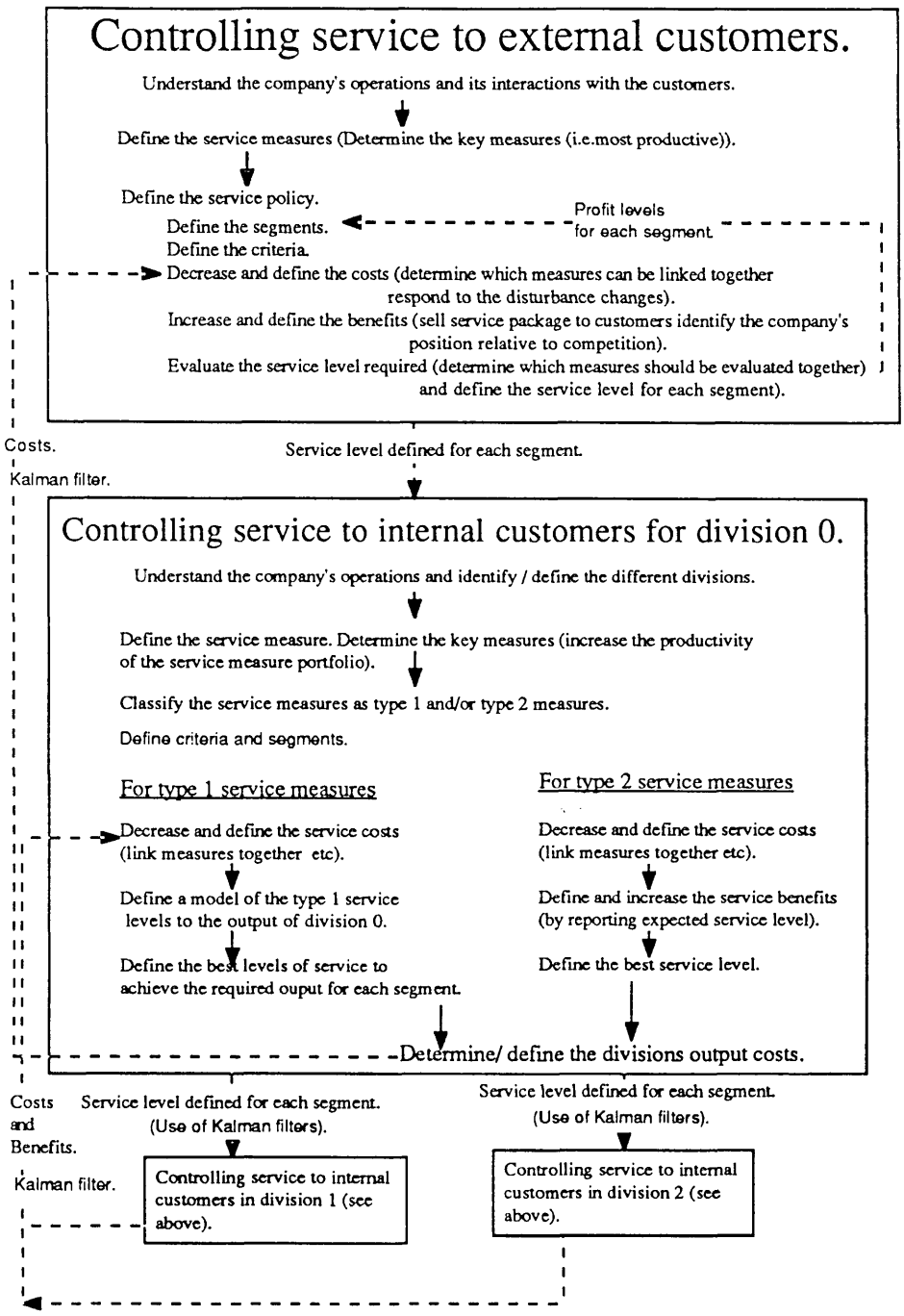


Fig 8.15 : A diagram showing the service control systems required for the whole company.



Several interesting points come out of this:

1) There is a continuous feedback of the achieved performance so the objectives are continuously updated. This ties in with Christopher's point of controlling service as part of the planning cycle (Christopher(1983)).

2) The system does not have to be a PD system. The principles contained in Fig8.15 can be transferred to other situations. For example the techniques defined for identifying the service measures are not dependent on the service being from a PD system. The service could by from any company division/department which affects another part of the same company

3) There is a need to define how the company is going to be split up into the different divisions. It would seem more sensible to split the company into divisions whose output are independent (i.e avoid the need to control type 2 service measures). It is felt that this could be done by looking at the entropy of the system's output for the different possible division splits and choose the split with the least entropy value. This idea ties in with Jamshidi(1983) work on hierarchical control of large scale systems where the interaction error of the coordinating variables, corresponding to the type 2 service measures, should be reduced. This could be an area for further research.

8.7 Summary.

This chapter has looked at the HASs involved in defining and achieving the best service policy and which are probably more cost effective when used frequently. Two basic types of HASs were identified: Information reporting systems and decision making systems.

The information reporting systems were divided into 3 parts:

1) The monitoring system.

2) The reporting system.

3) The translating system.

When looking at monitoring system it was argued that there are various possible

information sources which can be used. Effectiveness criteria, shown below, were established for identifying the best information source.

1) Completeness of information.

2) Objectiveness of information.

3) Age of information.

4) Meaningfulness of information.

It was argued that the reporting systems need to have requisite variety. It was proposed this can either done by reducing the level of data being transmitted or by increasing the reporting system's data handling capacity. The level of data being transmitted can be reduced whilst maintaining the information level, by transmitting it in a more concise, statistical, format and also by the use of exception reporting. The reporting system's data handling capacity can be increased by choosing a good actor to carry it out.

The translating system involves translating the data into a format which the information recipient wants.

The main factor influencing the design of the DMSs was the need for them to have requisite variety. It was argued that the variety of the information relevant to a decision is greater than the DMS can handle. Five basic ways were proposed for eliminating this variety gap.

1) Ignore part of the information.

2) Define the inputs into the DMS.

3) Use management information systems.

4) Filtering done by the structure of the organisation by giving autonomy to the organisational lower divisions.

5) Increase the DMS's variety handling capacity. It was shown that various actors can be used in a DMS including the use of computer systems in a decision support system. A new modelling technique, entropy decreasing modelling technique, was suggested for generating the computer models to be used in such systems.

A serendipity of this investigation was seeing controlling of service to internal customers as:

> "The retrieval of the system's performance (synergy) which is lost, due to the system being split into smaller parts. This is as a result of the decision making system of the whole organisation not having requisite variety to handle the relevant information."

Two different types of customer service were also identified. These were:

> Type 1: PD's performance which combined with the service customers performance produces the output of the whole system.
>
> Type 2: PD's performance which affects the service customer's operating fixed costs.

It was proposed that type 1 service measures should be controlled by using a coordinating system whereas type 2 service measures should be controlled by defining the optimum service level by looking at its service costs and benefits.

The differences in the HAS for when the customer is external and when the customer is internal were also examined. The main differences were shown to be the DMS's role in the two situations. With internal customers it was seen as coordinating the divisional performances under its control to meet its own divisional performance level objectives at the lowest cost. Where as the role of the DMS for external customers can be seen as managing the interface between the company and its customers to maximise the profits. This meant that different information and different models were relevant to the decision making in the two situations.

Finally the chapter looked at controlling service for an entire organisation both externally and internally. It was suggested that when decided how a company should be split into divisions that this should be done so as to avoid type 2 service measures.

CHAPTER 9
CONCLUSIONS.

9.1 Summary

This thesis investigated the measurement and control of service from a Physical Distribution (PD) system. Emphasis was placed on the case of internal service customers and the results were compared with previous studies which have concentrated on external service customers.

The activities involved in controlling the service to internal customers were identified by considering the various views of the problem as held by different problem owners. This process was aided by the use of Checkland's soft system methodology to define the required Human activity systems (HASs) required. Three main activities were identified:

1) Understanding the company's Physical Distribution operation.
2) Defining the service elements.
3) Defining and achieving the optimum service strategy.

All of which had to be both feasible and cost effective. Various ways of carrying out each of the above HASs were considered. Their relative merits were analysed by trying them out where possible with a participating company and testing their performance against a yardstick defined by using Checkland's 3 E (efficacy, effectiveness and efficiency) test .

Understanding the company's PD system was successfully carried out by performing a material and information flow audit.

When defining the service elements a very broad view of service was adopted, resulting in several new service elements and defining techniques being suggested. Also the previously

unidentified need to define the service customers was highlighted. It was also argued that customers are not just recipients of stock but can also be information recipients.

The factors (associated with service) which were felt to influence a company's profits were investigated. This defined the activities that were felt to be required in defining and achieving the optimum service strategy. Five basic activities which influence the profit level being achieved were highlighted:

1) Determining the best market segments.

2) Defining the best measuring criteria.

3) Reducing and determining the service costs.

4) Increasing and defining the service benefits to a customer.

5) Determining the optimum service level.

How each of these activities could be cost effectively carried out were explored in detail (several new techniques were introduced such as linking several service measures together). The information requirements and the decision making process required to carry out these activities were also identified and investigated.

The research findings suggest that there are both similarities and differences between the cases of external and internal customers. These are summarised in Table 9.1. The main differences were found to be concerned with the benefits associated with service.

The control of service to internal customers was seen as:

> "The retrieval of the system's performance (synergy) which is lost, due to the system being split into smaller parts. This is as a result of the decision making system of the whole organisation not having requisite variety to handle the relevant information."

Table 9.1: A table showing the differences in the HASs required for external and internal customers.

Human Activity System.	Required for external customers?	Required for internal customers?	Comments.
1 Understanding the company's PD operation.	YES	YES	No differences between the two situations as who the customers are does not affect the PD system.
2 Defining the service measures.	YES	YES	The service measures are the same. However the techniques that can be used are different. Need to define the customers.
3 Defining the best service policy and achieving it.	YES	YES	The elements that make up this HAS differ between the 2 service situations (see below).
3.1 Defining the market segments.	YES	YES	No real differences. However there is a need to look at the optimal profit levels rather than the profit curve when using cluster analysis.
3.2 Defining the criteria.	YES	YES	No real differences. This HAS has not been identified before. Can use loose and tight criteria to identify possible criteria.
3.3 increasing and defining the service benefits.	YES	YES	There are differences in the benefits. For internal customers the benefits are the reduction in the customers costs where as with external customers the benefits are associated with the increase in sales level. Increasing the benefits for internal customers by informing them of the expected service level is similar in nature to developing a program to sell the service package with external customers.
3.4 Decreasing and defining the service costs.	YES	YES	This is the same for both internal and external customers. Several new approaches were defined for doing this. Including linking measures together and responding to disturbance changes.
3.5 Evaluating the optimum service level.	YES	YES	No real differences. The service benefits being reported to the system will be different but this makes little difference to the actual evaluation process. The efficiency and productivity can be increased by the use of exception reporting.
3.6 Control and information systems.	YES	YES	There are not much differences in the two situations. There is a need for them to have requisite variety to handle the information's variety. There are greater problems with external customers in obtaining relevant information.
4 Test market the service program.	YES	YES	With internal customers the 3 E test should be used to determine how productively each approach is actually carrying out the required HASs and then select the best approach. For external customers the service program should be tested in certain parts of the company's operations.
5 Identify the key service measures.	YES	YES	This is done to increase the productivity of the portfolio of service measures suggested. Unfortunately it proved impossible to use previously suggested approach, conjoint analysis. Several new approaches were suggested.
6 Identify the company's position on key service measures relative to competition.	YES	NO	This activity is not required for internal customers as there is only one supplier and hence no direct competition between different suppliers.
7 Develop a program to sell the service package	YES	NO	This activity is part of increasing the service benefits. See HAS 3.3.

Whereas the control of service to external customers was seen as:

> "Increase in the organisation's performance, profit levels,by considering its interaction with its environment (customers)."

Thus it was suggested that by being able to control the company's internal performance (controlling service to internal customers) and by being able to control its relationship with its environment (controlling service to external customers) it is possible to control the whole of the organisation's performance. A possible outline of how this could be done was included.

Two types of service measures for internal customers were identified:

> **Type 1**: PD's performance which combined with the service customers performance produces the output of the whole system.
>
> **Type 2**: PD's performance which affects the service customer's operating fixed costs.

It was suggested that these classifications may give an indication of how organisations can be cost effectively split into divisions. It was proposed that: when companies are split into divisions it should be carried out in a way which avoids type2 service measures.

It was also argued that the principles in controlling PD service could be extended to other company's operations providing service to customers and not just PD operations.

In conclusion, this research has investigated areas of Physical Distribution customer service which have not been dealt with before. Principally this has involved looking at the case of internal service customers and comparing this with the situation of external service customers. Also several new approaches for increasing the profit levels associated with service have been developed. In addition this research has given insights into other areas of study- such as cybernetics by suggesting a possible approach for determining how an

organisation can be effectively subdivided. Further more it is felt that the research results may be applicable to systems other than Physical Distribution systems.

9.2 Suggestions for further research.

During the course of carrying out this research several possible areas of further research have been highlighted. These are:

1) Extending the research to cover other companies to see if the same activities are felt to be required in controlling service.

2) Determine the actual effect that linking certain service measures has on the service costs in a case study.

3) To look at the similarities between the work on controlling service and the work that has been carried out on controlling large scale systems.

4) Investigate whether avoiding type 2 service measures can give an indication of how a company should be split into its smaller divisions.

APPENDIX A
GLOSSARY OF TERMS.

This appendix, gives a glossary of terms used in the thesis. For each term a brief definition of its meaning is given. This glossary is split into two parts. The first part looks at the theoretical terms used in the thesis. The second part looks at the case study terminology.

Part 1 : The Theoretical terms.

Cognitive mapping

Cognitive mapping is a system which visually represents a particular person's perceived mental relationship between two or more variables.

Conceptual models.

A conceptual model is a systematic account of a human activity system, derived from that system's root definition, usually in the form of a structured set of verbs, or actions required to be done. Conceptual models should only contain activities that are explicitly defined in the root definition of the system.

The conceptual models can only be justified in terms of logic and not by comparing them against the actual world. However, they do have to abide by formal systems thinking or any universal properties required to be present in any system. Generally, conceptual models produce a set of activities which have to be present, to be the total system defined by the root definition. These activities are themselves carried out by HASs.

Human Activity Systems (HAS).

A Human Activity System is a system, which describes some purposeful human activity which in theory could be present in the real world. These systems are intellectual constructions of what ideally would be present in the situation. Thus they can be used to produce debate about possible changes that can occur in the organisation to make sure that the systems are present.

Linking service measures together.

Two or more service measures are linked together when it is possible to transfer service responses from one service measure to another. This reduces the service costs.

Loose criteria.

Loose criteria are criteria for monitoring service measures which have both low costs and benefits. Loose criteria are generally not greatly affected by variations in the disturbance level.

Root definition.

A root definition is a concise description of a human activity system which states what the system is. The root definition is used to derive a conceptual model of what the human activity does. A well-formulated root definition will make explicit each of the CATWOE elements present in the Human activity system. It should be noted that CATWOE stands for.

Customer: Those who profits from the system existing.

Actor: Those who carry out the activity of the transformation.

Transformation: The transformation that is carried out by the system. That is the transformation of the inputs into the outputs.

Weltanschauung: (world view): what world view is being taken.

Owner: Who owns the system.

Environmental Constraints: What is allowed or not allowed.

For each different Weltanschauung and Transformation there will be a different root definition.

Tight criteria.

Tight criteria are criteria for monitoring a service measure which have both high costs and benefits. Tight criteria are generally highly affected by variations in the disturbance level.

Part 2 terminology used in the Case study.

ASCOT ordering technique.

ASCOT was an automatic stock control ordering technique using the stock counts produced from the Company's stores. By knowing these stock counts plus the previous stock counts and the stock levels delivered in the intervening time, this system worked out the level of stock sold. Any known seasonal factors were taken out of this sales figure before this figure was placed into a forecasting technique. This gave, after seasonal weighting had been included, a predicted sales figure for the next period. A further amount of safety stock was then added to this figure. This safety stock level, was a function of the standard deviation of the errors in the previous forecasts and the level of 'service' required by the Supply Manager.

The store stock counts, were performed every 4 weeks. However, the stock was picked

weekly in the warehouses. Consequently, the amount of stock required, in the 4 week period, was separated into 4 parts. If there was not enough stock in the warehouses to meet the demand of the various stores on a particular day, then various forms of rationing schemes were introduced.

ASCOT service level.

The ASCOT service level was an estimate of the percentage of the general public demand for stock that had been met. It was calculated from the store's stock counts.

Business Centres.

The Boot's company was divided into various Business Centres, each dealing with their own specific range of merchandise lines. Each Business Centre had a senior Supply Manager with several Supply Managers under his command. Each Business Centre, also had several buyers who dealt with buying new merchandise lines.

Common Stock Rooms.

A Common Stock Room (CSR), was a regional warehouse which served approximately 50 stores. The CSR held the store's back store stock for their 2000 fastest volume selling lines.There were daily deliveries, 6 days a week, from the CSRs to their stores. The frequency with which any particular line was delivered-up to 6 times a week- was dependent on its sales volume. Stock counts were performed at the store the day before the stock was due to be delivered. This information was then transmitted electronically to the store's CSR computer. This then worked out the stock quantity required.

COMPASS ordering technique.

COMPASS ordering technique was used for seasonal merchandise. The store's stock counts were performed weekly instead of the every four weeks for the ASCOT system. This increase in stock counts frequency was needed to give a greater sensitivity to changes in demand.

Count Sheet.

A count sheet was a document indicating the amount of stock ordered by the company. It was used to check that the right amount of stock had been delivered.

D6 Building.

The D6 building was used for sorting out the returns from the stores. When returning stock arrived it was sorted out and sent to the parent warehouses.

D42 Building.

The D42 building was used for several functions, of which, the following two had a bearing on service: Sorting out inter-stores transfers (where more than one RDC region was involved) and sorting out customer repairs and then sending them to the repairers.

First Class (1st Class) Stock.

First class stock was given a high priority. To do this, it had to be picked in the warehouse within a day of the invoices arriving in the warehouse.

FOCUS Line Stock.

FOCUS lines were high priority stock. The company guaranteed a high level of service for this stock to their customers. All FOCUS lines were classified as first class stock.

Hotline Orders.

The Hotline ordering technique was meant to be used only when the orders were really urgent. These orders were requested by the stores phoning their orders centrally to the company's headquarters. These stores were informed, on the phone, of the availability of the stock for picking. The picking invoices for these orders were produced in the actual warehouses, where the stock was picked as quickly as possible..

Merchandise Accounting.

Merchandise accounting was a computer program which accounted for the company's merchandise. This data storage system kept a track of the levels and the availability of stock in the warehouse. Consequently, showing what stock was actually available for satisfying the store ordering requirements.

Merchandise Technical Services (MTS).

MTS were an in-company quality control department, who checked stock coming into the warehouses.

Missing And Excess (M/E) Forms.

These forms were used by the stores to report the level of Missing and Excess stock. When these forms arrived back at the company's headquarters the computer stock levels were

readjusted accordingly.

On-Line-Order-Retrieval (OLOR) Terminals.

The OLOR system enabled details of a delivery order, from a supplier, to become available; so as to produce count sheets and to check the supplier's delivery dates when suppliers were booking in their trailers.

On-Line Dispensary Ordering.

Every Boot's store had an ordering terminal which was originally designed to be used for ordering dispensary items. However this system was extended to cover all the company's items. Thus providing an emergency ordering technique.

O/Rs.

An O/R occurred whenever there was no available stock for a picker to pick in a particular warehouse's picking location. An O/R was marked on the picking invoice, which was then photocopied and sent to the PI department to readjust the computer stock levels.

Parent Warehouse.

The parent warehouse was the warehouse that normally stocked and picked a particular line.

Perpetual Inventory (P.I.) Department.

The perpetual inventory department role in the company was to make sure that the

theoretical warehouse computer stock levels matched the actual stock levels. Regular stock counts were performed by this department. Alterations were made to the computer stock levels whenever a mismatch was found. Also corrections were invoked, whenever the following situations occurred.

1) An O/R was indicated on a picking invoice.

2) Missings were reported by stores.

3) Excesses were reported by stores.

Redistribution Centre (RDC).

RDCs were regional centres where stock coming from the company's different warehouses on various lorries, was sorted into smaller van loads. This system enabled the company to transport its stock, as far as was economically viable, using the more economically efficient 40 foot trailers. The stock was delivered to a RDC in the evening and sorted out over night. The stock was delivered to the stores the following morning. Each RDC serviced around 50 stores.

Repository function of a warehouse.

The task of the warehouse's repository function was to regulate the stock flow between the parent warehouse and the repository warehouse. Also they decided whether stock should be delivered to the parent or the repository warehouse.

Repository Warehouse.

The repository warehouse was used to warehouse excess stock not required in the parent warehouse.

Rollcages.

Rollcages were containers that had small wheels on the bottom, to help with their movement. They were used for transporting stock to the stores.

Second Class (2nd) stock.

Second class stock was of low priority, consequently it was permissible for the warehouses to take up to 2 days to pick this stock after the invoices had arrived in the warehouse.

Stock Location Control (SLC) computer.

The SLC computer determined where in a warehouse stock was to be stored. When stock came into a warehouse, the SLC computer was feed the stock's reference number. The computer then allocated a spare storage location space, permissible for that merchandise line, to each pallet. When it had decided, where to store each pallet, a printer printed out a label showing the stock reference number and storage location. This information was also relayed to the fork-lift drivers.

Special request forms.

These forms enabled the Store Managers to order extra stock when they needed it. This system was being replaced by other emergency ordering systems by the end of the research period.

Supply Managers.

Each senior Supply Manager was responsible for the flow of stock for one particular

Business Centre's stock to and from the stores. Each Supply Manager in a Business Centre was in turn responsible for the supply of stock for the particular lines under his control.

Towntrays.

Towntrays were boxes used for sending stock to the stores.

APPENDIX B
THE SERVICE MEASURES IDENTIFIED BY EACH DEFINING TECHNIQUE.

This appendix indicates which of the service measures were identified by each of the defining techniques. This is split into two parts the defining of the store's service measures and the defining of the Supply Manager's service measures.

For the stores the effectiveness of five approaches are listed here, these are as follows:

1) The use of brainstorming sessions.

2) The use of literature survey results.

3) The use of material and information audit results.

4) The use of the backward-forward link method.

5) The use of first hand experience.

For the Supply Managers the effectiveness of three approaches are shown:

1) The use of brainstorming sessions.

2) The use of material and information audit results.

3) The use of the backward-forward link method.

It should be noted that it proved impossible to use the other 2 approaches (i.e. they were not efficacious).

Store manager's service measures.

Table showing the store's service measures identified by each of the approaches.

SERVICE MEASURE IDENTIFIED.	APPROACH 1	2	3	4	5
1) The number of minutes late that a RDC van is.	Y	N	Y	Y	Y
2) The number of minutes late that a CSR van is.	Y	N	Y	Y	Y
3) The number of minutes taken to unload a RDC van.	N	N	Y	Y	Y
4) The number of minutes taken to unload a CSR van.	N	N	Y	Y	Y
5) The number of working days warning a store manager receives of a change in the CSR/RDC van arrival time.	Y	N	N	Y	N
6) The number of working days after expected arrival day that 1st class stock arrives.	Y	Y	Y	Y	Y
7) The number of working days after expected arrival day that 2nd class stock arrives.	Y	Y	Y	Y	Y
8) The number of working days after expected arrival day that FOCUS class stock arrives.	Y	Y	Y	Y	Y
9) The number of working days it takes for a hotline delivery to occur after the order has been phoned in.	Y	Y	Y	Y	Y
10) The number of working days it takes for a catalogue order to be delivered after it has been ordered.	Y	N	N	Y	Y
11) The number of working days it takes for stock resulting from a special request form to arrive at the store.	Y	Y	N	Y	Y
12) The number of working days after the expected arrival day that CSR stock arrives.	Y	Y	Y	Y	N
13) The number of working days it takes for customer repairs to be returned to the store.	Y	Y	N	Y	N
14) The number of working days it takes for a interstore transfer to be completed.	N	Y	Y	Y	Y
15) The number of unexpected vans arriving at the store per day.	Y	N	N	N	Y
16) The number of working days notice given, to a store manager, of an extra van arriving.	Y	N	N	Y	N

Store manager's service measures.

Continuation of table showing the store's service measures identified by each of the approaches.

SERVICE MEASURE	APPROACH 1	2	3	4	5
17) The number of times a merchandise group is delivered per week	N	N	N	Y	N
18) The number of minutes it takes to check of RDC stock.	N	N	Y	N	Y
19) The number of minutes it takes to check of CSR stock.	N	N	Y	N	Y
20) The number of minutes spent doing M & E forms.	Y	N	Y	N	Y
21) The percentage volume excess RDC stock.	Y	N	N	N	Y
22) The percentage volume excess CSR stock.	Y	N	N	N	Y
23) The level of breakages occurring in RDC stock.	Y	N	Y	Y	Y
24) The level of missing RDC stock.	Y	N	Y	Y	N
25) The level of missing CSR stock.	Y	N	Y	Y	N
26) The level of mispricing in CSR stock.	N	N	N	Y	N
27) The ease of identifying incoming stock.	Y	N	N	N	Y
28) The percentage difference between actual volume and expected volume of stock.	N	N	N	Y	N
29) Matching delivery outer size to the store's requirements.	N	N	N	N	Y
30) The number of working days difference between stock and invoices arriving.	N	Y	N	Y	N
31) The ASCOT service level.	Y	N	N	Y	N
32) The comatibility of delivery times to the store's procedures.	Y	N	N	Y	Y

Supply Manager's service measures.

Table showing the Supply Manager's service measures that were identified by each of the approaches.

SERVICE MEASURE IDENTIFIED.	APPROACH 1	2	3
1) The amount of warehouse space actually available to a Supply Manager compared to the amount that is needed for his stock.	N	N	Y
2) The accuracy of the warehouse's computer stock levels.	Y	Y	Y
3) The accuracy of costing the storing of stock in the warehouses.	Y	Y	Y
4) For new merchandise lines: The number of working days it took for stock to get to the stores.	Y	N	N
5) The number of working days it took for an inter-store transfer to be completed.	Y	N	Y
6) The number of working days a store was out of stock, whilst stock was available in the Physical Distribution system.	Y	N	Y
7) The number of working days it takes for returning stock to be ready for dispatch in the warehouse from the time it left the store.	Y	N	Y
8) For allocation stock, the number of working days after expected arrival day that stock arrives.	Y	N	Y
9) The usefulness of information being sent to the Supply Manager.	N	N	Y

APPENDIX C
QUESTIONNAIRES
AND RESULTS.

This appendix is split into two parts. The first part looks at the store's questionnaires and results. The second part deals with the Supply Manager's questionnaires and results. The reasons for using questionnaires was to obtain different customer's value judgements for different service measures. Thus, the questionnaires contained hypothetical service situations, to which the questionnaire recipients attached a value judgement. These hypothetical service situations were set at feasible service levels which were determined by consulting with the participating company.

To reduce the questionnaire's size it was assumed that the questionnaire recipients would always give the highest possible value judgement to hypothetical service levels known to have the highest service value attached to them (for example a delivery van arriving on time). It was thus felt these hypothetical service levels could be left out of the questionnaire without any information loss. It should be noted that these service situations have been included in the questionnaire results and have been given the highest possible service judgement level.

A) Store questionnaire and results.

One of the reasons for using questionnaires was to discern if there were any benefit differences between different segments. It was considered by the company, that there were two factors possibly influencing the likely benefit on a particular store:

1) The store's size.

2) The store's geographical location.

Two geographical regions of the company's operations were selected, the North and the East. Two sizes of stores were selected, using the company's classification, Large and Small. 40 questionnaires were used in a crossed experimentally designed framework; ten being sent to small and large stores in each of the specified regions. The following number of questionnaires were received back:

1) Small Stores in the North: 6

2) Small Stores in the East: 10

3) Large stores in the North: 9

4) Large stores in the East: 9

The design of the questionnaire used is shown below followed by the questionnaire results.

APPENDIX C

The store's questionnaire.

QUESTIONNAIRE

Listed below are several hypothetical service situations. Please could you indicate, by circling one of the numbers provided, what your opinion of each of these situations would be; circling 1 if you would consider the service as being excellent and circling 7 if you would consider it to be very bad see example:

(It is assumed that there are 5 working days in a week)

PLEASE GIVE YOUR '1 TO 7' RATING FOR THE FOLLOWING SITUATIONS.

EXAMPLE

The number of working days later that the invoices arrived than the associated stock arrived was:

	EXCELLENT						VERY BAD
a) 0 days (arrive together)	(1)	2	3	4	5	6	7
b) 2 days (stock after invoices)	1	2	3	4	(5)	6	7
c) 4 days (stock after invoices)	1	2	3	4	5	6	(7)

Please complete the rest of the questionnaire indicating for each measure your '1 to 7' ratings (as in the example.)

1) The number of minutes after the expected arrival time that the R.D.C. van arrived was.

	EXCELLENT						VERY BAD
a) 30 minutes early.	1	2	3	4	5	6	7
b) 30 minutes late.	1	2	3	4	5	6	7
c) 60 minutes late.	1	2	3	4	5	6	7

2) The number of minutes after the expected arrival time that the C.S.R. van arrived was:

	EXCELLENT						VERY BAD
a) 15 minutes early	1	2	3	4	5	6	7
b) 15 minutes late	1	2	3	4	5	6	7
c) 30 minutes late	1	2	3	4	5	6	7

3) The number of minutes it took to unload the RDC van was:

	EXCELLENT						VERY BAD
a) 10 minutes	1	2	3	4	5	6	7
b) 20 minutes	1	2	3	4	5	6	7
c) 30 minutes	1	2	3	4	5	6	7

4) The number of minutes it took to unload the CSR van was:

	EXCELLENT						VERY BAD
a) 10 minutes	1	2	3	4	5	6	7
b) 20 minutes	1	2	3	4	5	6	7
c) 30 minutes	1	2	3	4	5	6	7

5) The number of working days notice received of a change in the CSR/RDC delivery time was:

	EXCELLENT						VERY BAD
a) 0 days warning	1	2	3	4	5	6	7
b) 2 days warning	1	2	3	4	5	6	7
c) 4 days warning	1	2	3	4	5	6	7

6) For 1st class lines stock; the number of working days taken for the stock to arrive after the expected delivery date was:

	EXCELLENT						VERY BAD
a) 1 day late	1	2	3	4	5	6	7
b) 2 days late	1	2	3	4	5	6	7
c) 3 days late	1	2	3	4	5	6	7

7) For 2nd class lines stock; the number of working days taken for the stock to arrive after the expected delivery date was:

	EXCELLENT						VERY BAD
a) 1 day late	1	2	3	4	5	6	7
b) 2 days late	1	2	3	4	5	6	7
c) 3 days late	1	2	3	4	5	6	7

8) For Focus lines stock; the number of working days taken for the stock to arrive after the expected delivery date was:

	EXCELLENT						VERY BAD
a) 1 day late	1	2	3	4	5	6	7
b) 2 days late	1	2	3	4	5	6	7
c) 3 days late	1	2	3	4	5	6	7

9) The number of working days it took for a hotline order to arrive from the time you had phoned in the order was:

	EXCELLENT						VERY BAD
a) 1 day	1	2	3	4	5	6	7
b) 2 days	1	2	3	4	5	6	7
c) 4 days	1	2	3	4	5	6	7

10) The number of working days it took for the stock ordered by a special request form, to have arrived at your store from the time you had sent the form in, was:

	EXCELLENT						VERY BAD
a) 3 days	1	2	3	4	5	6	7
b) 5 days	1	2	3	4	5	6	7
c) 7 days	1	2	3	4	5	6	7

11) The number of working days taken for a inter-branch transfer to be completed (from store to store) was:

	EXCELLENT						VERY BAD
a) 1 days	1	2	3	4	5	6	7
b) 3 days	1	2	3	4	5	6	7
c) 5 days	1	2	3	4	5	6	7

12) The number of working days warning you received of a extra van arriving was:

	EXCELLENT						VERY BAD
a) 0 days (no warning)	1	2	3	4	5	6	7
b) 2 days warning	1	2	3	4	5	6	7
c) 4 days warning	1	2	3	4	5	6	7

13) The amount of time spent daily doing M&E forms was:

	EXCELLENT						VERY BAD
a) 15 minutes	1	2	3	4	5	6	7
b) 30 minutes	1	2	3	4	5	6	7
c) 60 minutes	1	2	3	4	5	6	7

14) The percentage volume of excess RDC stock was:

	EXCELLENT						VERY BAD
a) 0.5% excess (RDC)	1	2	3	4	5	6	7
b) 1% excess (RDC)	1	2	3	4	5	6	7
c) 2% excess (RDC)	1	2	3	4	5	6	7

15) The level of excess CSR stock delivered, measured as a percentage volume of the expected stock levels was:

	EXCELLENT						VERY BAD
a) 1% excess(CSR)	1	2	3	4	5	6	7
b) 2% excess(CSR)	1	2	3	4	5	6	7
c) 3% excess(CSR)	1	2	3	4	5	6	7

16) The percentage of expected RDC stock that did not arrive or was not fit for use (i.e. the missings and the breakages) was:

	EXCELLENT						VERY BAD
a) 0.5%	1	2	3	4	5	6	7
b) 1%	1	2	3	4	5	6	7
c) 2%	1	2	3	4	5	6	7

17) The percentage of expected CSR stock that did not arrive or was not fit for use (i.e. the missings and the breakages) was:

	EXCELLENT						VERY BAD
a) 0.5%	1	2	3	4	5	6	7
b) 1%	1	2	3	4	5	6	7
c) 2%	1	2	3	4	5	6	7

18) The percentage of CSR stock mispriced was:

	EXCELLENT						VERY BAD
a) 0.5% mispriced	1	2	3	4	5	6	7
b) 1.0% mispriced	1	2	3	4	5	6	7
c) 2.0% mispriced	1	2	3	4	5	6	7

19) The number of working days later that the invoices arrived than the associated stock arrived was:

	EXCELLENT						VERY BAD
a) 1 day early (stock before invoices)	1	2	3	4	5	6	7
b) 2 days early(stock before invoices)	1	2	3	4	5	6	7
c) 1 day late (invoices before stock)	1	2	3	4	5	6	7
d) 2 days late (invoices before stock)	1	2	3	4	5	6	7

20) The ASCOT service level achieved was:

	EXCELLENT						VERY BAD
98%	1	2	3	4	5	6	7
95%	1	2	3	4	5	6	7
92%	1	2	3	4	5	6	7

21) The compatibility of the delivery time to your stores situation.

	EXCELLENT						VERY BAD
How good are the present delivery times.	1	2	3	4	5	6	7

What time would you like deliveries A) CSR:
B) RDC:

Could you indicate, below, any important service areas that have been ommited:

Thank you for your time and effort.

STORE NO:- MANAGERS SIGNATURE:-

Questionnaire results.

The service levels known to have a highest service value attached to them have been given the highest value judgement of 6. This affects service measures: 1,2,6,7,8,9, 13,14,15,16,17,18 and 19. These results numbers are indicated by a * whilst the other question numbers refer to those used in the questionnaire. The questionnaire results have also been transformed to give higher service level a higher judgement value. (This was done by taking the original questionnaire results away from 7).

QUESTION	1	2	3	4	5	6
NUMBER	a * b c	a * b c	a b c	a b c	a b c	* a b c
NORTHERN SMALL	2 6 2 0	2 6 2 0	6 6 2	6 6 2	0 3 3	6 0 0 0
NORTHERN SMALL	3 6 3 0	5 6 5 3	6 4 3	6 4 2	0 0 0	6 3 0 0
NORTHERN SMALL	4 6 2 0	4 6 2 0	6 3 0	6 3 0	0 0 2	6 2 1 0
NORTHERN SMALL	6 6 0 0	6 6 3 0	6 4 0	6 4 0	0 1 2	6 3 2 0
NORTHERN SMALL	2 6 0 0	3 6 2 0	5 2 0	5 2 0	0 3 6	6 4 2 0
NORTHERN SMALL	4 6 2 0	4 6 2 0	6 6 4	6 6 4	0 0 2	6 4 1 0
EASTERN SMALL	3 6 1 0	5 6 5 0	6 5 4	6 5 4	0 0 0	6 1 0 0
EASTERN SMALL	4 6 2 0	5 6 2 0	6 3 0	6 3 0	0 1 2	6 3 2 1
EASTERN SMALL	4 6 0 0	4 6 2 0	6 3 1	6 3 1	0 0 0	6 2 1 0
EASTERN SMALL	2 6 2 0	2 6 2 0	6 6 5	6 6 5	0 4 5	6 4 3 2
EASTERN SMALL	4 6 2 0	3 6 4 3	6 2 0	6 3 0	0 3 5	6 3 0 0
EASTERN SMALL	3 6 2 1	4 6 3 2	6 4 2	5 3 1	0 1 2	6 3 2 1
EASTERN SMALL	4 6 3 1	5 6 5 1	6 4 1	5 1 0	0 3 6	6 6 3 0
EASTERN SMALL	6 6 4 2	6 6 4 2	6 4 0	6 4 0	0 2 5	6 4 2 0
EASTERN SMALL	6 6 2 0	6 6 2 0	6 5 3	6 5 3	0 2 4	6 3 1 0
EASTERN SMALL	6 6 1 0	6 6 2 1	6 5 4	6 6 5	1 4 6	6 2 0 0
NORTHERN LARGE	4 6 2 0	5 6 2 0	6 5 2	6 4 2	0 2 4	6 1 0 0
NORTHERN LARGE	3 6 2 0	6 6 3 0	6 6 6	6 4 1	0 6 6	6 4 0 0
NORTHERN LARGE	3 6 3 0	3 6 3 0	6 6 6	6 6 6	0 1 2	6 2 1 0
NORTHERN LARGE	3 6 4 0	3 6 4 0	6 5 4	6 5 4	0 1 2	6 3 1 0
NORTHERN LARGE	5 6 2 0	5 6 2 2	6 5 4	6 2 0	0 2 3	6 1 0 0
NORTHERN LARGE	3 6 2 0	0 6 3 1	6 5 3	6 5 4	0 2 3	6 4 2 0
NORTHERN LARGE	3 6 3 0	4 6 3 1	6 4 3	6 4 1	0 0 1	6 3 2 1
NORTHERN LARGE	6 6 4 1	2 6 5 0	6 5 4	6 5 2	0 2 3	6 4 2 0
NORTHERN LARGE	4 6 4 0	4 6 4 0	6 6 6	6 6 0	0 5 6	6 5 2 0
EASTERN LARGE	6 6 2 0	2 6 2 0	6 6 6	6 1 0	0 0 4	6 2 0 0
EASTERN LARGE	4 6 2 0	2 6 2 1	6 5 4	6 4 3	0 1 1	6 2 0 0
EASTERN LARGE	6 6 3 1	6 6 3 1	6 6 3	6 6 3	0 3 5	6 2 0 0
EASTERN LARGE	1 6 2 0	1 6 2 0	6 5 3	6 5 3	0 3 6	6 6 2 0
EASTERN LARGE	4 6 4 2	6 6 4 2	6 6 4	6 6 5	0 4 6	6 2 1 0
EASTERN LARGE	2 6 1 0	3 6 2 0	6 3 1	6 4 3	0 2 3	6 3 1 0
EASTERN LARGE	6 6 1 0	6 6 4 2	6 5 3	6 6 3	0 3 6	6 3 2 0
EASTERN LARGE	5 6 2 0	5 6 3 1	6 5 4	6 5 3	0 4 6	6 4 3 2
EASTERN LARGE	6 6 2 0	6 6 3 0	6 6 4	6 5 3	0 3 6	6 5 3 3

QUESTION	7	8	9	10	11	12
NUMBER	* a b c	* a b c	a b c	a b c	a b c	a b c
NORTHERN SMALL	6 3 3 3	6 2 1 0	6 3 0	6 4 2	6 3 0	3 6 6
NORTHERN SMALL	6 5 3 0	6 1 0 0	6 5 0	6 5 0	6 5 0	0 4 6
NORTHERN SMALL	6 3 2 1	6 0 0 0	6 2 0	6 2 0	6 5 2	0 2 4
NORTHERN SMALL	6 3 2 0	6 2 0 0	6 5 0	5 3 0	6 5 0	0 2 4
NORTHERN SMALL	6 4 2 0	6 2 1 0	6 3 0	5 2 0	6 4 2	3 3 3
NORTHERN SMALL	6 5 2 0	6 4 0 0	6 4 1	6 4 2	6 6 2	0 3 5
EASTERN SMALL	6 2 1 0	6 0 0 0	6 3 0	6 6 3	6 3 1	3 6 6
EASTERN SMALL	6 5 4 3	6 2 1 0	6 5 3	6 4 2	6 4 1	1 5 6
EASTERN SMALL	6 3 2 1	6 2 1 0	6 5 0	6 3 0	6 4 1	0 3 5
EASTERN SMALL	6 3 2 1	6 5 4 3	6 5 1	6 4 2	6 4 2	3 5 6
EASTERN SMALL	6 3 2 1	6 0 0 0	6 5 0	6 3 1	6 5 1	0 2 5
EASTERN SMALL	6 3 3 3	6 2 1 0	6 6 3	6 5 4	6 5 2	1 4 5
EASTERN SMALL	6 6 6 1	6 6 2 0	6 4 0	6 3 0	6 2 0	1 6 6
EASTERN SMALL	6 5 2 0	6 5 2 0	6 5 1	6 2 0	6 3 0	0 4 6
EASTERN SMALL	6 5 4 3	6 2 0 0	6 4 1	6 4 2	6 4 2	3 5 6
EASTERN SMALL	6 3 0 0	6 0 0 0	6 5 1	6 3 0	6 6 3	2 4 6
NORTHERN LARGE	6 3 2 1	6 1 0 0	5 3 0	4 2 1	6 3 3	0 5 5
NORTHERN LARGE	6 3 1 0	6 3 0 0	6 5 0	6 5 2	6 5 2	0 4 6
NORTHERN LARGE	6 3 3 2	6 1 0 0	6 6 3	6 4 2	6 5 3	1 5 6
NORTHERN LARGE	6 4 2 1	6 1 0 0	6 4 0	6 4 1	6 3 2	0 2 4
NORTHERN LARGE	6 4 3 0	6 2 0 0	6 4 0	6 3 0	6 5 2	4 4 6
NORTHERN LARGE	6 4 2 0	6 0 0 0	6 6 0	5 3 0	6 4 1	1 4 6
NORTHERN LARGE	6 4 3 2	6 2 1 0	6 5 1	6 3 0	6 3 0	2 4 6
NORTHERN LARGE	6 4 3 2	6 4 1 0	6 4 2	6 4 2	6 5 3	2 4 6
NORTHERN LARGE	6 5 4 2	6 0 0 0	4 2 0	6 3 0	6 4 0	0 5 6
EASTERN LARGE	6 4 0 0	6 0 0 0	6 5 0	5 0 0	6 4 0	0 6 6
EASTERN LARGE	6 2 1 0	6 0 0 0	6 5 0	6 3 0	6 5 0	0 5 6
EASTERN LARGE	6 3 2 1	6 2 0 0	6 5 0	6 4 3	6 5 3	0 4 5
EASTERN LARGE	6 6 2 0	6 6 3 0	6 6 4	6 4 3	6 4 2	2 5 6
EASTERN LARGE	6 4 3 1	6 1 0 0	6 5 3	6 5 3	6 3 0	0 4 6
EASTERN LARGE	6 4 3 0	6 3 1 0	6 4 1	4 2 0	6 4 1	0 3 6
EASTERN LARGE	6 4 3 0	6 2 1 0	6 3 0	5 3 1	6 4 1	0 4 6
EASTERN LARGE	6 5 4 3	6 4 3 2	6 4 1	5 2 0	6 4 2	2 4 5
EASTERN LARGE	6 5 4 4	6 5 1 0	6 4 0	6 3 0	6 3 0	0 3 6

QUESTION	13	14	15	16
NUMBER	* a b c	* a b c	* a b c	* a b c
NORTHERN SMALL	6 6 1 0	6 6 0 0	6 6 0 0	6 6 0 0
NORTHERN SMALL	6 5 0 0	6 5 0 0	6 0 0 0	6 5 3 0
NORTHERN SMALL	6 5 3 0	6 5 3 1	6 5 2 0	6 5 3 1
NORTHERN SMALL	6 6 0 0	6 6 3 0	6 3 0 0	6 3 0 0
NORTHERN SMALL	6 6 5 2	6 5 2 0	6 2 1 0	6 2 1 0
NORTHERN SMALL	6 6 3 0	6 3 2 0	6 3 1 0	6 3 0 0
EASTERN SMALL	6 2 1 0	6 2 1 0	6 4 3 2	6 3 1 0
EASTERN SMALL	6 5 3 1	6 5 2 0	6 3 2 1	6 1 0 0
EASTERN SMALL	6 3 1 0	6 3 2 1	6 2 1 0	6 2 0 0
EASTERN SMALL	6 3 1 0	6 4 3 1	6 3 2 0	6 3 2 0
EASTERN SMALL	6 5 3 0	6 5 3 0	6 5 3 1	6 4 3 2
EASTERN SMALL	6 3 1 0	6 4 2 1	6 4 2 1	6 2 1 0
EASTERN SMALL	6 3 3 0	6 6 0 0	6 1 0 0	6 2 1 0
EASTERN SMALL	6 6 2 0	6 2 1 0	6 0 0 0	6 1 0 0
EASTERN SMALL	6 4 2 1	6 5 3 1	6 1 1 1	6 3 1 0
EASTERN SMALL	6 4 0 0	6 6 3 1	6 5 2 0	6 5 3 0
NORTHERN LARGE	6 5 4 0	6 5 2 0	6 4 2 0	6 5 2 0
NORTHERN LARGE	6 5 3 0	6 5 3 1	6 4 2 0	6 5 3 1
NORTHERN LARGE	6 6 4 0	6 2 1 0	6 1 0 0	6 2 1 0
NORTHERN LARGE	6 3 2 1	6 4 3 2	6 2 1 0	6 3 2 0
NORTHERN LARGE	6 6 2 0	6 4 2 0	6 3 0 0	6 4 2 0
NORTHERN LARGE	6 5 2 0	6 2 1 0	6 4 2 0	6 1 0 0
NORTHERN LARGE	6 5 3 1	6 5 4 3	6 5 4 3	6 5 3 1
NORTHERN LARGE	6 6 3 1	6 6 4 2	6 6 4 2	6 6 3 0
NORTHERN LARGE	6 6 3 0	6 6 3 0	6 6 3 0	6 6 3 0
EASTERN LARGE	6 6 0 0	6 0 0 0	6 0 0 0	6 0 0 0
EASTERN LARGE	6 4 2 0	6 2 1 1	6 2 1 1	6 0 0 0
EASTERN LARGE	6 5 1 0	6 2 1 0	6 2 1 0	6 3 1 0
EASTERN LARGE	6 6 5 3	6 6 2 0	6 6 4 2	6 6 4 1
EASTERN LARGE	6 3 2 0	6 3 2 0	6 2 1 0	6 2 1 0
EASTERN LARGE	6 6 4 0	6 6 4 3	6 5 3 1	6 3 1 0
EASTERN LARGE	6 5 3 1	6 5 3 1	6 4 2 1	6 5 3 0
EASTERN LARGE	6 6 4 1	6 6 4 1	6 6 5 3	6 5 3 2
EASTERN LARGE	6 6 5 3	6 5 3 0	6 5 3 2	6 5 3 2

QUESTION	17	18	19	20	21
NUMBER	* a b c	* a b c	a b * c d	* a b c	
NORTHERN SMALL	6 6 0 0	6 2 1 0	6 6 6 0 0	6 4 2 0	3
NORTHERN SMALL	6 4 1 0	6 3 1 0	2 1 6 5 4	6 5 5 1	4
NORTHERN SMALL	6 5 3 1	6 4 1 0	2 1 6 2 1	6 6 4 3	6
NORTHERN SMALL	6 3 0 0	6 0 0 0	5 2 6 5 2	6 6 1 0	4
NORTHERN SMALL	6 2 1 0	6 2 1 0	3 2 6 3 2	6 6 5 4	3
NORTHERN SMALL	6 3 0 0	6 2 0 0	3 1 6 6 3	6 6 4 2	5
EASTERN SMALL	6 2 1 0	6 6 3 0	1 0 6 1 0	6 6 3 2	6
EASTERN SMALL	6 1 0 0	6 0 0 0	1 0 6 3 2	6 5 3 1	6
EASTERN SMALL	6 2 0 0	6 3 1 0	1 0 6 3 2	6 5 3 2	5
EASTERN SMALL	6 3 2 0	6 2 1 0	1 2 6 4 3	6 5 4 2	5
EASTERN SMALL	6 5 2 0	6 0 0 0	0 0 6 3 3	6 6 4 1	6
EASTERN SMALL	6 2 1 0	6 4 2 1	0 0 6 4 4	6 5 3 1	5
EASTERN SMALL	6 1 0 0	6 0 0 0	0 0 6 6 4	6 6 3 0	2
EASTERN SMALL	6 1 0 0	6 0 0 0	1 0 6 6 6	6 5 4 3	6
EASTERN SMALL	6 0 0 0	6 2 0 0	2 1 6 4 2	6 6 3 0	6
EASTERN SMALL	6 5 3 0	6 4 2 0	3 2 6 2 0	6 6 4 3	4
NORTHERN LARGE	6 5 2 0	6 5 2 0	0 0 6 4 4	6 5 4 1	6
NORTHERN LARGE	6 5 3 0	6 3 0 0	2 1 6 5 4	6 6 3 0	5
NORTHERN LARGE	6 1 0 0	6 1 0 0	1 0 6 4 3	6 5 3 1	6
NORTHERN LARGE	6 2 1 0	6 2 1 0	0 0 6 6 5	6 5 3 1	5
NORTHERN LARGE	6 3 0 0	6 0 0 0	0 0 6 3 0	6 6 4 2	5
NORTHERN LARGE	6 0 0 0	6 0 0 0	2 1 6 3 2	6 6 2 1	2
NORTHERN LARGE	6 3 2 0	6 2 1 0	2 0 6 2 0	6 6 4 1	0
NORTHERN LARGE	6 6 3 0	6 6 2 0	3 3 6 2 1	6 6 3 1	5
NORTHERN LARGE	6 6 3 0	6 3 1 0	2 0 6 2 0	6 5 2 0	4
EASTERN LARGE	6 0 0 0	6 0 0 0	2 0 6 3 0	6 6 0 0	2
EASTERN LARGE	6 2 1 0	6 2 1 0	0 0 6 4 4	6 5 3 1	6
EASTERN LARGE	6 2 0 0	6 4 3 1	5 5 6 0 0	6 6 4 1	6
EASTERN LARGE	6 3 2 0	6 4 3 1	0 0 6 5 3	6 6 4 2	2
EASTERN LARGE	6 1 0 0	6 1 0 0	6 6 6 0 0	6 6 4 1	6
EASTERN LARGE	6 4 1 0	6 6 1 0	0 0 6 3 3	6 6 4 3	3
EASTERN LARGE	6 5 3 1	6 5 4 2	1 0 6 5 5	6 6 4 1	6
EASTERN LARGE	6 5 3 2	6 5 3 1	2 0 6 5 6	6 5 3 1	5
EASTERN LARGE	6 5 3 0	6 2 1 0	1 0 6 4 1	6 5 2 0	5

Summary of results.

Question No	TOTAL		NORTHERN SMALL		EASTERN SMALL		NORTHERN LARGE		EASTERN LARGE		LARGE		SMALL		NORTHERN		EASTERN	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
01a	4.029	1.47	3.500	1.52	4.200	1.40	3.778	1.09	4.444	1.88	4.111	1.53	3.938	1.44	3.667	1.23	4.316	1.60
01*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
01b	2.147	1.10	1.500	1.22	1.900	1.10	2.889	0.93	2.111	0.93	2.500	0.99	1.750	1.13	2.333	1.23	2.000	1.00
01c	0.235	0.55	0.000	0.00	0.400	0.70	0.111	0.33	0.333	0.71	0.222	0.55	0.250	0.58	0.067	0.26	0.368	0.68
02a	4.088	1.68	4.000	1.41	4.600	1.35	3.556	1.81	4.111	2.09	3.833	1.92	4.375	1.36	3.733	1.62	4.368	1.71
02*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
02b	2.971	1.06	2.667	1.21	3.100	1.29	3.222	0.97	2.778	0.83	3.000	1.91	2.938	1.24	3.000	1.07	2.947	1.08
02c	0.676	0.94	0.500	1.22	0.900	1.10	0.444	0.73	0.778	0.83	0.611	0.78	0.750	1.13	0.467	0.92	0.842	0.96
03a	5.971	0.17	5.833	0.41	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	5.938	0.25	5.933	0.26	6.000	0.00
03b	4.706	1.19	4.167	1.60	4.100	1.20	5.222	0.67	5.222	0.97	5.222	0.81	4.125	1.31	4.800	1.21	4.632	1.21
03c	2.912	1.90	1.500	1.76	2.000	1.89	4.222	1.48	3.556	1.33	3.889	1.41	1.813	1.80	3.133	2.07	2.737	1.79
04a	5.912	0.29	5.833	0.41	5.800	0.42	6.000	0.00	6.000	0.00	6.000	0.00	5.813	0.40	5.933	0.26	5.895	0.32
04b	4.324	1.47	4.167	1.60	3.900	1.60	4.556	1.24	4.667	1.58	4.611	1.38	4.000	1.55	4.400	1.35	4.263	1.59
04c	2.147	1.83	1.333	1.63	1.900	2.13	2.222	2.05	2.889	1.27	2.556	1.69	1.688	1.92	1.867	1.88	2.368	1.80
05a	0.206	1.04	0.000	0.00	0.700	1.89	0.000	0.00	0.000	0.00	0.000	0.00	0.438	1.50	0.000	0.00	0.368	1.38
05b	2.088	1.58	1.167	1.47	2.000	1.49	2.333	1.94	2.556	1.33	2.444	1.62	1.688	1.49	1.867	1.81	2.263	1.41
05c	3.441	2.09	2.500	1.97	2.900	2.38	3.333	1.73	4.778	1.79	4.056	1.86	2.750	2.18	3.000	1.81	3.789	2.27
06*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
06a	3.029	1.38	2.667	1.51	3.100	1.37	3.000	1.41	3.222	1.48	3.111	1.41	2.938	1.39	2.867	1.41	3.158	1.38
06b	1.235	1.05	1.000	0.89	1.400	1.17	1.111	0.93	1.333	1.22	1.222	1.06	1.250	1.06	1.067	0.88	1.368	1.16
06c	0.294	0.72	0.000	0.00	0.400	0.70	0.111	0.33	0.556	1.13	0.333	0.84	0.250	0.58	0.067	0.26	0.474	0.90
07*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
07a	3.882	1.04	3.833	0.98	3.800	1.32	3.778	0.67	4.111	1.17	3.944	0.94	3.813	1.17	3.800	0.77	3.947	1.22
07b	2.500	1.21	2.333	0.52	2.600	1.71	2.556	0.88	2.444	1.33	2.500	1.10	2.500	1.37	2.467	0.74	2.526	1.50
07c	1.059	1.20	0.667	1.21	1.300	1.25	1.111	0.93	1.000	1.50	1.056	1.21	1.063	1.24	0.933	1.03	1.158	1.34
08*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
08a	2.118	1.82	1.833	1.33	2.400	2.22	1.556	1.33	2.556	2.13	2.056	1.80	2.188	1.91	1.667	1.29	2.474	2.12
08b	0.706	1.03	0.333	0.52	1.100	1.29	0.222	0.44	1.000	1.22	0.611	0.98	0.813	1.11	0.267	0.46	1.053	1.22
08c	0.147	0.61	0.000	0.00	0.300	0.95	0.000	0.00	0.222	0.67	0.111	0.47	0.188	0.75	0.000	0.00	0.263	0.81
09a	5.735	1.08	6.000	0.00	6.000	0.00	5.667	0.71	5.333	2.00	5.500	1.47	6.000	0.00	5.800	0.56	5.684	1.38
09b	4.235	1.30	3.667	1.21	4.700	0.82	4.333	1.32	4.000	1.73	4.167	1.50	4.313	1.08	4.067	1.28	4.368	1.34
09c	0.765	1.16	0.167	0.41	1.000	1.15	0.667	1.12	1.000	1.50	0.833	1.29	0.688	1.01	0.467	0.92	1.000	1.29
10a	5.706	0.58	5.667	0.52	6.000	0.00	5.667	0.71	5.444	0.73	5.556	0.70	5.875	0.34	5.667	0.62	5.737	0.56
10b	3.353	1.18	3.333	1.21	3.700	1.16	3.444	0.88	2.889	1.45	3.167	1.20	3.563	1.15	3.400	0.99	3.316	1.34
10c	1.059	1.23	0.667	1.03	1.400	1.43	0.889	0.93	1.111	1.45	1.000	1.19	1.125	1.31	0.800	0.94	1.263	1.41
11a	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
11b	4.147	0.96	4.667	1.03	4.000	1.15	4.111	0.93	4.000	0.71	4.056	0.80	4.250	1.13	4.333	0.98	4.000	0.94
11c	1.294	1.09	1.000	1.10	1.300	0.95	1.778	1.20	1.000	1.12	1.389	1.20	1.188	0.98	1.467	1.19	1.158	1.01
12a	1.000	1.26	1.000	1.55	1.400	1.26	1.111	1.36	0.444	0.88	0.778	1.17	1.250	1.34	1.067	1.39	0.947	1.18
12b	4.088	1.16	3.333	1.51	4.400	1.26	4.111	0.93	4.222	0.97	4.167	0.92	4.000	1.41	3.800	1.21	4.316	1.11
12c	5.529	0.79	4.667	1.21	5.700	0.48	5.667	0.71	5.778	0.44	5.722	0.57	5.313	0.95	5.267	1.03	5.737	0.45
13*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
13a	4.882	1.23	5.667	0.52	3.800	1.23	5.222	0.97	5.222	1.09	5.222	1.00	4.500	1.37	5.400	0.83	4.474	1.35
13b	2.382	1.46	2.000	2.00	1.700	1.06	2.889	0.78	2.889	1.76	2.889	1.32	1.813	1.42	2.533	1.41	2.263	1.52
13c	0.441	0.82	0.333	0.82	0.200	0.42	0.333	0.50	0.889	1.27	0.611	0.98	0.250	0.58	0.333	0.62	0.526	0.96
14*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
14a	4.294	1.62	5.000	1.10	4.200	1.48	4.333	1.50	3.889	2.20	4.111	1.84	4.500	1.37	4.600	1.35	4.053	1.81
14b	2.147	1.21	1.667	1.37	2.000	1.05	2.556	1.13	2.222	1.39	2.389	1.24	1.875	1.15	2.200	1.26	2.105	1.20
14c	0.588	0.86	0.167	0.41	0.500	0.53	0.889	1.17	0.667	1.00	0.778	1.06	0.375	0.50	0.600	0.99	0.579	0.77

Summary of results.

Question No	TOTAL		NORTHERN SMALL		EASTERN SMALL		NORTHERN LARGE		EASTERN LARGE		LARGE		SMALL		NORTHERN		EASTERN	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
15*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
15a	3.353	1.87	3.167	2.14	2.800	1.75	3.889	1.69	3.556	2.13	3.722	1.87	2.938	1.84	3.600	1.84	3.158	1.92
15b	1.706	1.38	0.667	0.82	1.600	1.07	2.000	1.50	2.222	1.64	2.111	1.53	1.250	1.06	1.467	1.41	1.895	1.37
15c	0.618	0.92	0.000	0.00	0.600	0.70	0.556	1.13	1.111	1.05	0.833	1.10	0.375	0.62	0.333	0.90	0.842	0.90
16*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
16a	3.412	1.78	4.000	1.55	2.600	1.26	4.111	1.76	3.222	2.22	3.667	2.00	3.125	1.50	4.067	1.62	2.895	1.76
16b	1.588	1.28	1.167	1.47	1.200	1.14	2.111	1.05	1.778	1.48	1.944	1.26	1.188	1.22	1.733	1.28	1.474	1.31
16c	0.294	0.63	0.167	0.41	0.200	0.63	0.222	0.44	0.556	0.88	0.389	0.70	0.188	0.54	0.200	0.41	0.368	0.76
17*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
17a	3.029	1.87	3.833	1.47	2.200	1.69	3.444	2.19	3.000	1.87	3.222	1.99	2.813	1.76	3.600	1.88	2.579	1.77
17b	1.206	1.23	0.833	1.17	0.900	1.10	1.556	1.33	1.444	1.33	1.500	1.29	0.875	1.09	1.267	1.28	1.158	1.21
17c	0.118	0.41	0.167	0.41	0.000	0.00	0.000	0.00	0.333	0.71	0.167	0.51	0.063	0.25	0.067	0.26	0.158	0.50
18*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
18a	2.500	1.94	2.167	1.33	2.100	2.13	2.444	2.07	3.222	2.05	2.833	2.04	2.125	1.82	2.333	1.76	2.632	2.11
18b	1.059	1.13	0.667	0.52	0.900	1.10	0.778	0.83	1.778	1.48	1.278	1.27	0.813	0.91	0.733	0.70	1.316	1.34
18c	0.176	0.46	0.000	0.00	0.100	0.32	0.000	0.00	0.556	0.73	0.278	0.57	0.063	0.25	0.000	0.00	0.316	0.58
19a	1.000	1.69	2.167	1.94	0.500	0.85	0.556	1.01	1.222	2.44	0.889	1.84	1.125	1.54	1.200	1.61	0.842	1.77
19b	1.765	1.71	3.500	1.64	1.000	0.94	1.333	1.12	1.889	2.20	1.611	1.72	1.938	1.73	2.200	1.70	1.421	1.68
19*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
19c	3.441	1.71	3.500	2.26	3.600	1.58	3.444	1.42	3.222	1.99	3.333	1.68	3.563	1.79	3.467	1.73	3.421	1.74
19d	2.324	1.87	2.000	1.41	2.600	1.84	2.111	1.96	2.444	2.30	2.278	2.08	2.375	1.67	2.067	1.71	2.526	2.01
20*	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
20a	5.559	0.56	5.500	0.84	5.500	0.53	5.556	0.53	5.667	0.50	5.611	0.50	5.500	0.63	5.533	0.64	5.579	0.51
20b	3.265	1.05	3.500	1.64	3.400	0.52	3.111	0.78	3.111	1.36	3.111	1.08	3.438	1.03	3.267	1.16	3.263	0.99
20c	1.265	1.05	1.667	1.63	1.500	1.08	0.889	0.60	1.111	0.93	1.000	0.77	1.563	1.26	1.200	1.15	1.316	1.00
21	4.559	1.58	4.167	1.17	5.100	1.29	4.222	1.99	4.556	1.74	4.389	1.82	4.750	1.29	4.200	1.66	4.842	1.50

2) Supply Managers questionnaire and results.

It was considered by the company, that the business centre which the Supply Manager worked for might affect the likely benefits. Thus it was proposed to use the questionnaires to determine if this was true. 40 questionnaires were sent to Supply Managers (5 to each of the Business Centres). Unfortunately only 11 questionnaires were returned. It is felt that this small return rate is attributable to the role of Supply Managers being a relatively new one. This meant that they had little experience to draw on in answering the questionnaires. Unfortunately, this small return rate made it impossible to actually carry out any analysis of the service differences between the different Business Centres.

Questionnaire design.

QUESTIONNAIRE

Listed below are several hypothetical service situations. Please could you indicate, by circling one of the numbers provided, what your opinion of each of these situations would be; circling 1 if you would consider the service as being excellent and circling 7 if you would consider it to be very bad. See example.

(It is assumed that there are 5 working days in a week.)

PLEASE GIVE YOUR "1 TO 7" RATING FOR THE FOLLOWING SITUATIONS.

EXAMPLE

The accuracy of the computer stock level (computer stock levels measured as percentage of the true figure) was:

	EXCELLENT						VERY BAD
(a) 80%	1	2	3	4	5	6	(7)
(b) 100%	(1)	2	3	4	5	6	7
(c) 105%	1	2	3	4	(5)	6	7

1. The amount of warehouse space that was actually available to you (measured as a percentage of space that you had required for your stock) was:

	EXCELLENT						VERY BAD
(a) 75%	1	2	3	4	5	6	7
(b) 85%	1	2	3	4	5	6	7
(c) 90%	1	2	3	4	5	6	7
(d) 95%	1	2	3	4	5	6	7
(e) 98%	1	2	3	4	5	6	7
(f) 102%	1	2	3	4	5	6	7

2. The accuracy of the computer stock level (computer stock levels measured as percentage of true figure) was:

	EXCELLENT						VERY BAD
(a) 90%	1	2	3	4	5	6	7
(b) 95%	1	2	3	4	5	6	7
(c) 98%	1	2	3	4	5	6	7
(d) 102%	1	2	3	4	5	6	7
(e) 105%	1	2	3	4	5	6	7
(f) 110%	1	2	3	4	5	6	7

3. The accuracy of the costing of storing stock in the warehouse (given figure as % of the true figure) was:

	EXCELLENT						VERY BAD
(a) 90%	1	2	3	4	5	6	7
(b) 95%	1	2	3	4	5	6	7
(c) 98%	1	2	3	4	5	6	7
(d) 102%	1	2	3	4	5	6	7
(e) 105%	1	2	3	4	5	6	7
(f) 110%	1	2	3	4	5	6	7

4. For new merchandise lines: the number of working days it took for the stock to get to the store, from the time you wanted the stock to be delivered to the warehouse (i.e. including the time that the deliverer had to wait to deliver, due to there being no free delivery slots on the warehouse's booking-in schedule) was:

	EXCELLENT						VERY BAD
(a) 3 days	1	2	3	4	5	6	7
(b) 5 days	1	2	3	4	5	6	7
(c) 10 days	1	2	3	4	5	6	7
(d) 15 days	1	2	3	4	5	6	7

5. The number of working days it took for an inter-store transfer to be completed (from store to store) was:

	EXCELLENT						VERY BAD
(a) 1 day	1	2	3	4	5	6	7
(b) 3 days	1	2	3	4	5	6	7
(c) 5 days	1	2	3	4	5	6	7

6. The number of working days a store was out of stock whilst stock was available in the warehousing and distribution system was:

	EXCELLENT						VERY BAD
(a) 1 day	1	2	3	4	5	6	7
(b) 3 days	1	2	3	4	5	6	7
(c) 5 days	1	2	3	4	5	6	7
(d) 10 days	1	2	3	4	5	6	7

100% RETURN

7. The number of working days it took for the stock to be ready for despatch in the warehouse from the time it left the store was:

	EXCELLENT						VERY BAD
(a) 5 days	1	2	3	4	5	6	7
(b) 7 days	1	2	3	4	5	6	7
(c) 10 days	1	2	3	4	5	6	7
(d) 15 days	1	2	3	4	5	6	7
(e) 20 days	1	2	3	4	5	6	7

8. For allocation stock, the number of working days after expected delivery date it arrived at the store was:

	EXCELLENT						VERY BAD
(a) 1 day	1	2	3	4	5	6	7
(b) 3 days	1	2	3	4	5	6	7
(c) 5 days	1	2	3	4	5	6	7

9. How useful is the present information available about the whereabouts and status of stock (such as cases when stock is shown as being unavailable)?

	EXCELLENT						VERY BAD
How useful is the information?	1	2	3	4	5	6	7

Please could you indicate below any further information requirements:

Could you indicate below any important service areas that have been omitted:

BUSINESS CENTRE: -

SIGNATURE: -

Questionnaire results.

The Supply Managers questionnaire results are shown below. Again the service levels known to have the highest service value attached to them are always given the highest value judgement of 6. This affected service measures 1,2,3,8 and are marked with a * in the results. The questionnaire results have also been transformed to give higher service levels a higher judgement value. (This was done by taking the original questionnaire results away from 7).

QUESTION NUMBER	1 a b c d e * f	2 a b c * d e f	3 a b c * d e f
RESPONSE 1	0 1 2 3 4 6 5	3 4 5 6 5 4 3	3 4 5 6 5 4 3
RESPONSE 2	0 1 3 4 6 6 5	0 2 5 6 5 3 0	2 3 4 6 3 2 0
RESPONSE 3	0 0 0 3 5 6 5	1 2 4 6 4 1 0	1 3 5 6 5 3 1
RESPONSE 4	0 1 2 6 4 6 4	1 2 4 6 4 2 1	2 3 3 6 3 3 2
RESPONSE 5	0 1 2 3 3 6 1	1 2 5 6 5 3 2	2 3 5 6 5 3 2
RESPONSE 6	0 0 0 1 3 6 5	0 1 4 6 4 3 2	0 2 4 6 4 3 0
RESPONSE 7	0 2 3 4 5 6 6	0 3 5 6 1 0 0	1 4 6 6 5 2 0
RESPONSE 8	0 0 2 2 4 6 5	2 2 4 6 4 0 0	3 3 4 6 4 3 3
RESPONSE 9	0 0 0 4 5 6 6	0 1 5 6 5 2 0	0 0 5 6 5 0 0
RESPONSE 10	0 0 0 1 3 6 5	1 3 5 6 5 3 1	0 2 4 6 4 2 0
RESPONSE 11	0 1 4 5 6 6 3	2 4 5 6 4 2 1	2 3 4 6 4 3 2

QUESTION NUMBER	4 a b c d	5 a b c	6 a b c d	7 a b c d e	8 * a b c	9
RESPONSE 1	5 4 0 0	6 4 2	3 2 1 0	6 4 3 1 0	6 6 4 2	3
RESPONSE 2	6 4 2 0	6 4 3	6 2 1 0	6 4 3 1 0	6 5 2 1	4
RESPONSE 3	4 2 0 0	6 4 2	2 1 0 0	5 4 2 0 0	6 4 2 0	3
RESPONSE 4	6 6 5 4	6 5 1	4 2 0 0	5 4 2 0 0	6 3 0 0	4
RESPONSE 5	5 3 1 0	6 4 1	3 1 0 0	4 3 2 1 0	6 5 2 0	3
RESPONSE 6	5 3 1 0	6 4 0	5 3 2 0	4 3 2 1 0	6 5 3 0	1
RESPONSE 7	4 2 0 0	6 4 2	4 3 1 0	4 3 1 0 0	6 3 1 0	3
RESPONSE 8	6 6 4 2	6 5 3	3 3 0 0	6 5 3 2 0	6 3 3 0	3
RESPONSE 9	6 5 0 0	6 6 3	0 0 0 0	6 5 3 2 0	6 6 5 2	5
RESPONSE 10	5 4 2 1	6 4 2	4 2 1 0	4 3 1 0 0	6 5 3 1	3
RESPONSE 11	6 5 3 0	6 6 6	6 5 2 0	4 3 1 0 0	6 2 1 0	3

Summary of results.

Question No	TOTAL	
	MEAN	SD
1a	0.000	0.00
1b	0.636	0.64
1c	1.636	1.37
1d	3.273	1.48
1e	4.364	1.07
1*	6.000	0.00
1f	4.545	1.37
2a	1.000	0.95
2b	2.364	0.98
2c	4.636	0.48
2*	6.000	0.00
2d	4.182	1.11
2e	2.091	1.24
2f	0.909	1.00
3a	1.455	1.08
3b	2.727	1.05
3c	4.455	0.78
3*	6.000	0.00
3d	4.273	0.75
3e	2.545	0.99
3f	1.182	1.19
4a	5.273	0.75
4b	4.000	1.35
4c	1.636	1.67
4d	0.636	1.23
5a	6.000	0.00
5b	4.545	0.78
5c	2.273	1.48
6a	3.636	1.67
6b	2.182	1.27
6c	0.727	0.75
6d	0.000	0.00
7a	4.909	0.90
7b	3.727	0.75
7c	2.091	0.79
7d	0.727	0.75
7e	0.000	0.00
8*	6.000	0.00
8a	4.273	1.29
8b	2.364	1.37
8c	0.545	0.78
9	3.182	0.94

APPENDIX D
THE RESULTS FOR THE STORE'S SERVICE MEASURES.

This appendix contains the information derived for each of the store's service measures when using the Human Activity Systems (HASs) described in chapter 7. The discussion for each of the service measures is split into the general areas indicated below:

A) General discussion about the service measure. This looks at the cognitive maps produced for each measure. Thus identifying the factors affecting the service measure and the areas in the customer's system affected by the service measure. The merits of the different possible monitoring criteria are discussed. Also, an indication will be given of whether there was a need for coordination between different divisions in the company.

B) Discussion on the questionnaire results. This section looks at the questionnaire results to indicate if there were any distinct market segments for the service measure. (The actual questionnaire results and the K means cluster analysis results are found in Appendix C and Appendix F respectively).

C) The trade-off areas between PD and the customer's system.

D) The disturbances which affect the service measures.

E) The service responses for the service measure and the classification of the possible change rate. This indicates how quickly disturbance changes could be responded to.

Service measure 1: The number of minutes late that a RDC van was.

A) General discussion (see Fig D.1):

It was very hard, in the short term, for PD to influence the level of one of the major service factors here; that is the time it took for delivery vans to get from the RDC to the store. However, PD could influence the time that the van left the RDC.

It is considered that using the mean value as the service criteria would have not been a very good indicator of the disservice to stores. This is because the expected time of arrival could have easily been shifted to change this mean value to zero. Consequently, often there existed two expected van arrival times: the official one and the unofficial one, held by the store's staff based on the mean time late. Consequently a better indicator of the level of disservice was the consistency (variation) in the arrival times.

If a delivery van arrived early then there were few problems from the store's viewpoint, as the van could always wait. But this generated a disservice to PD by increasing the time that vans were stationary. However, if a van arrived late, then the stores experienced a disservice in the following areas:

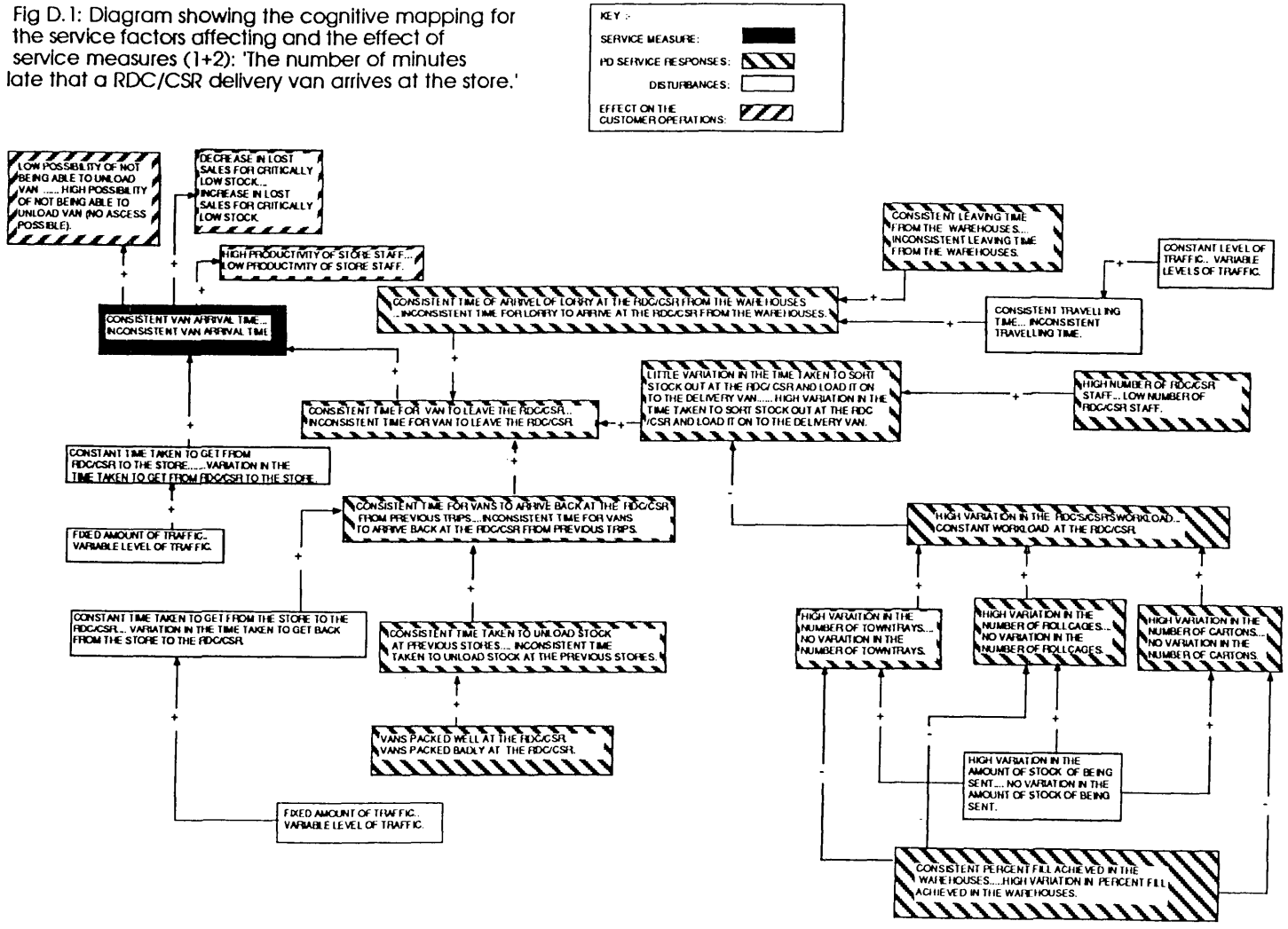
1) Backstore staff were waiting around doing no productive work.

2) For incoming lines at critically low levels there was a possibility of an increase in the level of lost sales- However it should be stressed that this effect was usually very minimal, unless the van was very late.

3) If the vans were very late, there was a possibility of there being no store staff available to unload it. This problem was more severe at the smaller stores, as often only part-time staff were used.

4) For stores that had restricted delivery times, due to their location, there was even the possibility of the van not being able to deliver at all.

Fig D.1: Diagram showing the cognitive mapping for the service factors affecting and the effect of service measures (1+2): 'The number of minutes late that a RDC/CSR delivery van arrives at the store.'



It was not easy to reduce the variation in the time it took to get from the RDC to the store. However, the variation in the time that the van left the RDC could be influenced. This was done by increasing the RDC staff levels to cope with the variation in the RDC's workload. A RDC manager's task can have been made easier by giving him an indication of the RDC's workload in advance. This could have been done by determining the level of stock that was being picked, or was due to be picked, in the warehouse. A possible way of doing this was to get an estimated workload from the ordering computer.

B) Questionnaire results (see Fig D.2):

The questionnaire results support the theory that store managers were more critical of vans arriving late than early. With the geographical areas there did not appear to be any real differences in the service judgements. However, there was some evidence, but not enough to merit segmentation, to support the hypothesis that smaller store managers were more critical of bad service than the larger store managers. The K Mean cluster analysis results, shown in Appendix F, produced segments which may have been more beneficial than the ones suggested by the company. Unfortunately it was impossible, due to the lack of relevant information, to pursue this investigation any further.

C) Trade-off areas:

1) The number of staff at the RDC.

against

1) The productivity of the store staff.

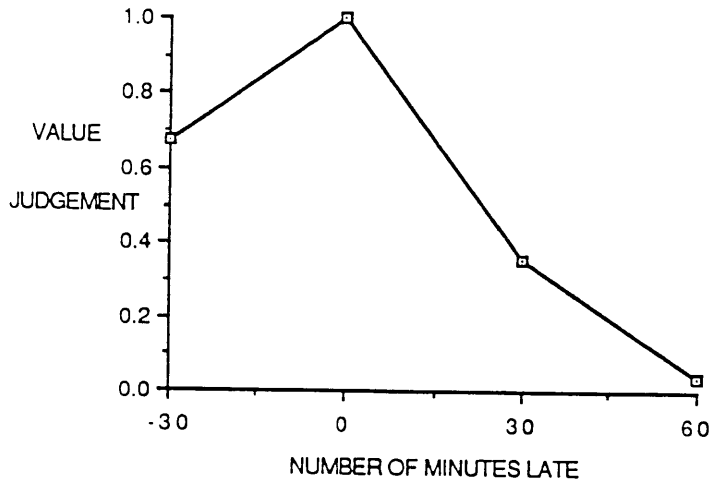
2) The level of lost sales.

D) Disturbances:

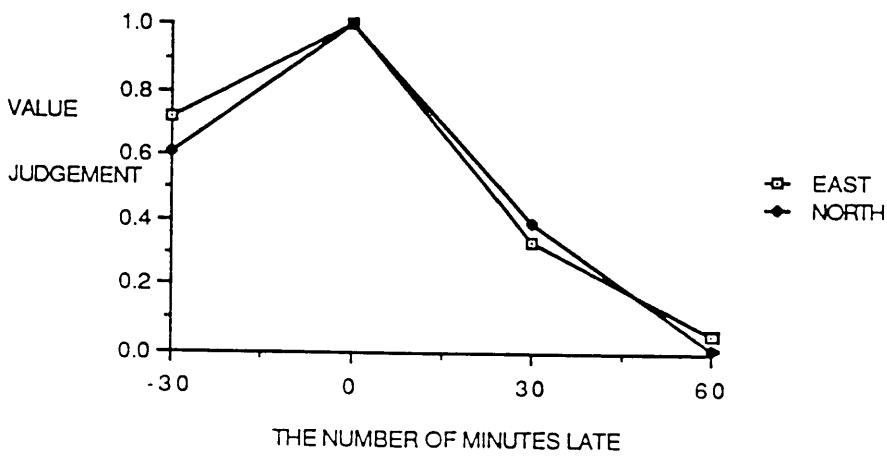
1) The level of RDC workload.

Fig D.2: The graph showing the value judgements for service measure 1:"The number of minutes late that the RDC van is."

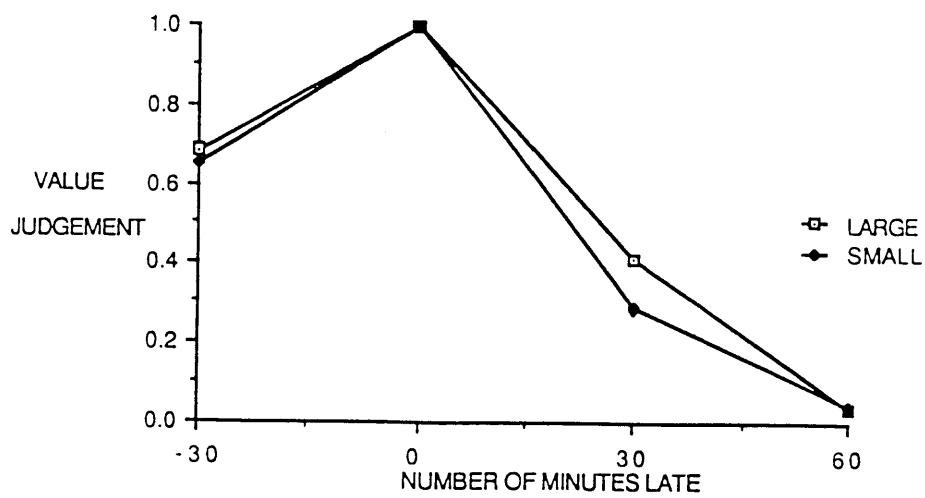
A) The overall mean judgement:



B) Regional differences:



C) Size differences:



E) Service responses/ the response rate:

1) The level of RDC staff. There were various ways of changing the level of RDC staff, each with different response times and costs. Use of overtime had a short response time but was costly whereas increasing the level of full time staff had a long response time but was cheap.

Service measure 2: The number of minutes late that a CSR van was.

A) General discussion (see Fig D.1):

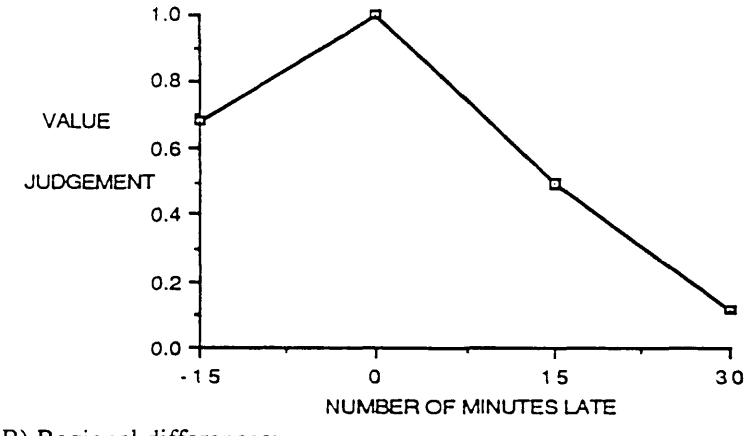
This service measure was similar to service measure 1 but the consequences of a van being late were greater due to the effect on lost sales being greater. This was because CSR stock l in the stores was kept at a low level, with a large proportion of the safety stock being kept at the CSR.

B) Questionnaire results (see Fig D.3 and Fig D.4):

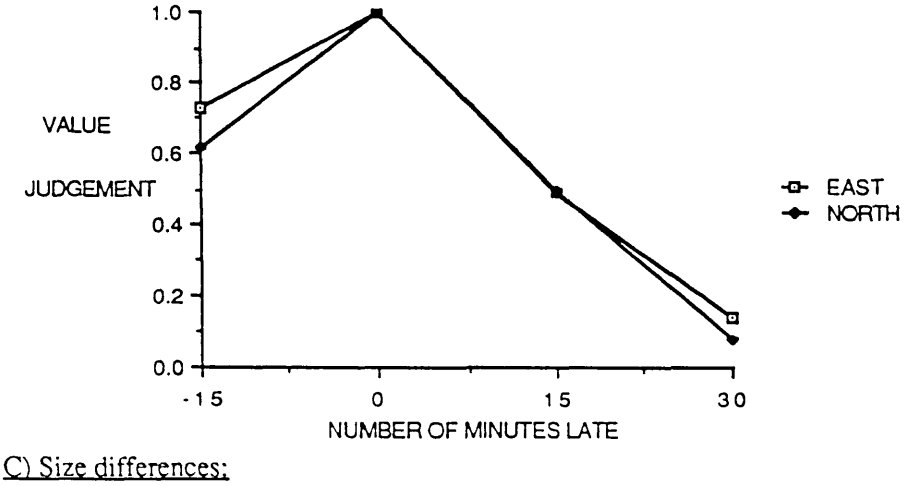
There was not much difference in the benefits either between geographical areas or between stores sizes. The K Mean cluster analysis results, shown in Appendix F, did not appear to produce segments that were more beneficial than the ones suggested by the company. It can be seen from Fig D.4 that there were large differences between the value judgement given for a CSR van being late compared to a RDC van, with greater emphasis being put on CSR vans arriving on time. This was due to the lower levels of safety stock with CSR lines and also the need to get stock onto the store's shelves before the stores opened. Consequently, these two service measure could not be combined into one measure.

Fig D.3: The graph showing the value judgements for service measure 2: "The number of minutes late that the CSR van is."

A) The overall mean judgement:



B) Regional differences:



C) Size differences:

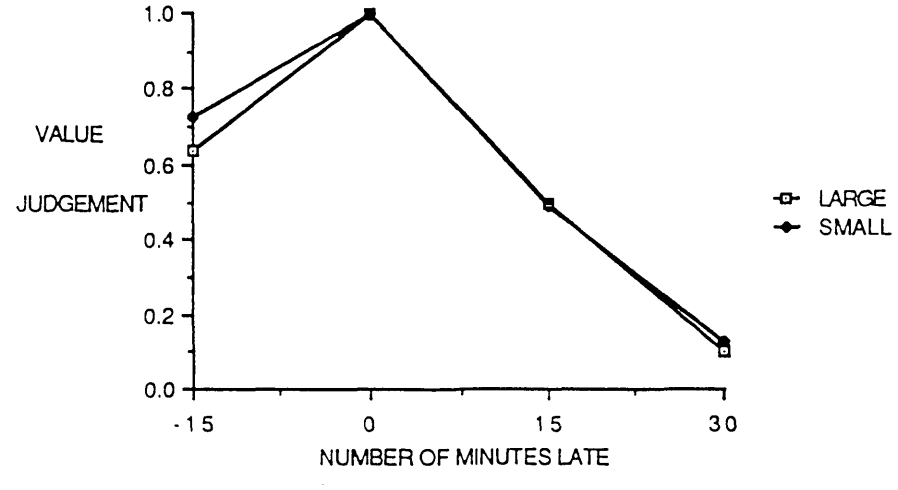
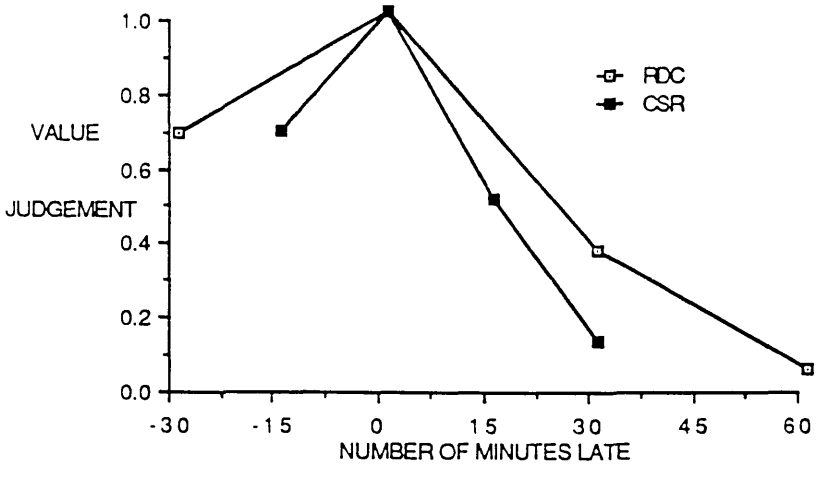


Fig D.4 : The graph showing the differences in the value judgement for service measures 1 and 2 the number of minutes late that a delivery van is.



C) Trade-off areas:

1) The number of CSR staff.

Against

1) The productivity of store staff.

2) The level of lost sales.

D) Disturbances:

1) The workload at the CSR.

E) Service responses/ response time:

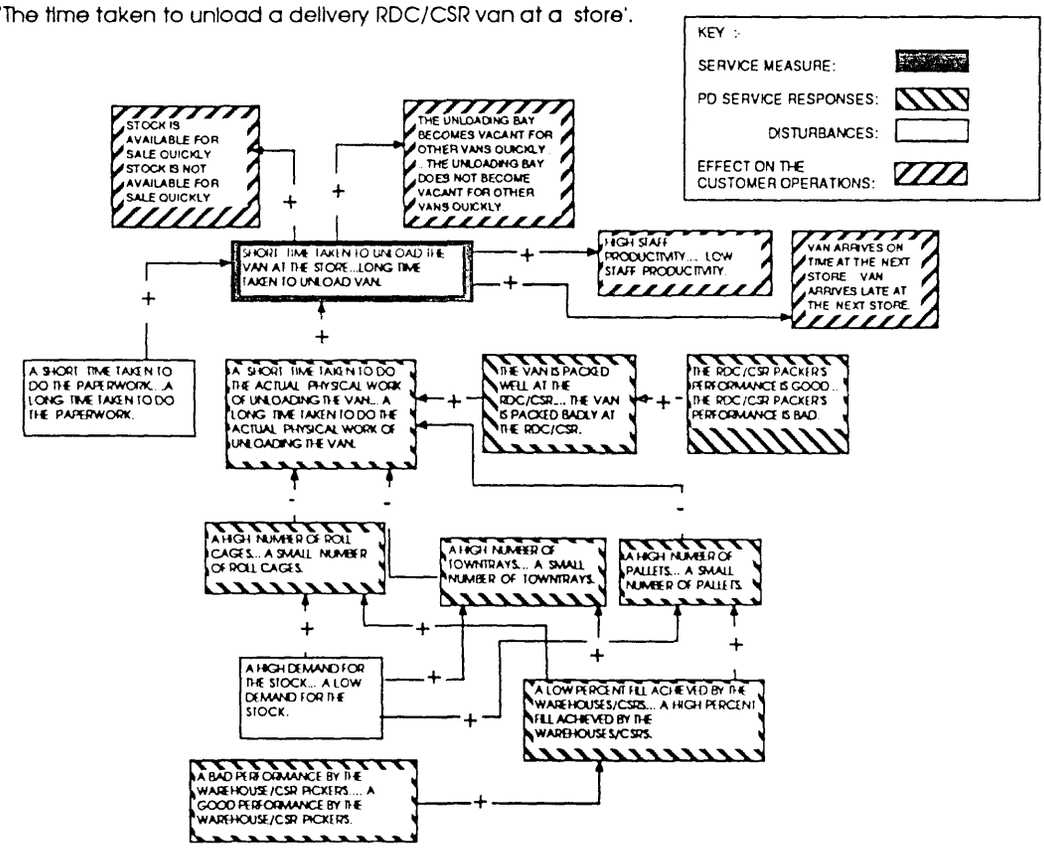
1) The level of CSR staff. The use of overtime had a short response time whereas use of full-time staff had a long response time.

Service measure 3/4: The time taken to unload a RDC/CSR delivery van.

A) General discussion (see Fig D.5):

A major influence on the time taken to unload a van was the number of containers needed to be unloaded. This was felt to be dependent on the level of stock coming into the store, which was outside of PD's control, and the percent fill of containers that was achieved in the warehouse/ CSR. However, the time taken was also affected by how well the vans were packed at the RDC. This was dependent on the time taken to pack them and the type of containers holding the stock. It should be stressed that if the delivery vans were unloaded too quickly there was often an increase in the level of breakages occurring.

Fig D.5: Diagram showing the cognitive mapping for the service factors which affect and the effects of service measures 3+4: 'The time taken to unload a delivery RDC/CSR van at a store'.



The consequences, of taking longer to unload a van, were considered to be:

1) Increase in the store's staff hours.

2) Stock was not available for sale so quickly.

3) The stores unloading bay becoming blocked up, thus stopping other vans delivering.

4) The van arriving late at the next store.

As the questionnaire results (see Fig D.6 and D.7) are almost linear it is felt that it might have been best to use a loose criteria , such as the mean, to monitor the service level.

B) Questionnaire results (see Fig D.6, Fig D.7 and Fig D.8):

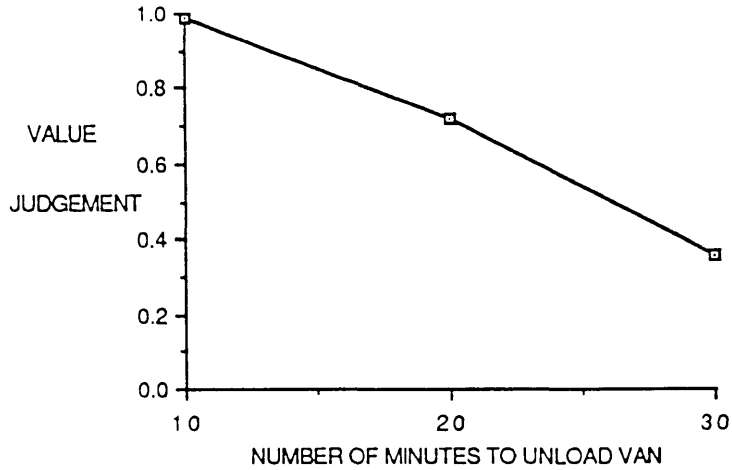
For service measure 3 there were big differences between the service expectations of different size stores. The smaller stores expected delivery vans to be unloaded quicker (because they received a smaller amount of stock). This resulted in a need for two distinct segments. The slight regional differences can be explained by the East respondents having a higher proportion of small store managers than the North. The K Mean cluster analysis results shown in Appendix F, did not appear to produce segments that were more beneficial than the ones suggested by the company.

For service measure 4 there were hardly any differences in the geographical regions. However, there was a difference with the store sizes, with the smaller stores demanding a higher service level. The K Mean cluster analysis results, shown in Appendix F produced segments which may be more beneficial than the ones suggested by the company. Unfortunately, it was impossible, due to the lack of relevant information, to pursue this investigation any further.

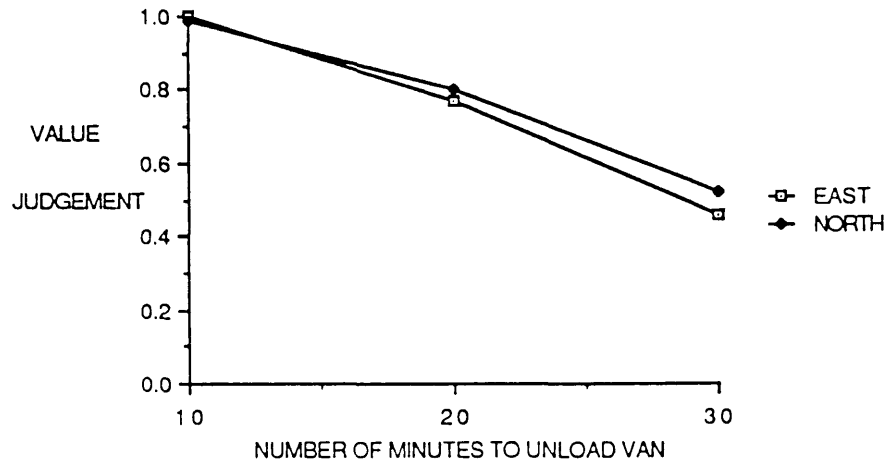
Also, the questionnaire results indicated that the two service measures could not be combined due to the need for CSR vans to be unloaded more quickly than the RDC vans.

Fig D.6: The graph showing the value judgements for service measure 3: "The number of minutes taken to unload a RDC van."

A) The overall mean judgement:



B) Regional differences:



C) Size differences:

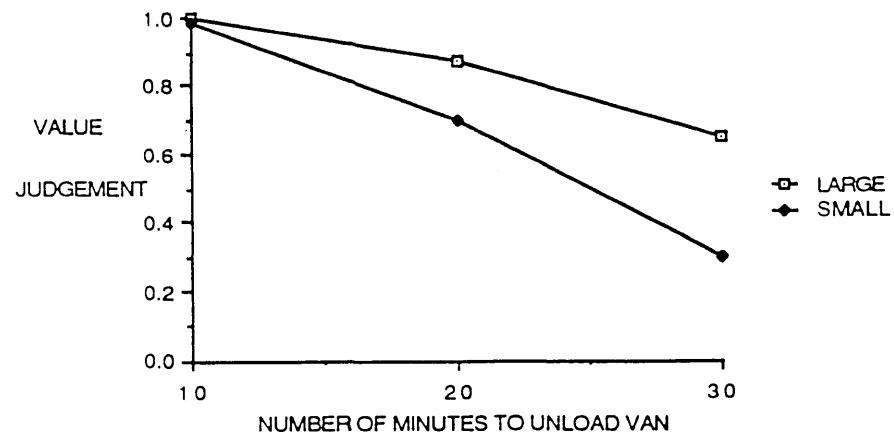
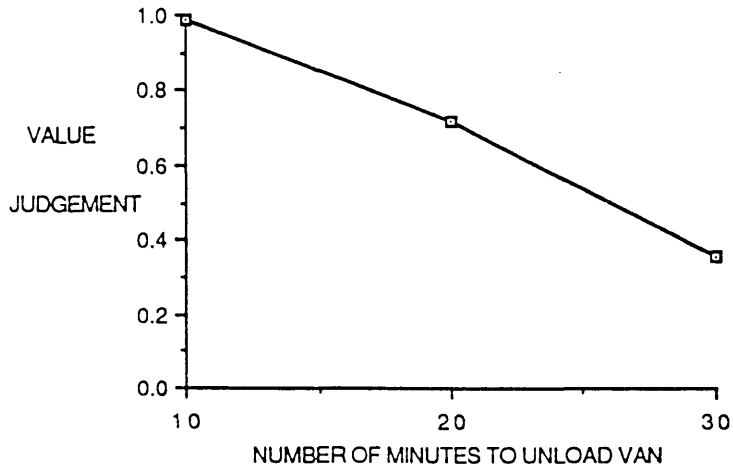
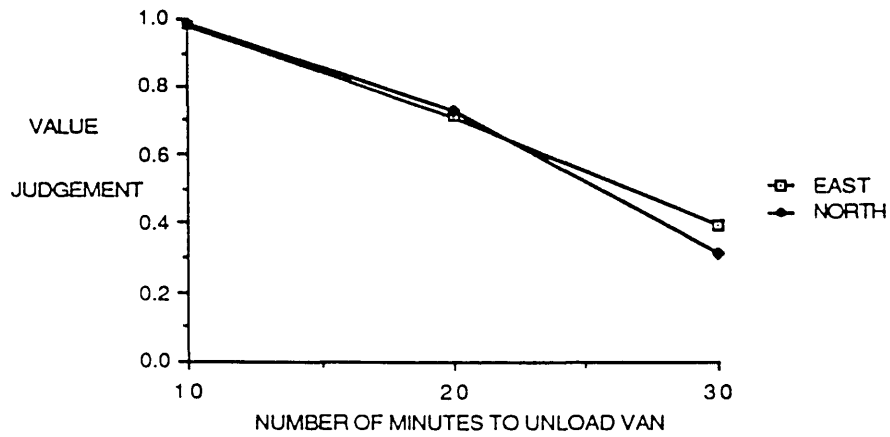


Fig D.7: The graph showing the value judgements for service measure 4: "The number of minutes taken to unload a CSR van."

A) The overall mean judgement:



B) Regional differences:



C) Size differences:

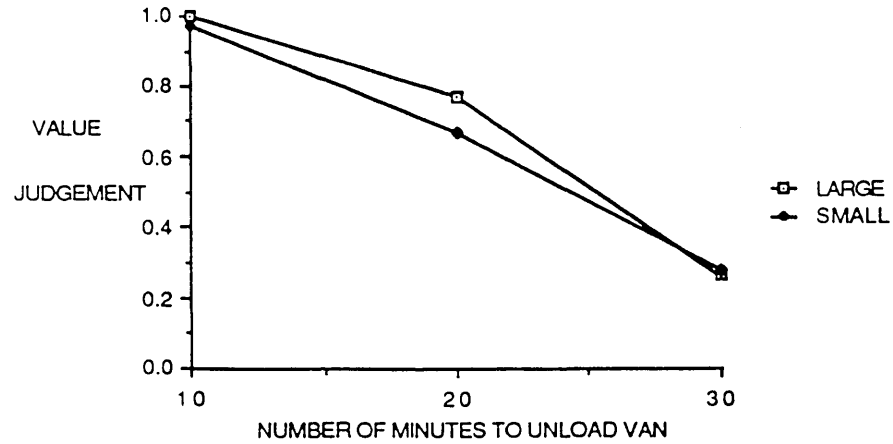
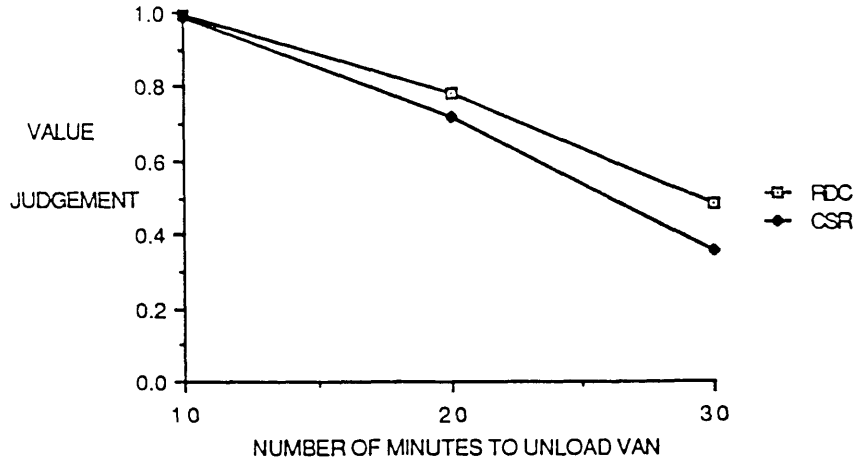


Fig D.8: The graph showing the value judgements for service measure 3 (RDC unloading time) compared to service measure 4 (CSR unloading time).



C) Trade-off areas:

1) How well the stock was loaded on the vans. (The level of manpower at the RDC/CSR).

2) The percent fill of containers achieved at the warehouse/CSR. (It is proposed that there was a trade-off between the fill-rate achieved and the staff productivity).

3) The type of containers that were used.

Against

1) The level of breakages occurring.

2) The level of manpower being used at the store.

3) The level of lost sales.

D) Disturbances:

1) The level of RDC workload.

E) Service responses/ response time:

1) The level of RDC/ warehouse staff. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

Service measure 5: The number of days warning given of change in delivery times.

A) General discussion (see Fig D.9):

If no warning was required to the stores concerning the deliveries then it would have been possible to assign the van delivery routes that minimised the costs everyday- this was determined by the number of vans required and the total distance covered. The greater the variation in the stock volume going to the particular stores the greater would have been the benefits associated with doing this. The effect of giving no notice was that all the van delivery routes could be linked together (see section 6.7.3) to minimise the costs of the lead time from the CSR/RDC to the store.

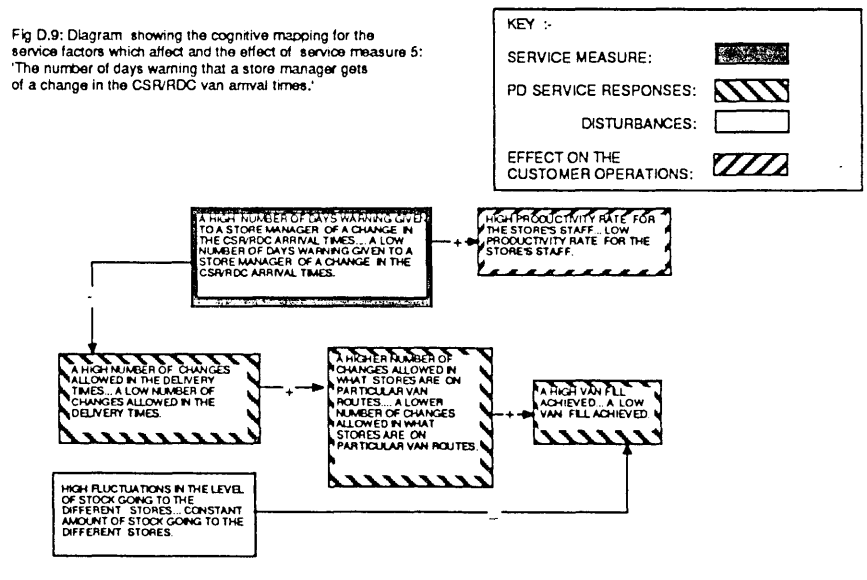


Fig D.9: Diagram showing the cognitive mapping for the service factors which affect and the effect of service measure 5: 'The number of days warning that a store manager gets of a change in the CSR/RDC van arrival times.'

The less warning that was required to be given the more frequently the van routes could have been altered. Consequently the greater were the possible cost savings. Also it was possible with a shorter notice interval, to reduce the number of overfills occurring at the

RDC/CSR due to the system's added flexibility.

The effects of this service measure on the stores were dramatic, especially if they had no idea when a van was arriving. This was more critical with small stores because they often used part-time staff. The more warning given to store managers, the more time he had to alter his staffing procedures- such as notifying the porters of changes in their working hours.

It is suggested that the mean number of days warning given should be used as the monitoring criterion. This is because the questionnaire graphs are almost linear (see Fig D.10)

B) Questionnaire results (see Fig D.10):

The questionnaire results indicated that stores were very critical of short notice being given. The results indicated that there were no geographical and surprisingly, no size differences. The K Mean cluster analysis results (Appendix F) did not appear to produce segments that were more beneficial than the ones suggested by the company.

C) Trade-offs areas:

1) The van fill.

2) The order lead time.

against

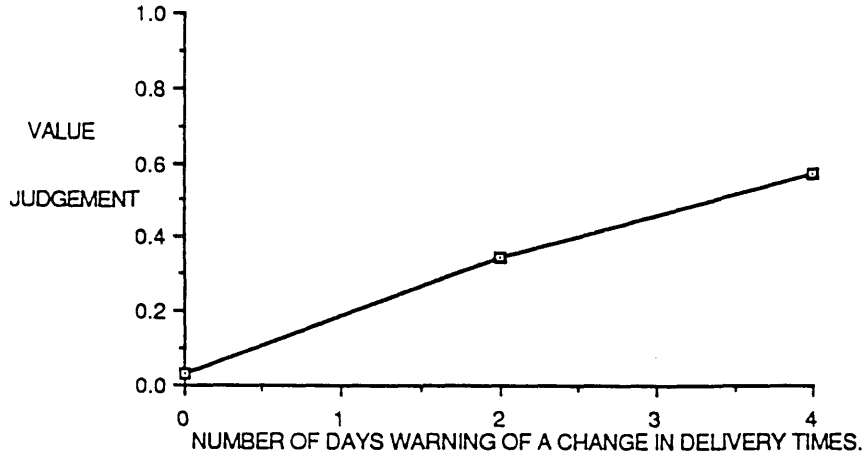
1) Staff scheduling problems (the productivity of the store's staff).

D) Disturbances:

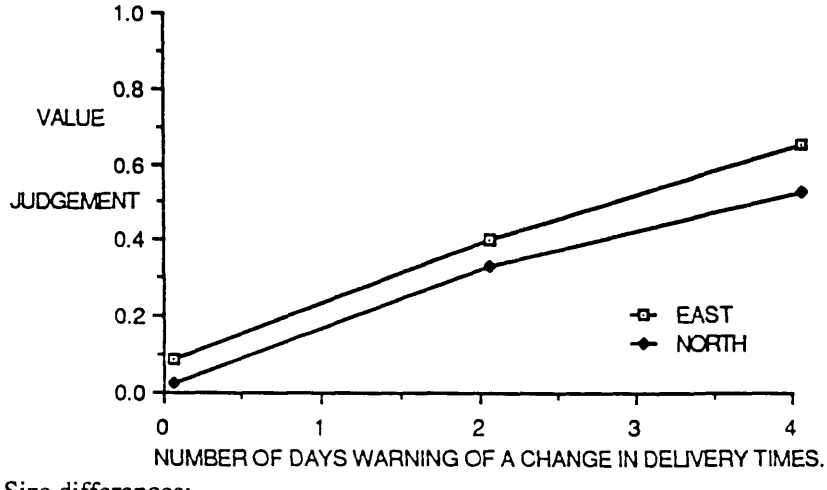
1) Variation in stock amount going to stores.

Fig D.10: The graph showing the value judgements for service measure 5: "The number of working days warning that a store manager receives of a change in the arrival time of a RDC/CSR delivery van."

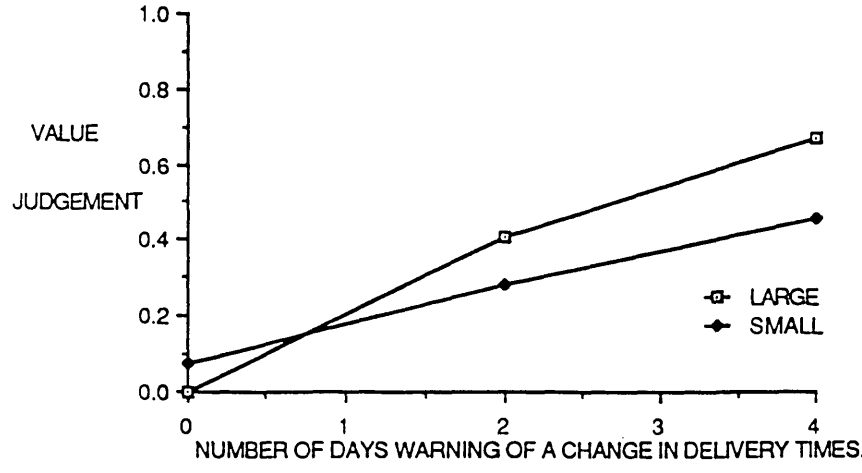
A) The overall mean judgement:



B) Regional differences:



C) Size differences:



E) Service responses/ response rate:

1) Decrease the van fills. It proved impossible to determine a figure for this response rate.

2) Decrease the lead times. It proved impossible to determine a figure for this response rate.

Service measure 6+7+8: The number of working days after the expected delivery date that 1st/2nd/FOCUS class stock arrives.

A) General discussion (see Fig D.11):

These three service measures will be discussed together here as they were very similar in nature and highly interrelated. The amount of stock being sent to stores was roughly the sum of 1st and 2nd class stock. FOCUS stock was a sub-category of 1st class stock.

The time taken for the stock to get to the stores was determined by three factors:-

I) The time it took for the stock to leave the warehouses.

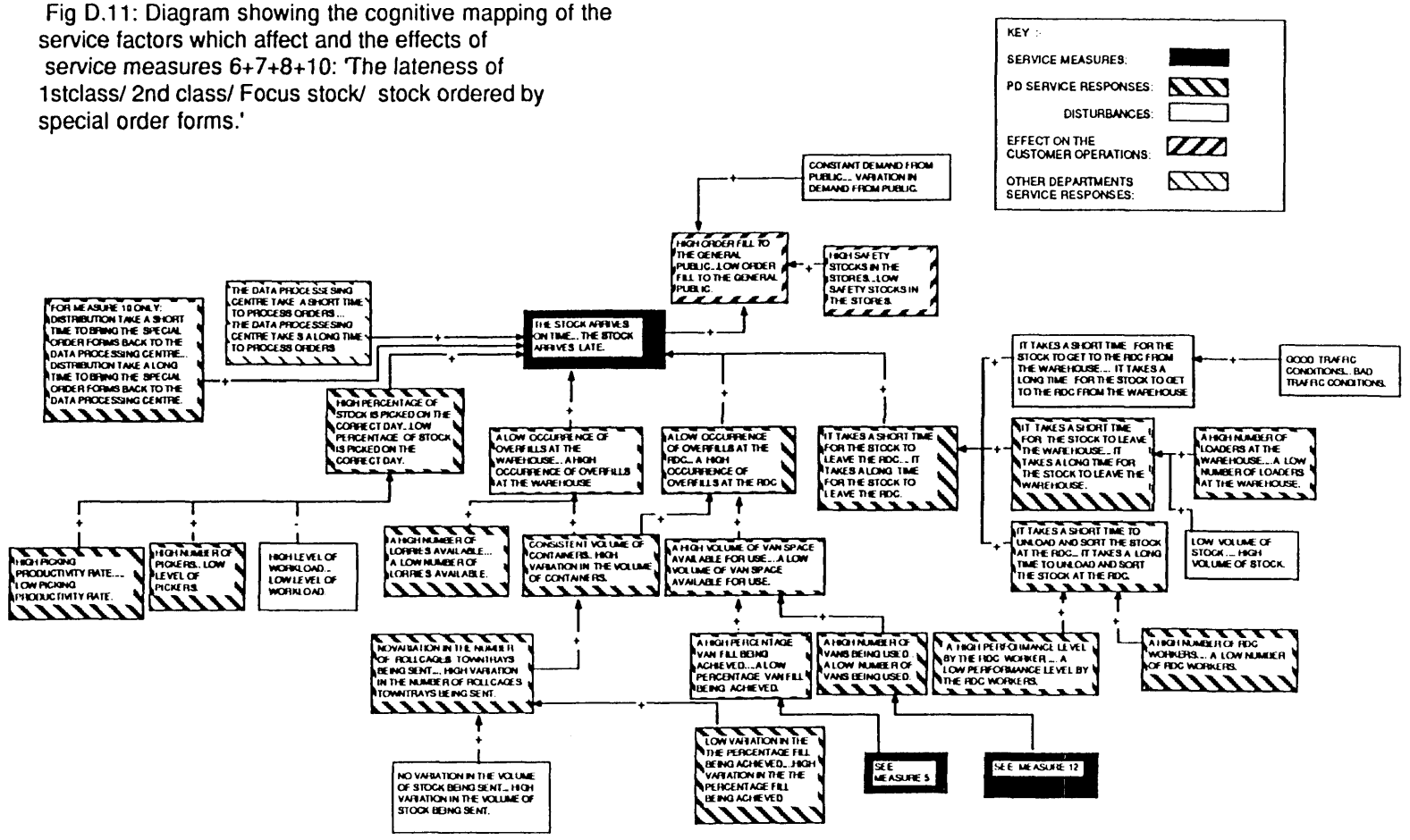
II) The time it took for the stock to get to the stores from the warehouses.

III) The time it took for the order to be processed.

This indicates that there was a need for coordination between PD and the Company's Data Processing Centre and also between the Company's warehousing and distribution departments. The influences on these 3 factors will now be investigated.

Factor I: The time it took for the stock to leave the warehouses. The warehouses only affected the time it took for stock to leave warehouses from the time that the invoices arrived in the warehouses. A new set of picking invoices arrived in each warehouse every working day. If a warehouse were unable to cope with a particular

Fig D.11: Diagram showing the cognitive mapping of the service factors which affect and the effects of service measures 6+7+8+10: 'The lateness of 1stclass/ 2nd class/ Focus stock/ stock ordered by special order forms.'



day's workload, then the remaining invoices were carried forward to the next day's workload- that is the disturbance was cumulative. If a warehouse could always meet the work load then the service was at its best value (that is picked within 1 day)

Thus, there was a need for a warehouse manager to match his level of workforce against the level of workload. This was easier to do when there was less variation in the workload as the manager could keep his level of staff almost constant. To cope with these variations in workload, the warehouse manager could have either increased his available manpower to deal with the workload peaks, or he could have tried to alter the level of workforce to match the workload. (That is responding to each disturbance differently, see section 6.7.3). However, there was also a third option, that was to keep the same level of manpower and accept a decrease in the service level. This made it possible to cancel out of the peaks in demand with future troughs in demand. However as this disturbance was cumulative, the level of manpower being used had to be capable of meeting at least the mean level of workload. There were two types of variations in the workload:

1) Seasonal Variations.

2) Temporary variations.

There were 3 basic options, open to a warehouse manager, of how he could meet the workload:

1) The use of full-time staff.

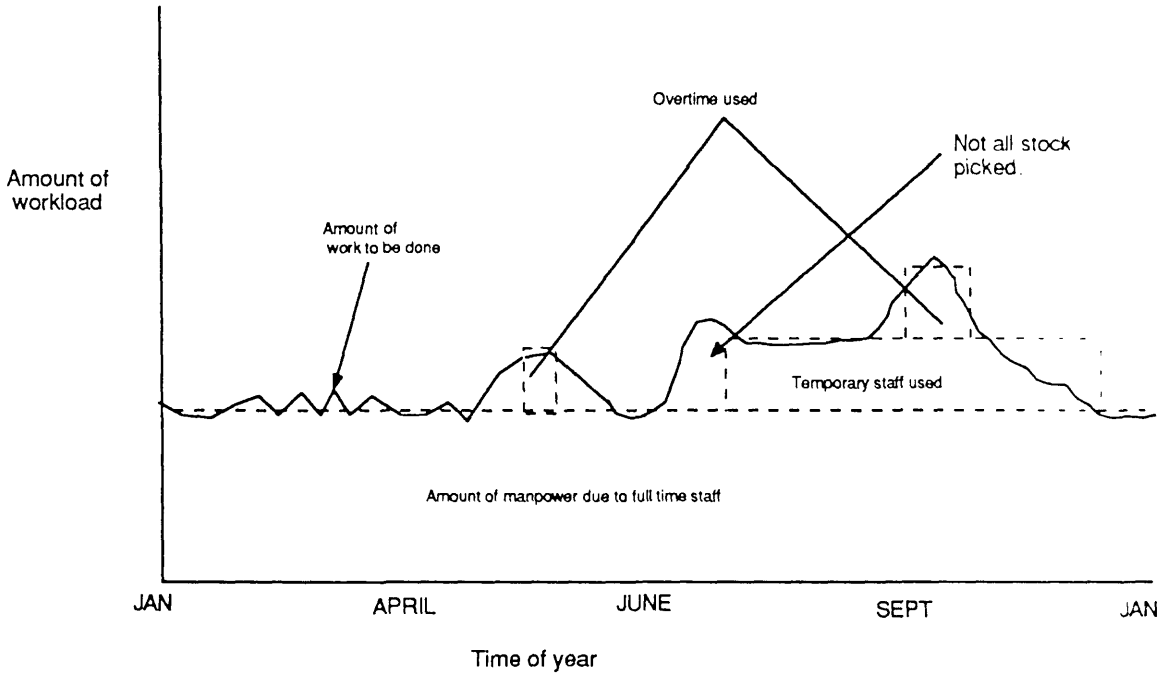
2) The use of overtime.

3) The use of temporary staff.

The level of full-time staff that was being used defined the base line of the amount of work that was achievable. That is the full-time staff were used to meet the basic all year round demand. The use of overtime was a relatively expensive way of

increasing the manpower available. However, its great advantage was its short response time. Thus, generally overtime was used to meet the temporary variations in the workload. The use of temporary staff was a relatively cheap way (compared to overtime) of increasing the manpower. However, there was generally a more long term commitment of resources required. Consequently, temporary staff were generally used to meet the more predictable seasonal variations in the workload. The use of different types of staffing policies to meet the different types of disturbances are shown in Fig D.12. It can be seen from above that there were basically two conflicting cost reduction policies occurring here:- Responding to each disturbance differently (implying overtime should be used) and the coordination between the different service responses (implying that full-time staff should be used).

Fig D.12:graph showing the possible use of temporary staff and overtime to match the variation in the warehouse's workload.



As the picking of different types of stock had a common response- the level of warehouse manpower- another way of reducing the cost of picking the various types of stock was to link them together, giving first class stock a higher priority grading than second class stock.

Factor II: The effect of the Distribution system: The Distribution system affected this level of service in 3 ways:

1) The time it took for the stock to get to the RDC from the warehouse.

2) The time it took for the stock to get through the RDC.

3) The time it took for the stock to get to the stores from the RDC.

The time it took for the stock to get to the RDC was mainly influenced by whether an overfill- not enough space on a lorry- occurred at the warehouse's dispatch dock. If an overfill did occur it was possible to dispatch another lorry, however, this increased the transport costs. The level of overfills occurring was determined by the variation in the volume of stock being dispatched to each RDC. However, by allowing lorries to carry stock from more than one warehouse it was possible for the company to link the different warehouse service factors together and thus reducing the total workload variation and hence, reducing the costs.

The time taken to get through the RDC was a similar situation to that of picking the stock in the warehouse, that of matching the manpower level against the workload. level. Unfortunately it was impossible with the participating company to give first class stock priority as there were no differences in the containers used for the different types of stock.

The time taken to get from the RDC to the store was a similar situation to that of getting from the warehouse to the RDC. When an overfill occurred there existed a dilemma of whether to send an extra delivery van. When an extra van was used, there was the further complication of notifying the store of the extra van arriving (see service measure 12).

Factor III: The time taken to process orders. The stock orders were processed overnight by computers. The speed of processing these orders could have been increased by using bigger and faster computers. However, as long as these orders

were processed and invoices produced before the warehouses started picking the stock in the morning this was unnecessary. Another important factor is the computer's reliability.

The above discussion has been concerned with the participating company's system as it stood. However, it would have been possible to start considering the more fundamental questions concerning the number and location of the warehouses and RDCs. Unfortunately, this was outside the direct brief of the project.

It should be stressed that, priority should have been given to 1st class stock, thus, if there was work that could not be completed, on a particular day, then it should have been 2nd class work that was left over. This was easy enough in the warehouses where 2nd class invoices were differentiated from the other invoices. However, once the stock was put into containers there was no way of telling different classes of stock apart. Thus, it was hard for the Distribution system to differentiate between the different types of containers. However there would have been a cost of differentiating between the containers which had to be taken into consideration when determining whether differentiating between the different classes of stock in the distribution system was cost effective.

The effect of decreasing the service level was to increase the lead time and consequently, increasing the store's stock levels to give a particular service level to the general public. There are several models given in the literature on the effect of service on the level of safety stock required below is shown one such model:

It can be seen from the above that, if the mean time late was used as the criterion for First class stock and Focus class stock then it would have not fully indicated the effect that the service measure had on the required level of stock. This is due to the level of stock being highly influenced by the variation in the lead time as a result of the short lead time. Thus, it

is considered that a better criteria here would have been a combination of mean and variation. However, the mean value would have been a more acceptable criterion for the second class stock as this measure is less affected by variation in the lead time, as a result of its longer lead time.

$$\text{Safety stock} = K\sqrt{\bar{L}\sigma_D^2 + \bar{D}^2\sigma_L^2}$$

Where $\bar{D}$=Average Demand, σ_D^2=Variance of demand.

$\bar{L}$ =Average lead time, σ_L^2=Variance of Lead time.

K=Standard normal deviate.

Source: Lewis: Scientific Inventory Control".(2nd edition) Butterworth & Co publishers. Ltd.

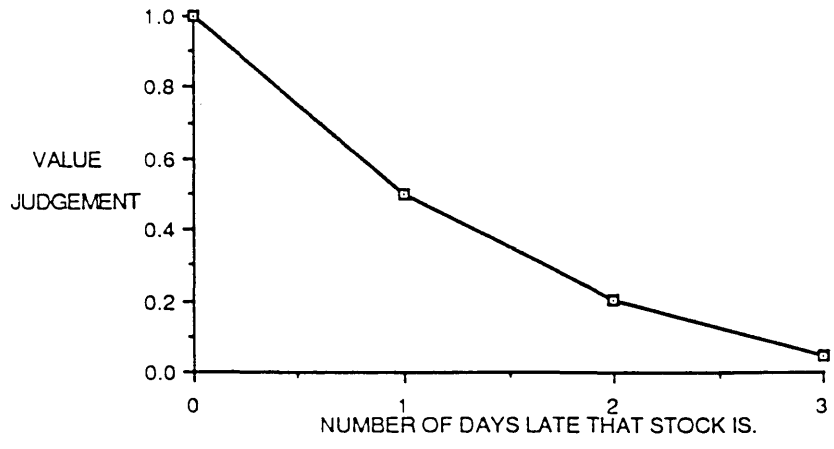
B) Questionnaire results (see Fig D.13, Fig D.14, Fig D.15 and Fig D.16):

Each of the service measures have remarkably similar looking graphs, with there being some differences between the geographical regions but not enough to merit their separation into 2 distinct markets.

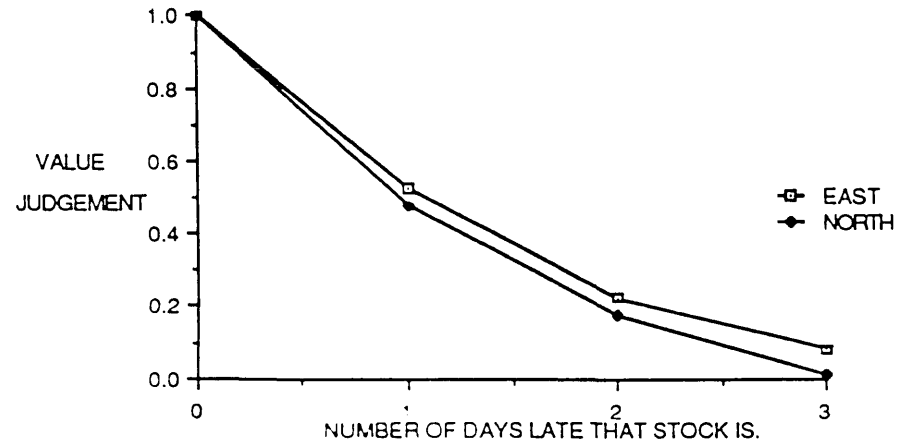
When the three service measure results were compared against each other there were distinct differences between each of the service measures. The store managers desired the highest service level for Focus lines (this was due to the pressure to guarantee a good service level to their customers). With 1st class stock, the store managers desired a better service level than with 2nd class stock. The service difference was greater between 1st and 2nd class than it was between 1st and FOCUS. This would seem to suggest that 1st class and FOCUS stock should have had one service classification with 2nd class stock having another. Also the K Mean cluster analysis results, shown in Appendix F, did not appear to produce segments that were more beneficial than the ones suggested by the company.

Fig D.13: The graph showing the value judgements for service measure 6: "The number of working days after expected arrival day that 1st class stock arrived."

A) The overall mean judgement:



B) Regional differences:



C) Size differences:

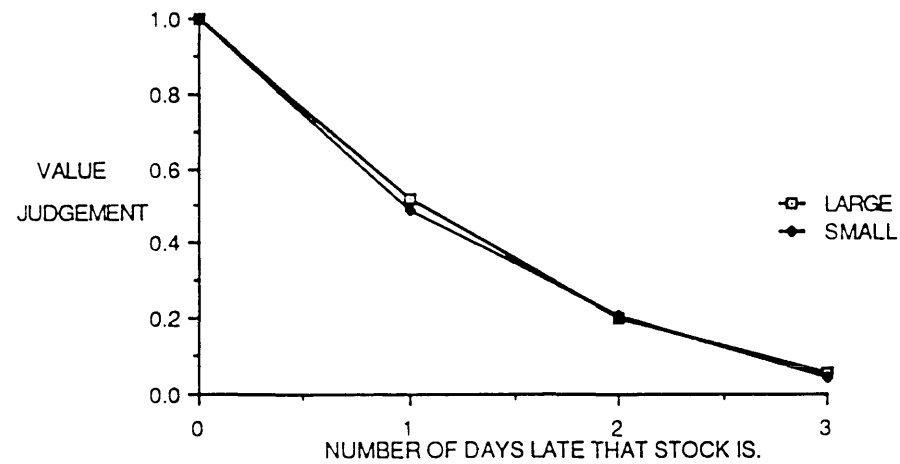
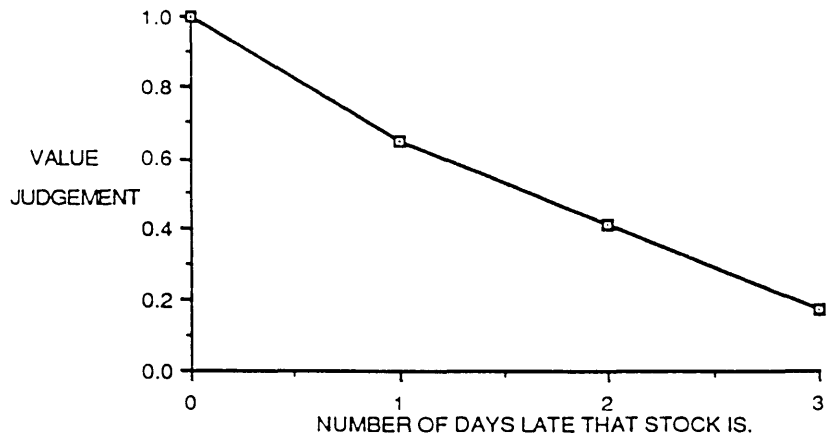
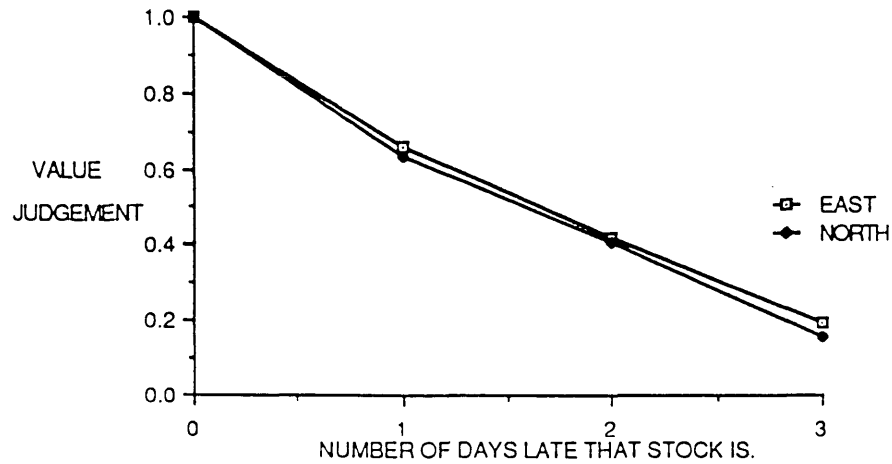


Fig D.14: The graph showing the value judgements for service measure 7: "The number of working days after expected arrival day that 2nd class stock arrived."

A) The overall mean judgement:



B) Regional differences:



C) Size differences:

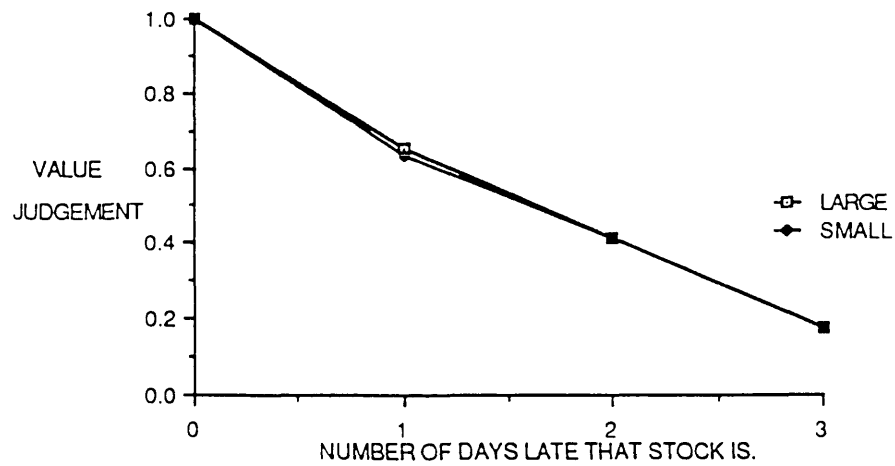
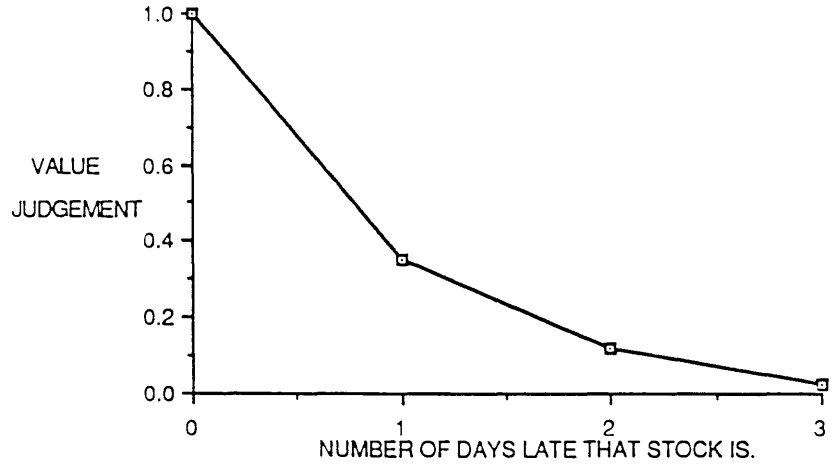
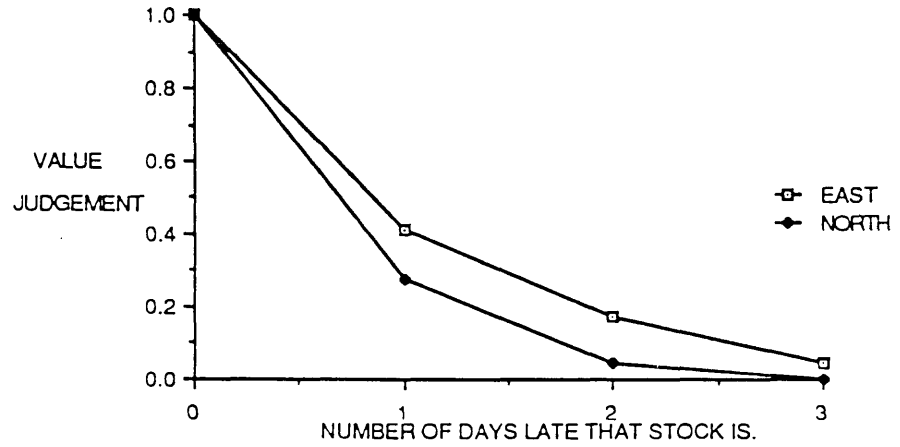


Fig D.15: The graph showing the value judgements for service measure 8: "The number of working days after expected arrival day that FOCUS stock arrived."

A) The overall mean judgement:



B) Regional differences:



C) Size differences:

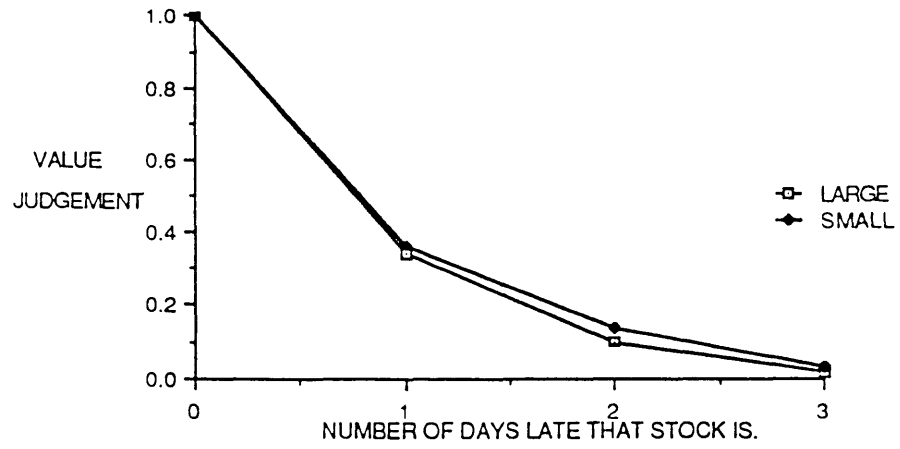
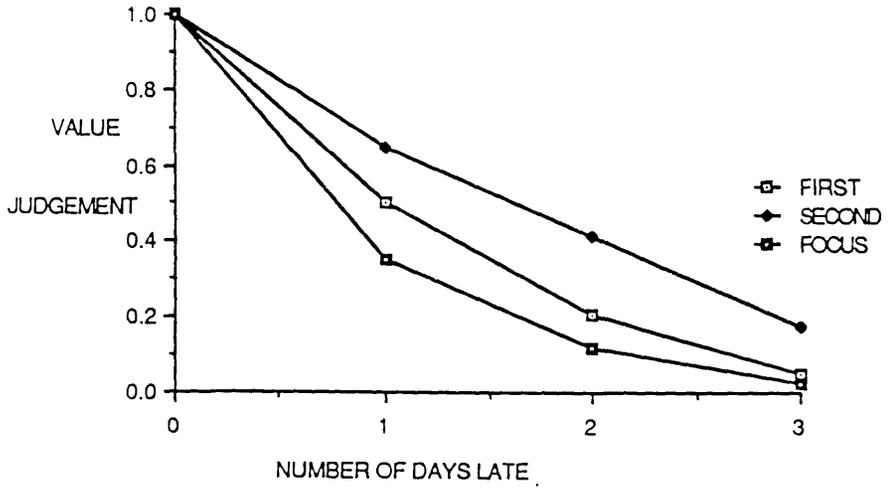


Fig D.16: The graph showing the different value judgements for 1st class and 2nd class and FOCUS stock.



C) Trade-off areas:

1) The level of staff at the warehouses and at the RDC (the wages bill).

2) The number of lorries and vans being used (cost of lorries and vans).

3) The increase in the cost due to different types of containers being used.

4) The number of warehouses and RDC (this affected the required safety stock levels).

Against

1) The service level to the final customer.

2) The level of safety stock.

D) Disturbances:

1) The warehouse's workload.

2) The level of stock going to the RDC.

3) The level of workload at the RDC.

4) The level of stock going to the store.

E) Service responses/and response times:

1) The level of staff at the warehouse/ RDC. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

2) The number of vehicles. Hiring more vehicles had a quick response time whereas buying own vehicles had a long response time.

3) Use of the different containers in Distribution. It was difficult to assess a response time for this service response.

4) The number and location of the warehouses and RDC. The response rate for this was very long term in nature.

Service measure 9: The number of working days it took for a hot-line order to arrive from the time the order was placed.

A) General discussion (see Fig D.17):

Three main areas were identified as having an influence on the service level for this particular service measure, these were:

1) The time it took for the stock to leave the warehouses.

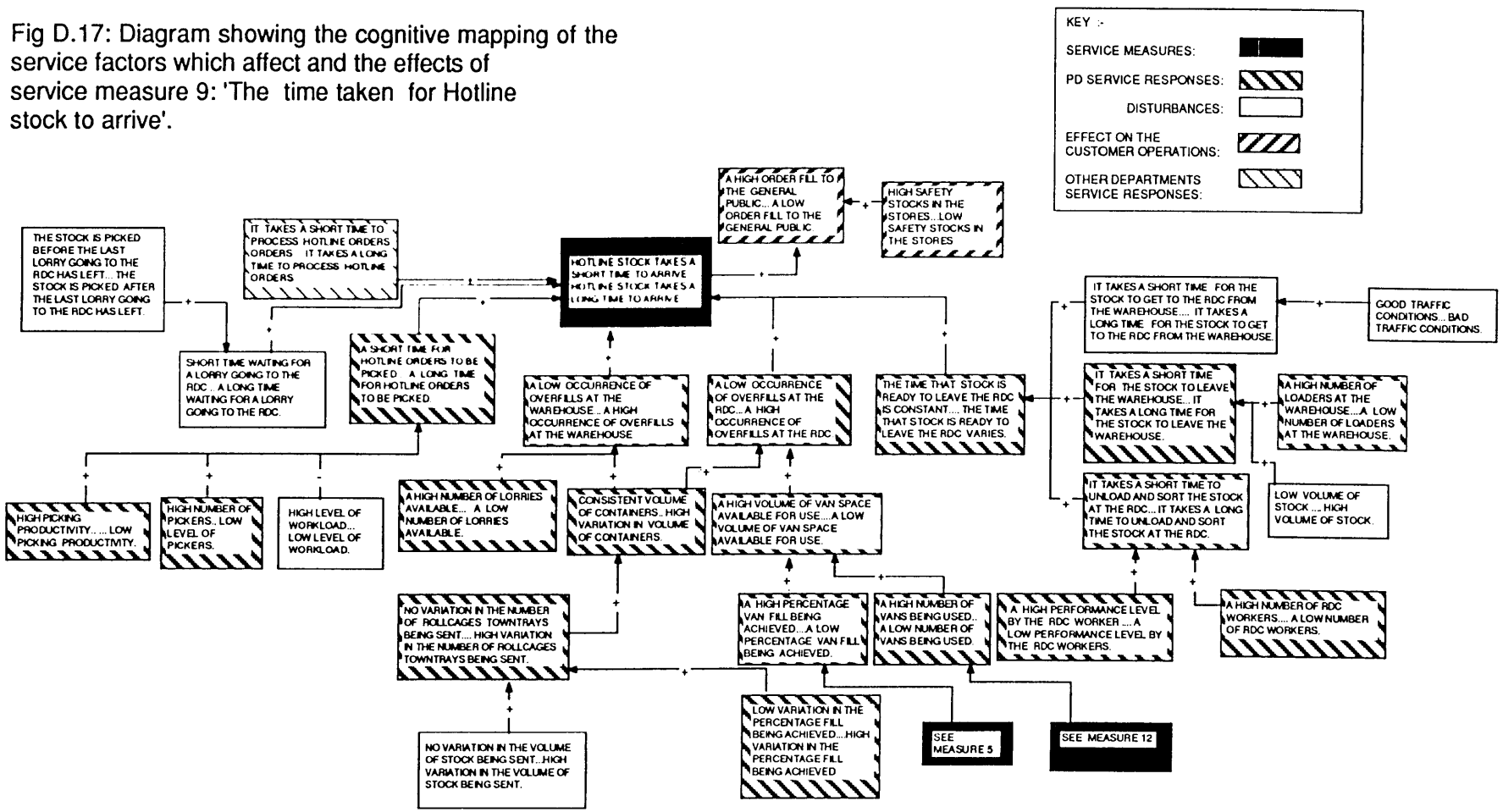
2) The time it took for the stock to get through the Distribution system.

3) The time it took for the data processing centre to produce the invoices.

These three factors are discussed below:

Factor I: The hot-line orders were picked as soon as the picking invoices were produced in the warehouse. However, if all the lorries for a particular RDC had already left then the orders were delayed by 24 hours. Consequently, the time it took for the stock to leave the warehouse was very much pot luck, dependent on whether the orders were picked before the last lorry left. This situation could have been

Fig D.17: Diagram showing the cognitive mapping of the service factors which affect and the effects of service measure 9: 'The time taken for Hotline stock to arrive'.



improved by emphasising the need for Store Managers to phone in their orders early in the morning; however there would have been a resultant increase in telephone costs. An alternative strategy would have been to keep a lorry back for each RDC, which then could deal with any late Hotline orders; however this scheme would have caused problems with the RDC dealing with this late stock.

Factor II: As there were no differences in the containers used for hot-line from the containers used for other type of orders; the time taken to get through the Distribution system was the same for the participating company, as for measures 6-8. Consequently, the speed of the system could have been improved, for this type of stock, by using different containers for hot-line orders and giving these priority. This would have helped in deciding which containers should have been left behind when an overfill situation occurred at either the RDC or at the warehouse. However this would have reduced the service level for the other type of deliveries, and increased the distribution costs because of the need to differentiate between the different containers.

Factor III: The time taken for the invoices to be produced was speeded up, compared to the situation in measures 6-8, by them being post-processed. That is they were processed by the merchandise accounting computer after being produced.

Due to the hotline being an 'emergency' ordering system a decrease in the service had higher financial penalties than the other type of delivery systems did. This was due to there being a higher likelihood of lost sales occurring if the service level was decreased. (It should be noted, that it is very hard to calculate the effect that this service measure had on the safety stock as this is not the only ordering system being used. That is to say there was a interconnected effect occurring on the safety stock levels required, between all the different ordering systems being used). However, there is an increase in the distribution

costs when using the hotline ordering system over the normal ordering systems. Therefore there was a need to strike a balance between the different types of ordering systems.

Ideally the Hotline system should have been used to react to the short term unpredicted increases in demand from public, whilst the ordinary delivery systems coped with the more predictable changes. This trade-off between the different types of ordering systems to achieve the best overall ordering system could be an area for further research.

Due to the great effect that this measure had on the customer's system, it is felt that a very tight criterion, such as the maximum number of days it took for an order to be delivered, should have been used.

B) Questionnaire results (see Fig D.18):

The questionnaire results indicated that there were no distinct different market segments. The K Mean cluster analysis results, (in Appendix F) did not appear to produce segments that were more beneficial than the ones suggested by the company.

C) Trade-off areas:

1) The number of vans being used.

2) The number of lorries being used.

3) The cost of differentiating between stock (the cost of the containers and the adverse effect on other service measures).

4) The number of staff at the RDC.

5) The number of warehouse staff being used.

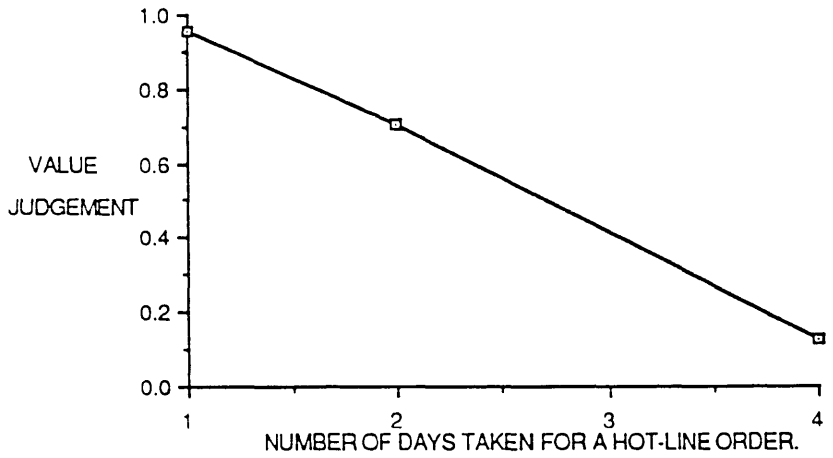
Against

1) The level of safety stock.

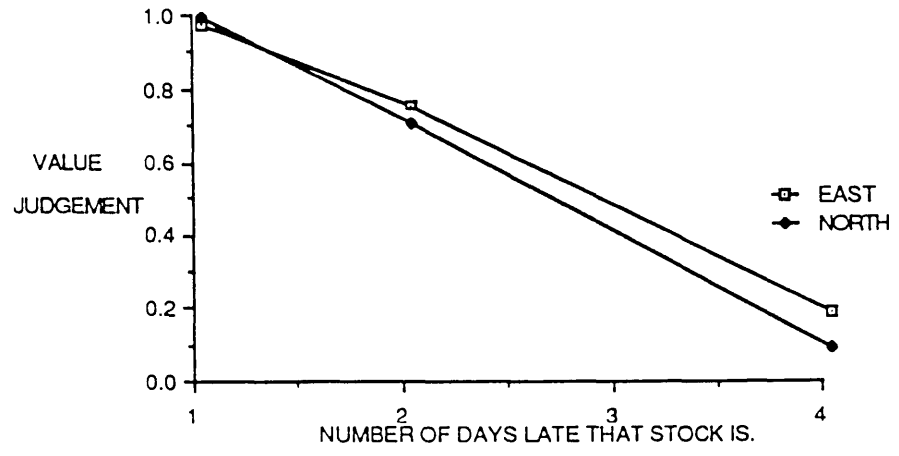
2) The level of lost sales.

Fig D.18: The graph showing the value judgements for service measure 9: "The number of working days it takes for a delivery to occur after a hotline order has been phoned in."

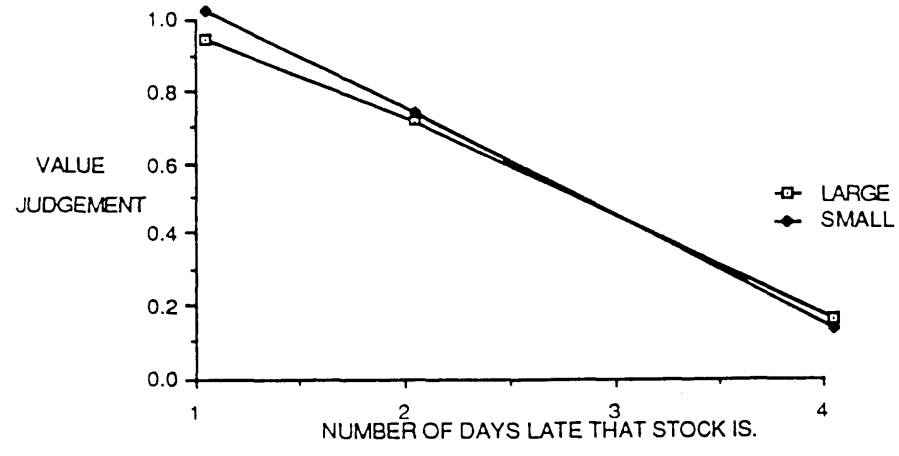
A) The overall mean judgement:



B) Regional differences:



C) Size differences:



D) Disturbances:

1) The variation in the RDC's workload.

2) The variation in the warehouse's workload.

3) The variation in the phoning in time.

E) Responses and response rates:

1) Number of vehicles being used. The response rate was dependent on whether the vehicles were hired (quick response); or owned by the company (slow response).

2) Number of staff at the warehouses and RDC. Using overtime had a quick response time whereas using full-time staff had a slow response rate.

3) Differentiating between the containers. It proved impossible to determine a figure for this response rate.

Service measure 10: The number of working days it takes for stock ordered by using a special request form to arrive at the store from the time the form left the store.

A) General discussion (see Fig D.11):

This ordering technique was yet another 'emergency' ordering system. However, this one was of a lower priority than the Hotline system. The invoices were produced along with the normal invoices. The time taken to get the stock to the store was the same as for service measures 6-8, as there was no differentiation between these orders and the normal orders. But this system allowed orders to be placed before the normal ordering time for stock in measures 6-8.

The service affected the service level to the general public and consequently the level of safety stock. Again, there was a problem of determining the interconnected effect of all the different ordering systems on the level of safety stock required.

Due to the non-linear questionnaire results (see Fig D.19) it is proposed that a suitable criterion for this service measure would have been the mean and variance combined. It should be noted that this ordering system had been abandoned by the participating company, by the end of the project due to other emergency ordering techniques being adopted making this system redundant.

B) Questionnaire results (see Fig D.19):

Large stores demanded a higher service than the small stores. The K Mean cluster analysis results, (Appendix F) did not appear to produce segments that were more beneficial than the ones suggested by the company.

C) Trade-off areas:

1) The level of staff at the warehouses and the RDCs.

2) Number of lorries and vans being used.

Against

1) The service level to the final customer.

2) The level of safety stock.

D) Disturbances:

1) The warehouse's workload.

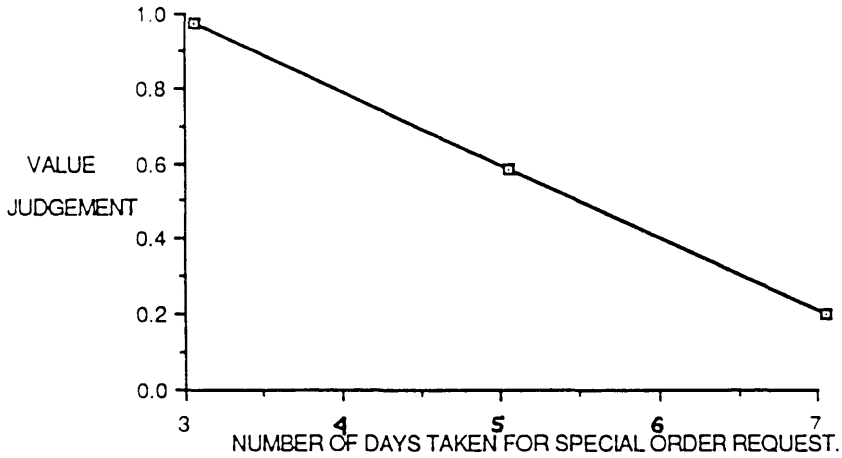
2) The workload on the RDC.

3) The amount of stock going to the RDC.

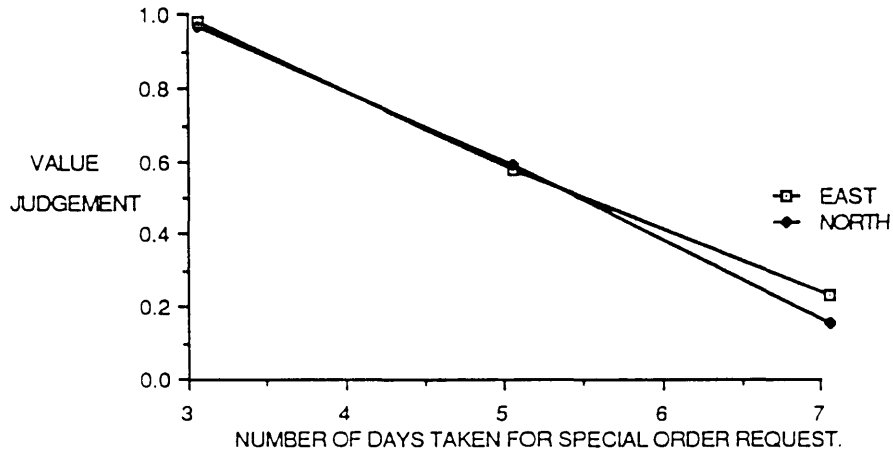
4) The amount of stock going to the stores.

Fig D.19: The graph showing the value judgements for service measure 10: "The number of working days it takes for a delivery to occur after a special order form has been sent in."

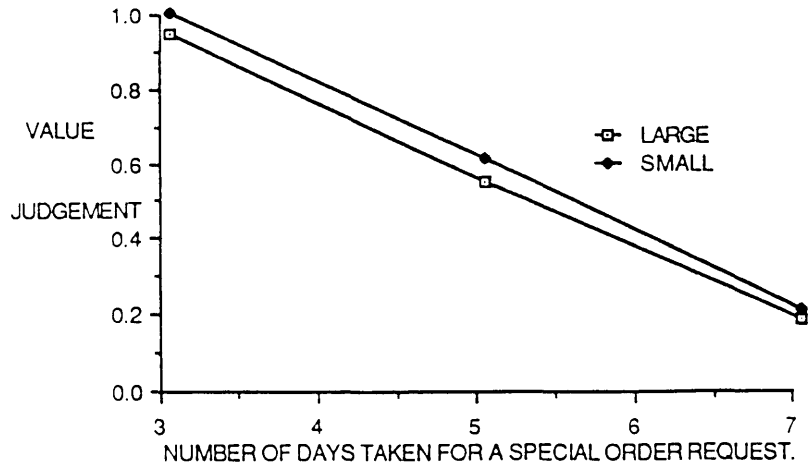
A) The overall mean judgement:



B) Regional differences:



C) Size differences:



E) Responses/ response rates:

1) The level of staff at the warehouse and RDC. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

2) The number of lorries and vans that were being used. Hiring more vehicles had a quick response time whereas purchasing vehicles had a long response time.

Service measure 11: The number of working days taken for an inter-branch transfer to be completed (from store to store).

A) General discussion (see Fig D.20):

There were two separate and quite distinct measures occurring here, these will be referred to as service measure 11a and service measure 11b. These two service measures were:

11a) The number of working days it took for an inter-branch transfer to be completed (from store to store), when the two stores were in the same RDC district.

11b) The number of working days it took for an inter-branch transfer to be completed (from store to store), when the two stores were in different RDC districts.

The first situation took less time, as stock was not routed through the central warehouses. The service level for measure 11a was determined by the following service factors:

1) The time it took for the stock to get from the donor store to the RDC.

2) The time it took for the stock to get through the RDC.

3) The time it took for stock to get from the RDC to the recipient store.

Service level for measure 11b was determined by the following service factors:

1) The time it took for the stock to get from the donor store to the RDC.

2) The time it took for the stock to get through the donor store's RDC.

3) The time it took for the stock to get from the donor store's RDC to the central

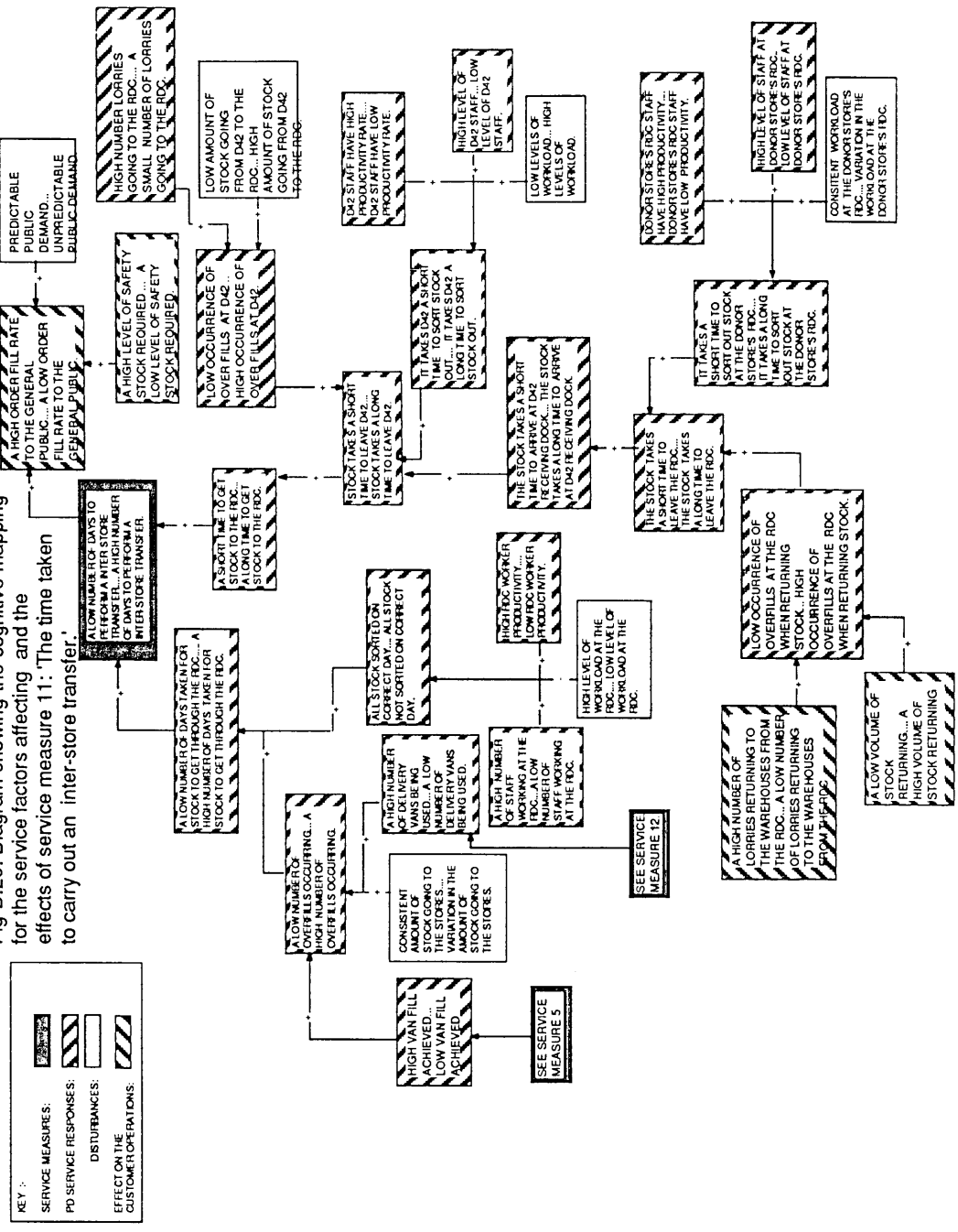


Fig D.20: Diagram showing the cognitive mapping for the service factors affecting and the effects of service measure 11: 'The time taken to carry out an inter-store transfer.'

warehouses (D42).

4) The time it took for the stock to get through D42.

5) The time it took for the stock to get from D42 to the recipient store's RDC.

6) The time it took for the stock to get through the recipient store's RDC.

7) The time it took for the stock to get from the recipient store's RDC to the recipient store.

The time it took for the stock to get from the donor store to its RDC was not affected by PD, as generally there was more stock being sent to the store than was being returned. Consequently, there was little chance of an overfill occurring at the store.

The time to get through the RDC was dependent on how well the RDC could cope with any particular day's workload. This was affected by the variation in the workload and the level of staff being employed at the RDC.

The time to get from the RDC back to the central warehouses was affected by whether there was space available on returning lorries. Usually, this was not a problem, as the returning lorries were generally less than full.

The problems facing the D42 manager were similar to that facing the RDC managers with a trade-off existing between the variation in manageable workload and the level of staff.

The time to get from D42 to the recipient store's RDC was dependent on whether an overfill occurred, this was dependent on the stock levels that were going to the RDC and the number of lorries that were going.

The influences on the time to get through the recipient RDC was the same as the time to get through the donor store's RDC. The time to get from the recipient store's RDC to the store

was dependent on whether an overfill situation occurred at the RDC.

The effects of a decrease in the service to the store was the possibility of lost sales occurring or the need of more safety stock. Again this effect was complicated due to the interconnected effect of all the different service measures. The questionnaire results indicate that a tight criteria should have been used (the graph is not linear). Thus, it is proposed that the criteria that should have been used was the mean and variance values combined.

B) Questionnaire results (see Fig D.21):

The East demanded a slightly better service than the North did, but not enough to merit segmentation. There were no differences for the different size of stores. It should be noted that, the K Mean cluster analysis results (Appendix F) did not appear to produce more beneficial segments than the ones suggested by the company.

C) Trade-off areas:

1) The number of staff at the RDC/D42 (the wages bill).

2) The cost of the extra vans and lorries.

Against

1) The level of lost sales.

2) The level of safety stock.

D) Disturbances:

1) Amount of work on donor's RDC.

2) Amount of work on recipient RDC.

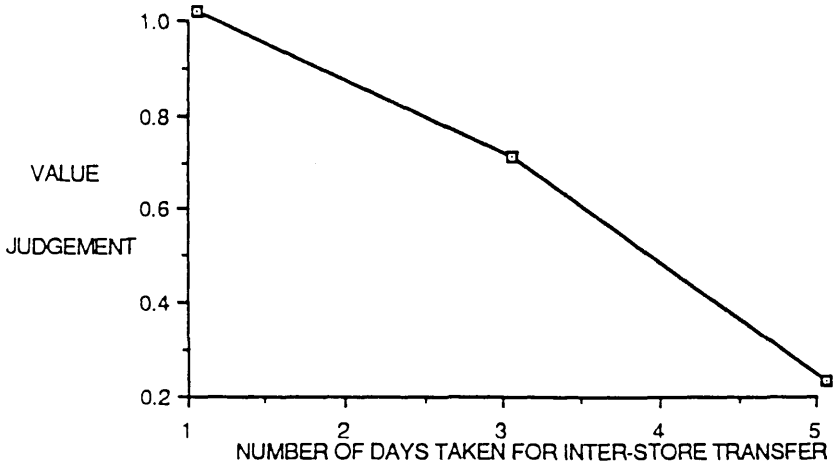
3) Amount of work on D42.

4) Amount of stock going to the RDC.

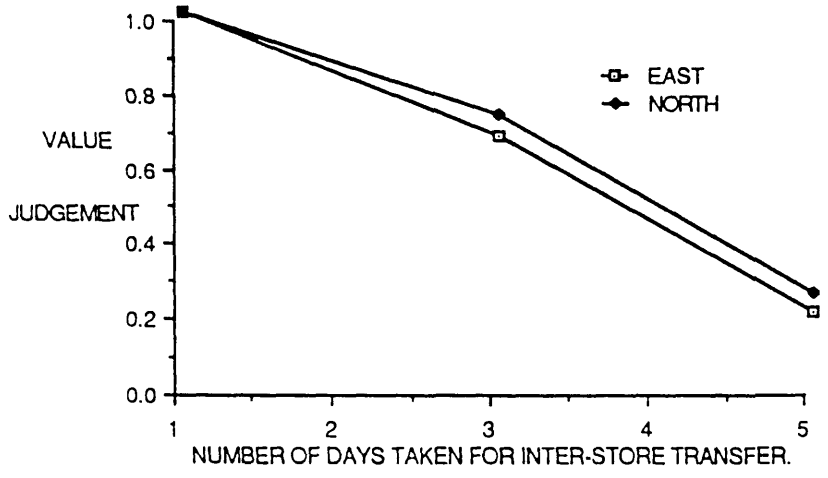
5) Amount of stock going to the store.

Fig D.21: The graph showing the value judgements for service measure 11: "The number of working days it takes for an inter-branch transfer to be completed."

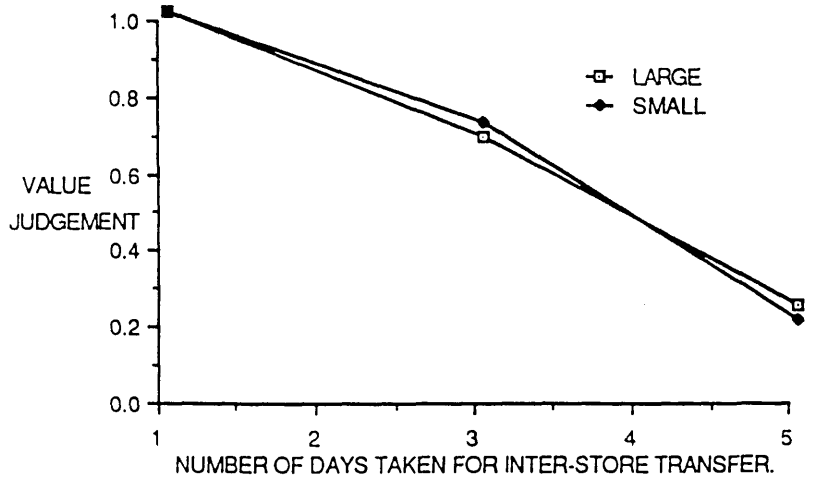
A) The overall mean judgement:



B) Regional differences:



C) Size differences:



E) Responses and response rates:

1) The number of RDC/D42 staff. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

2) The cost of the extra vans and lorries. Hiring more vehicles had a quick response time, whereas buying own vehicles had a long response time.

Service measure 12: The number of working days notice given of an extra van arriving.

A) General discussion(see Fig D.22):

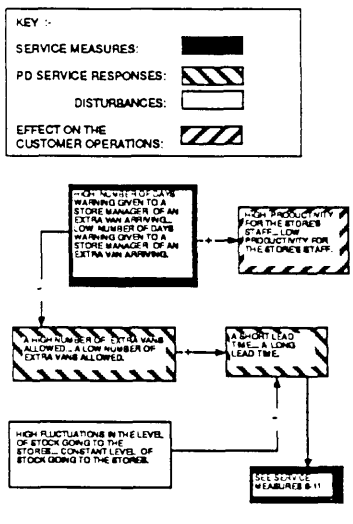
An extra van was sent to the store when an overfill occurred at the RDC. If the overfill situation was not dealt with the stock became late with the usual associated consequence, see service measures 6-11. The less warning that was required of an extra van arriving the greater the number of overfill situations that could be dealt with. If no warning was required then each days overfills could have been dealt with straight away (assuming that the costs of the extra van was justifiable). If only 1 days warning was required, then the overfill situation could be dealt with a day later and so on. Thus the amount of warning required dictated the response change time for the number of vans used at the RDC. Consequently, this determined the level of savings that could have been achieved by responding differently to the different disturbances (that was changes in the volume of stock going through the RDC).

Overfills occurred when there was a variation in the amount of stock (or containers) going to the store. Thus the greater this variation the greater were the advantages to PD of a shorter notice time.

The effects of the amount of warning given to the store manager were that the more

warning he received of a extra van, the more time he had to plan out his staffing policies. Due to the problems facing small store managers over their staffing it would have been expected that a higher service level was required by them. It is suggested that, due to the severe effects on the stores, the criterion that should have been used was the minimum number of days warning given. This hypothesis is supported by the questionnaire results (see Fig D.23).

Fig D.22: Diagram showing the cognitive mapping for the service factors which affect and the effect of service measure 12: 'The number of days warning that a store manager gets of a extra van arriving.'



B) Questionnaire results (see Fig D.23):

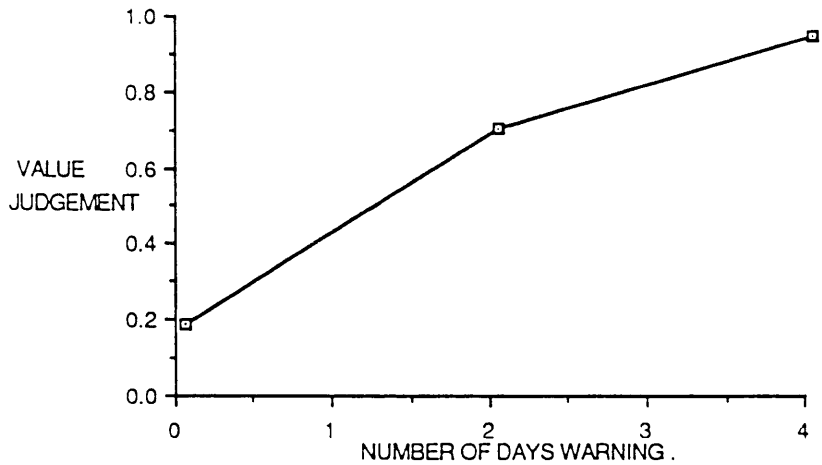
The results indicated that the small stores demanded, as was expected from the above discussion, a slightly higher service level than did the larger stores. There were no regional differences.The K Mean cluster analysis results (in Appendix F) did not appear to produce segments that were more beneficial than the ones suggested by the company.

C) Trade-off areas:

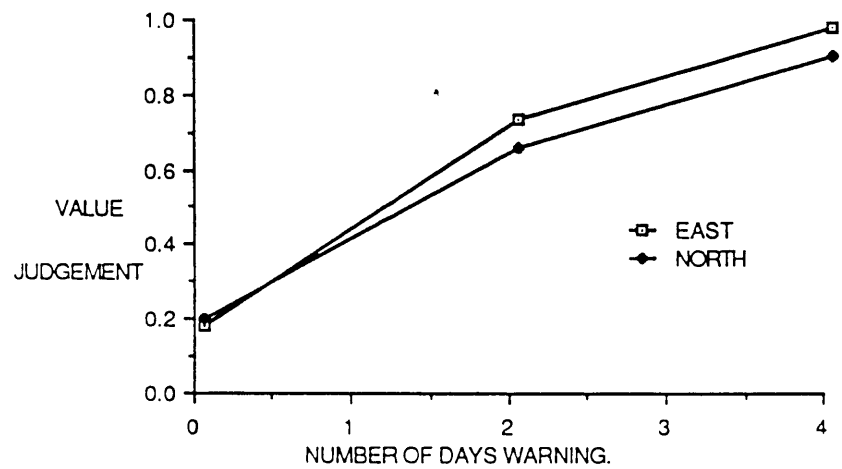
1) Decrease the variation, by increasing the lead times, (see measures 6-8 for the effect of this).

Fig D.23: The graph showing the value judgements for service measure 12: "The number of working days notice given, to the store manager, of a extra van arriving."

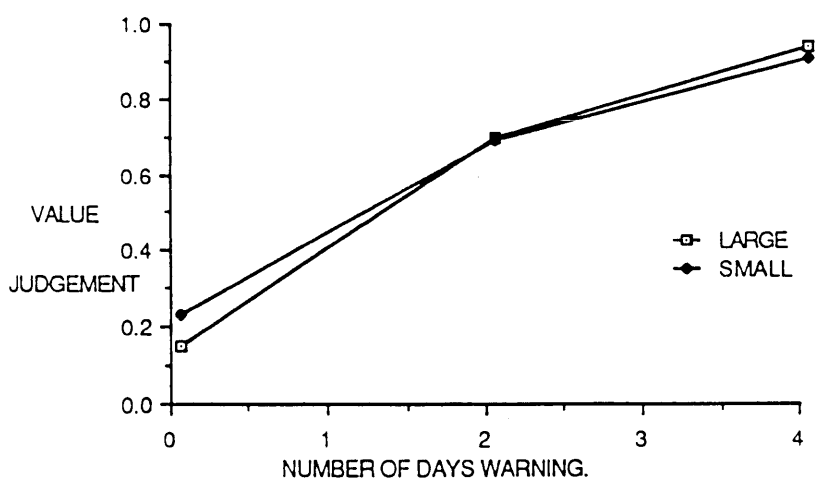
A) The mean value judgement:



B) Regional differences:



C) Size differences:



Against

1) The staffing policy problems at the store.

D) Disturbances:

1) Variation in the stock levels going to the stores.

E) Responses/ response times:

1) Decrease the variation by increasing lead times. It was impossible to actually determine a figure for this response time.

Service measure 13: The number of minutes spent filling out M and E forms.

A) General discussion (see Fig D.24):

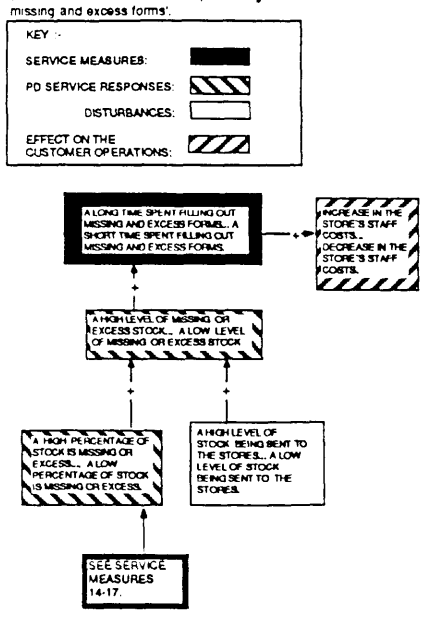
This service measure was dependent on:

1) The percentage level of missing stock.
2) The percentage level of excess stock.
3) The amount of stock being delivered.

Due to the amount of stock that different stores received it would have been expected that large stores would spend more time filling out M and E forms than small stores do.

A discussion on the percentage of missing and excess stock can be found for service measure 14-15. The consequences to the stores, of this service measure, were the wages of the staff doing the paperwork. As the questionnaire results, see Fig D.25, indicated that, the penalties/benefits increased linearly with the level of service, therefore it is proposed that the mean value could have been used as the monitoring criterion

Fig D.24: Diagram showing the cognitive mapping for the service factors affecting and the effects of service measure 13: 'The time spent filling out missing and excess forms'.



B) Questionnaire results (see Fig D.25):

The questionnaires showed, as was expected, that the smaller stores demanded a higher service level than the large stores. The K Mean cluster analysis results (Appendix F) did not appear to produce segments that were more beneficial than the ones suggested by the company.

C) Trade-off areas:

1) The number of pickers.

Against

1) The store's staff levels.

D) Disturbances:

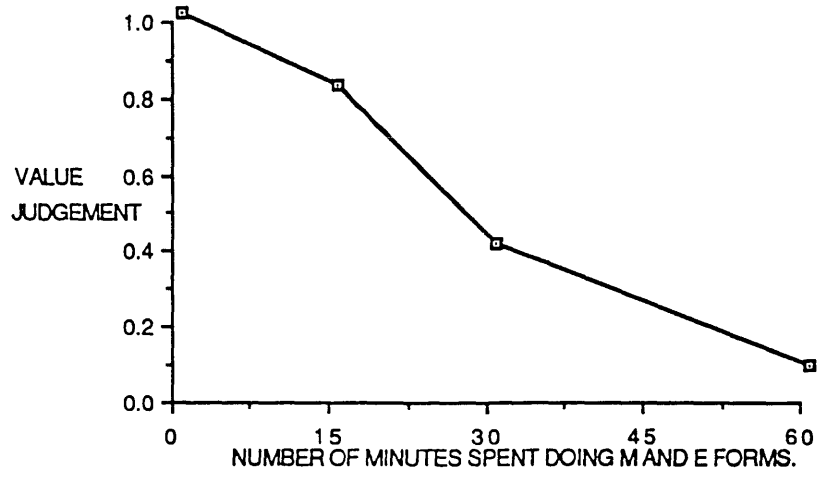
1) Amount of workload on the warehouses.

E) Responses:

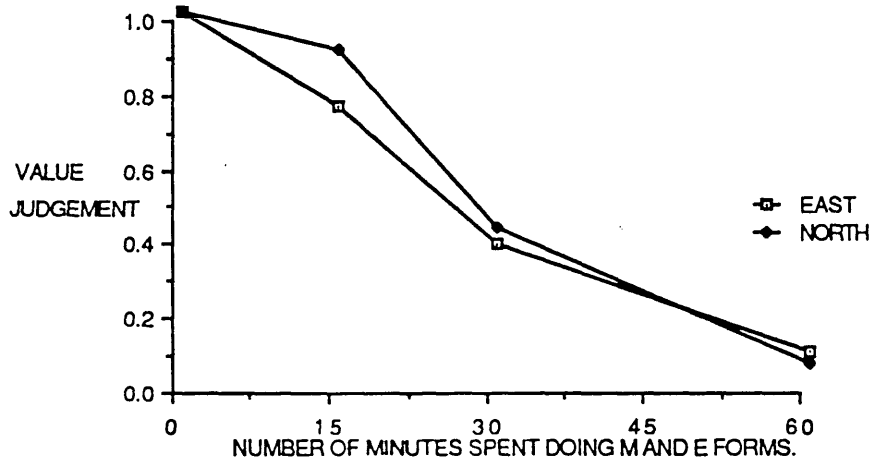
1) The number of pickers. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

Fig D.25: The graph showing the value judgements for service measure 13 : "The number of minutes spent filling out M and E forms."

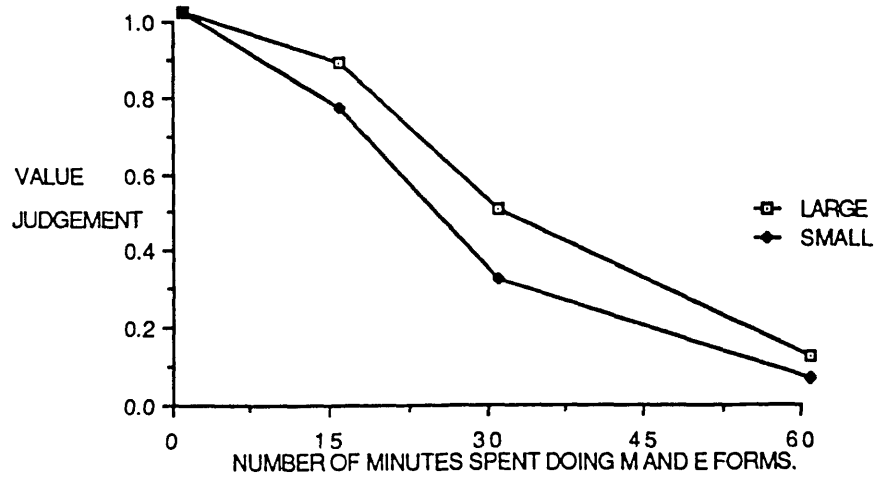
A) The mean value judgement:



B) Regional differences:



C) Size differences:



Service measure 14 and 15: The percentage volume of excess RDC/CSR stock.

A) General discussion (see Fig D.26):

As the causes and consequences of these two service measures were very similar, they will be discussed together here.

The level of excess stock was dependent on the level of two occurrences:

1) The wrong stock actually being picked, crossovers.

2) The wrong amount of stock being picked.

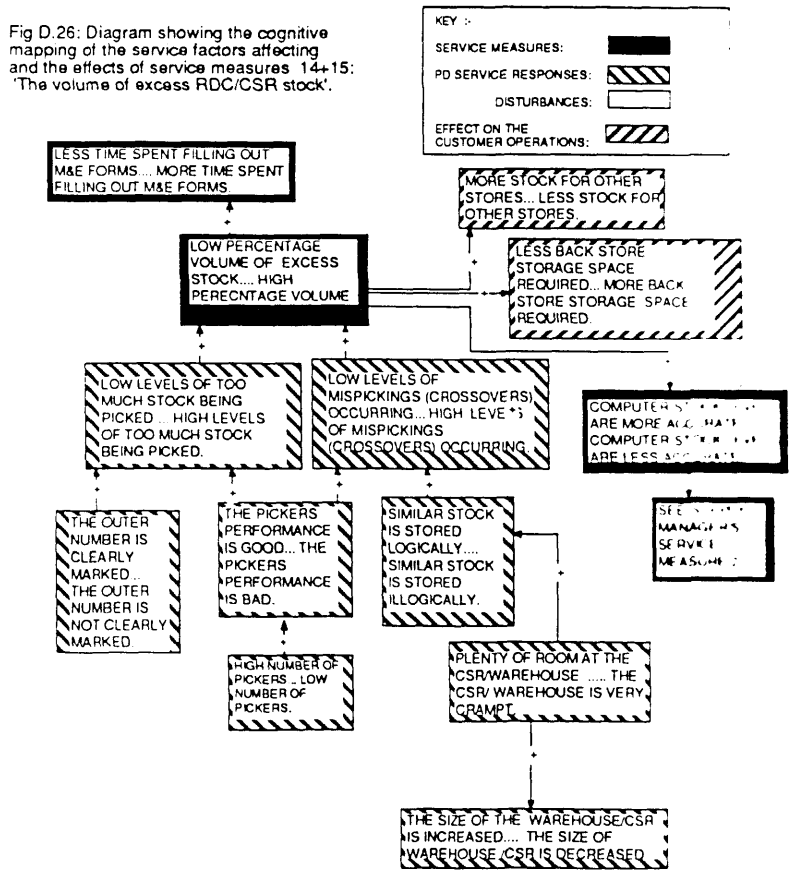


Fig D.26: Diagram showing the cognitive mapping of the service factors affecting and the effects of service measures 14+15: 'The volume of excess RDC/CSR stock'.

The level of crossovers occurring was influenced by the layout of the warehouse/CSR. That is to say that, if easily confused items were stored next to each other then it was more

likely that crossovers would occur. Unfortunately this generally increased the amount of warehouse space that was required.

The amount of excess stock was also dependent on the speed of picking. If the speed of picking had been increased, then it is felt that there would have been a resultant increase in the level of mis-pickings.

The consequences of a decrease in the service level were:

1) The store had stock that it did not require, this used up the store's storage space.

2) The computer stock levels were inaccurate (see Supply Manager's service measure 2, in appendix E, for the consequences of this).

The questionnaire results indicated that the penalties were approximately linearly correlated with the level of disservice. Consequently this suggests that the mean level of excess stock (a loose criteria) should have been used to monitor the service.

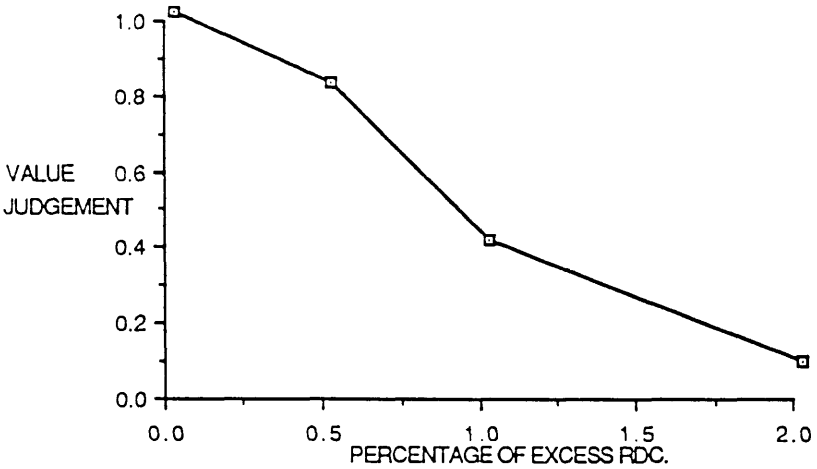
B) Questionnaire results (see Fig D.27 and Fig D.28):

For service measure 14, there were some regional differences, the East appeared to want a higher service than the North did. It is possible that this was due to there being less storage space in the East stores as a large number of them were in London.

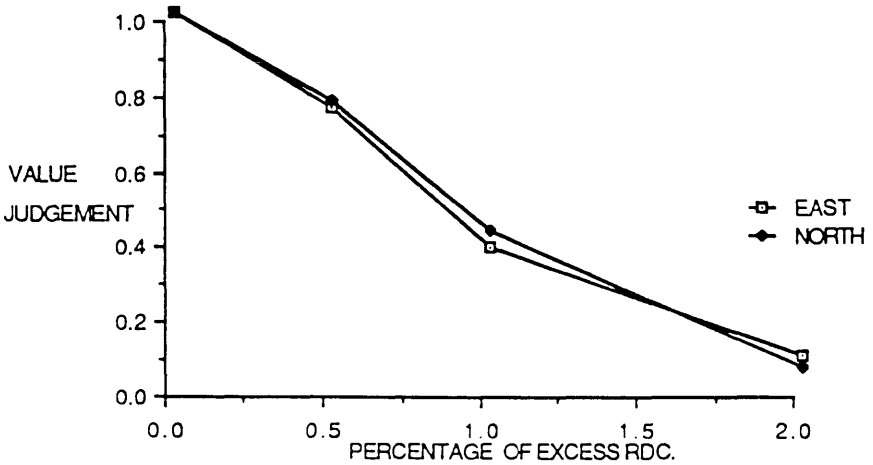
For service 15, there were both regional and size differences. The East wanted a higher service level (again probably due to the shortage of space) and also the small stores expected a higher service level than the large stores. For both of these service measures the K Mean cluster analysis results (Appendix F) produced segments which may have been more beneficial than the ones suggested by the company. Unfortunately, it was impossible, due to the lack of relevant information, to pursue this investigation any further.

Fig D.27:The graph showing the value judgements for service measure14: "The percentage volume of excess RDC stock."

A) The overall mean judgement:



B) Regional differences:



C) Size differences:

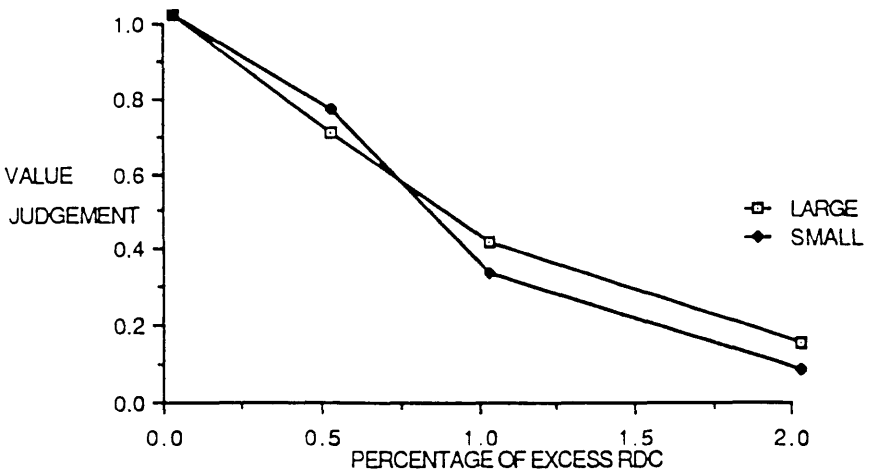
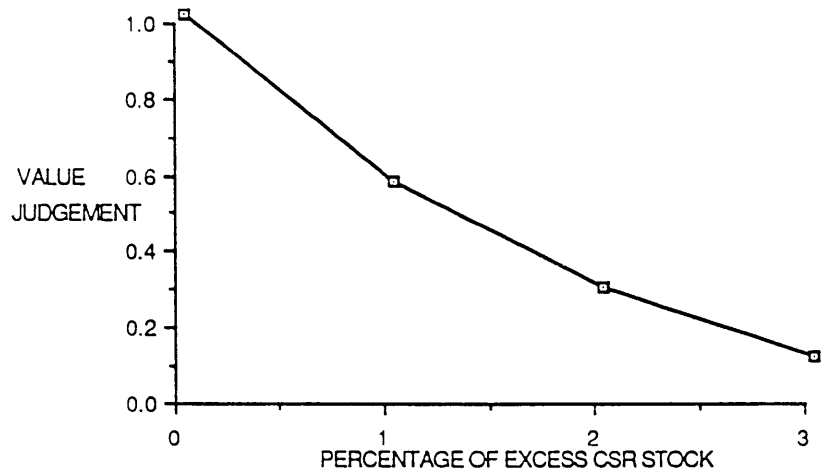
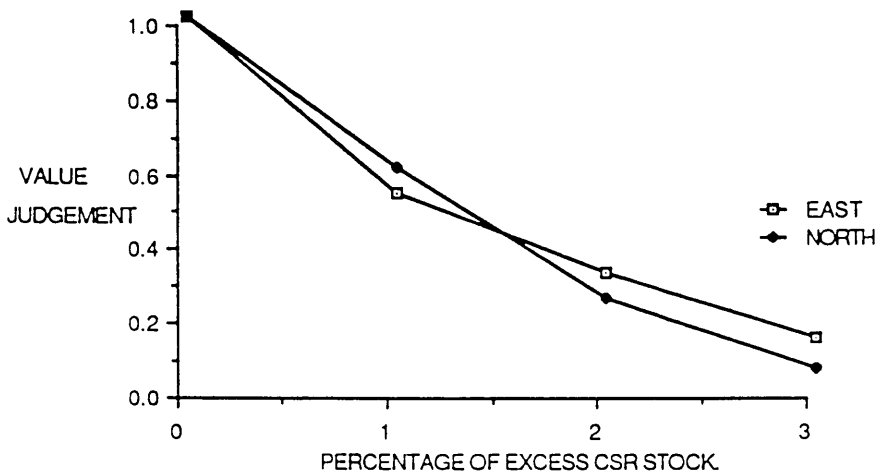


Fig D.28 : The graph showing the value judgements for service measure 15: "The percentage volume excess CSR stock."

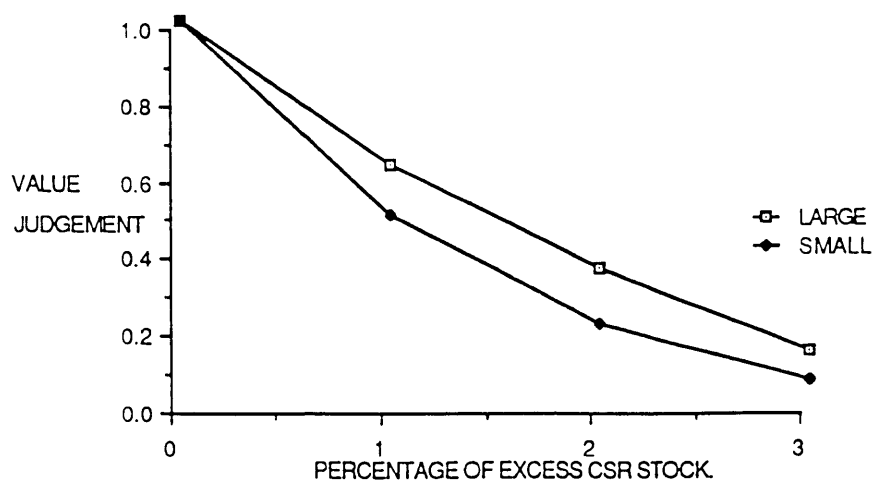
A) The overall mean judgement:



B) Regional differences:



C) Size differences:



C) Trade-off areas:

1) The warehouse/CSR space.

2) The warehouse/CSR pickers productivity (the number of staff).

Against

1) The space in the stores back store.

2) The accuracy of computer stock levels.

D) Disturbances:

1) The warehouse/CSR workload.

E) Responses and the response rates:

1) The warehouse/CSR space. Hiring extra warehouse space had a medium response time, whereas, building a warehouse had a very long response time.

2) The number of warehouse/CSR pickers. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

Service measure 16 and 17: The percentage of RDC/CSR stock that did not arrive or was not fit for use (i.e. the level of missings and breakages).

A) General Discussion (see Fig D.29 and Fig D.30):

The level of missing stock was dependent on level of occurrence of the following two situations:

1) The wrong type of stock being picked (crossovers).

2) The wrong amount of stock being picked.

It should be noted that, the factors affecting these two situations were very similar to those described for service measures 14 and 15.

Fig D.29: Diagram showing the cognitive mapping for the service factors affecting and the effects of service measure 16: 'The level of missing and breakages in the RDC stock.'

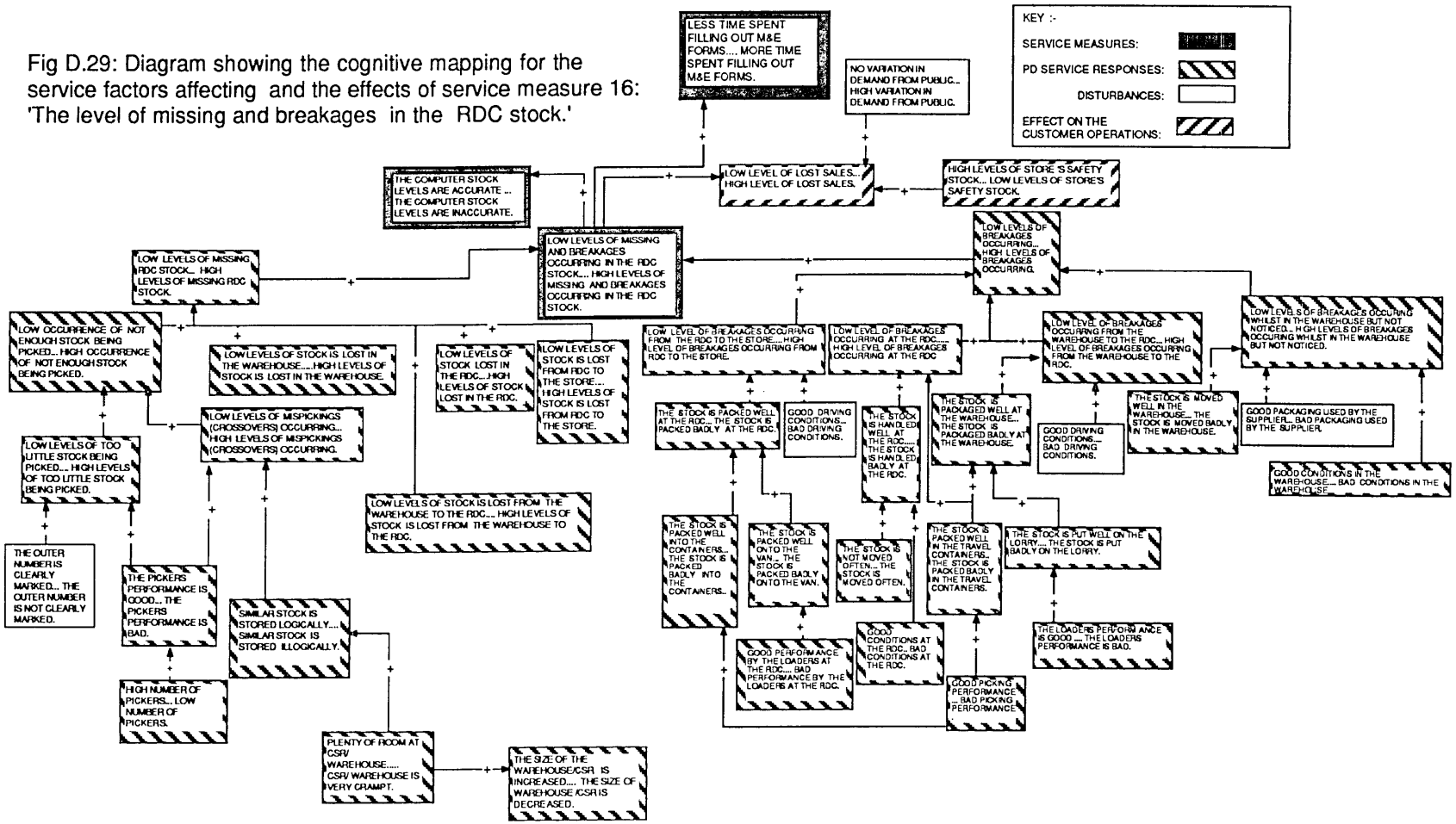
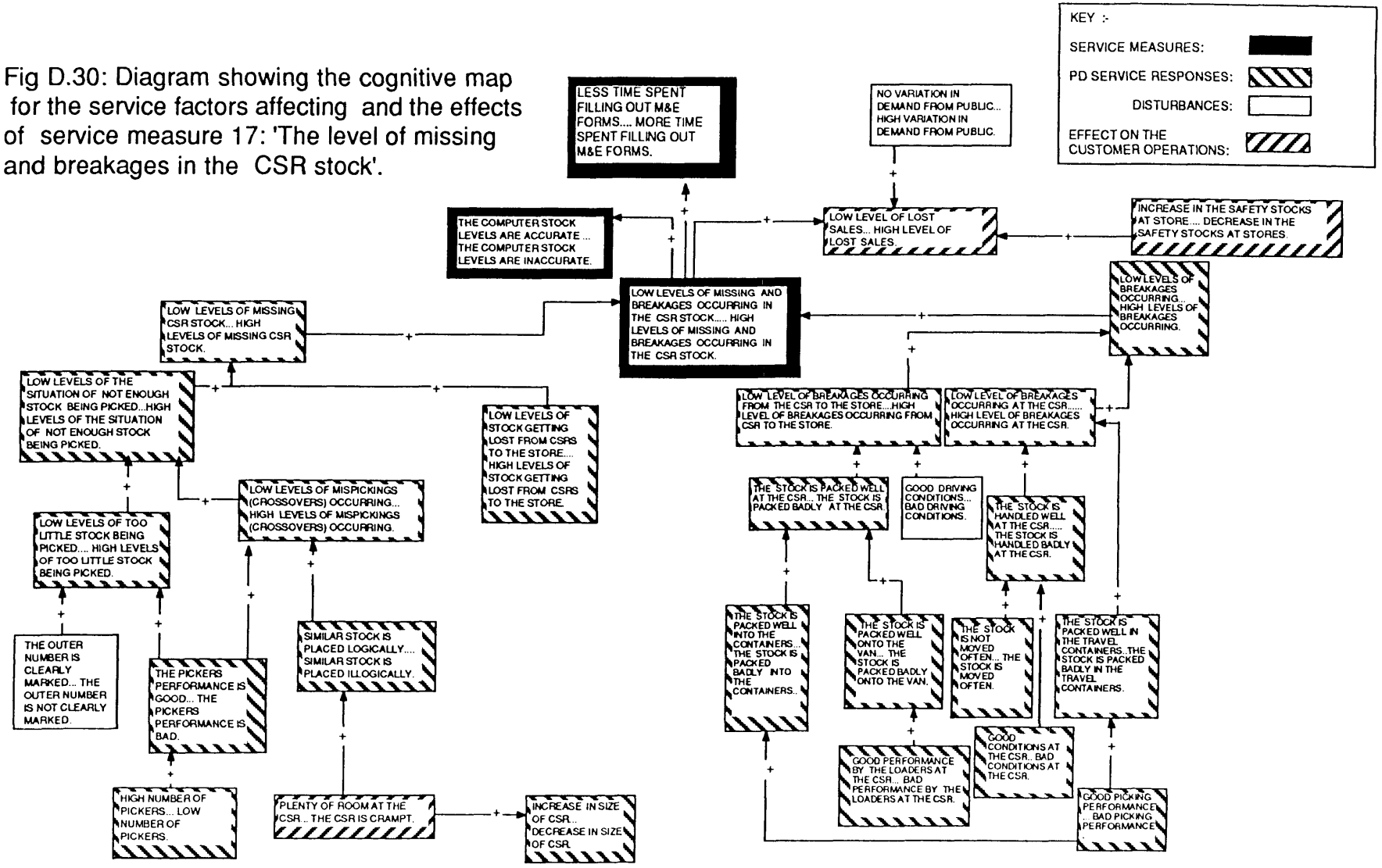


Fig D.30: Diagram showing the cognitive map for the service factors affecting and the effects of service measure 17: 'The level of missing and breakages in the CSR stock'.



The level of breakages that were occurring was caused by many factors:

1) How well the stock was actually packed in the containers and the amount of packaging and type of containers that were being used. For an increase in the service level there was usually an increase in the time taken to pack the containers and consequently an increase in the staff levels.

2) How well the containers were loaded on to the lorry or delivery van. It should be noted that this caused an increase in the time taken and consequently, the number of staff that were required.

3) How well the containers were handled in the warehouse and RDC and CSR.

The effect of a bad service level at the store was that there was a shortage in the stock levels being delivered. This meant that there was an increase in the level of lost sales. This effect was interconnected with the lead time service measures (see measures 6-11). Missing stock also caused the warehouse computer to underestimate the warehouse stock levels, possibly resulting in the company's buyers buying too much stock, (see Supply Manager's service measure 2, in appendix E)

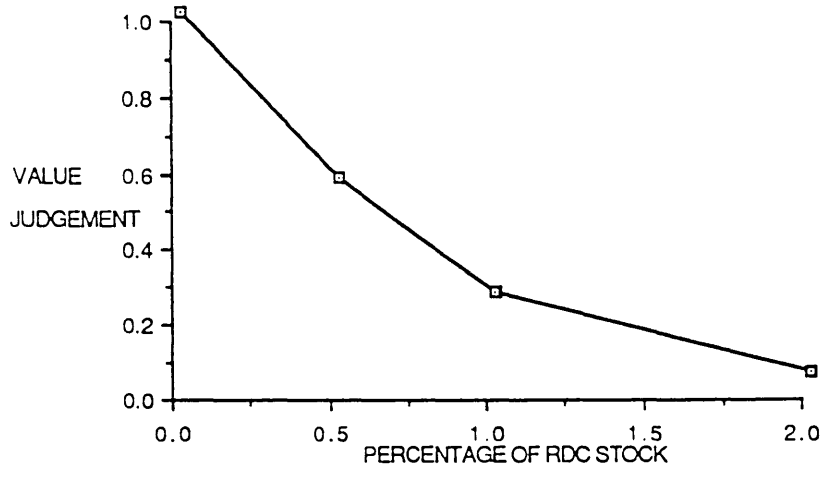
The questionnaire results indicated that the penalties to the stores were, within certain limits, linearly correlated with the level of disservice. Thus, it is felt that the mean service value would have been a good criterion to use.

B) Questionnaire results (see Fig D.31 and Fig D.32):

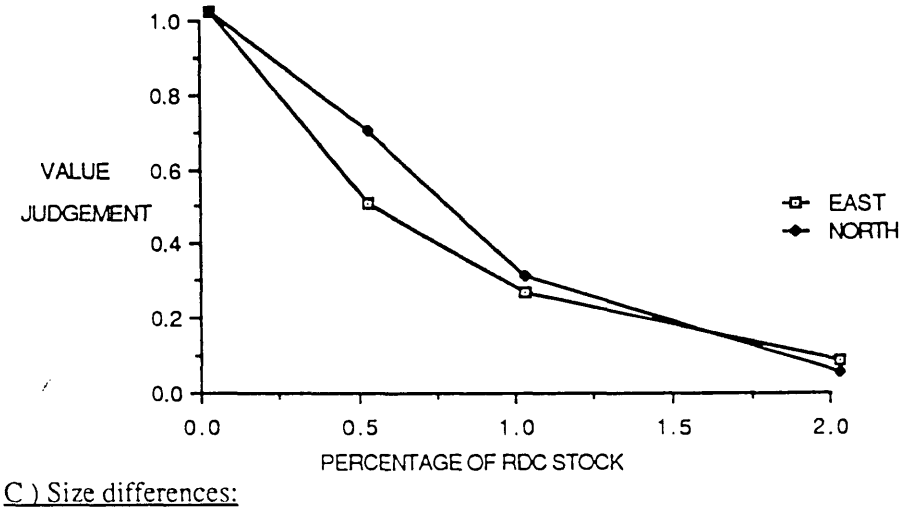
The results for service measure 16 and 17 were very similar. The East demanded a slightly higher service level and so did the smaller stores, but not enough to merit segmentation. It should be noted that the K Mean cluster analysis results (Appendix F) produced segments which may have been more beneficial than the ones suggested by the company. Unfortunately, due to the lack of relevant information it was impossible to pursue this any

Fig D.31 The graph showing the value judgements for service measure16: "The percentage of RDC stock missing or broken."

A) The overall mean judgement:



B) Regional differences:



C) Size differences:

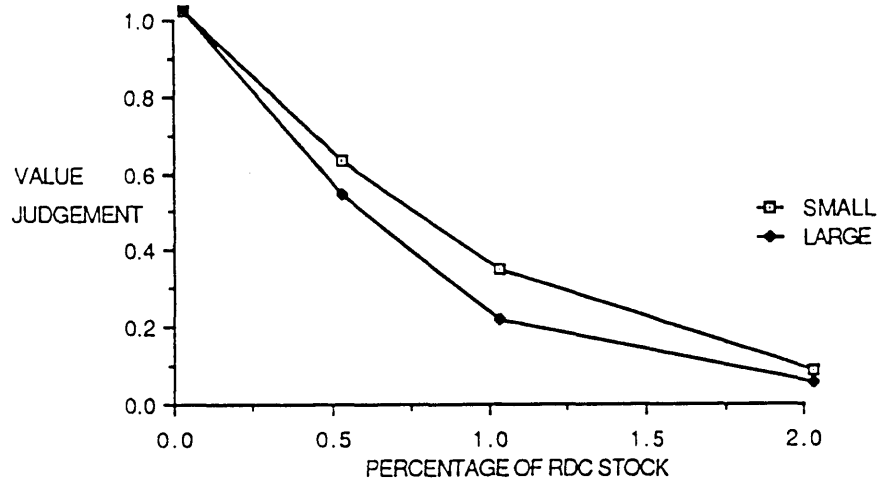
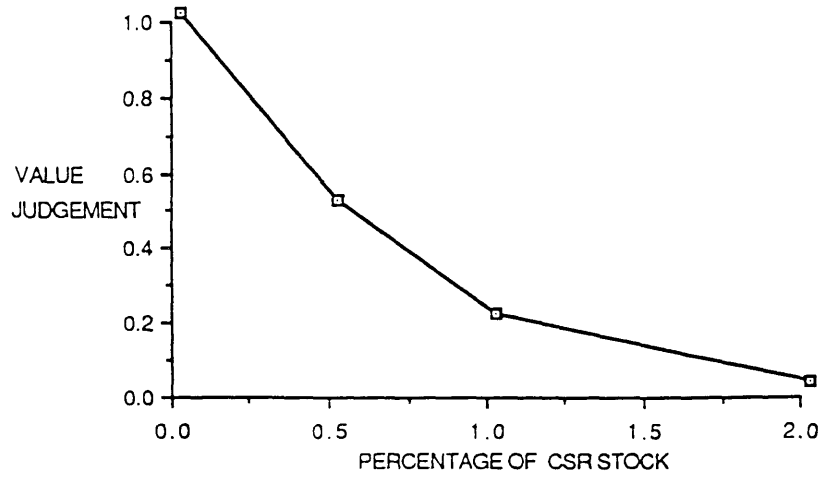
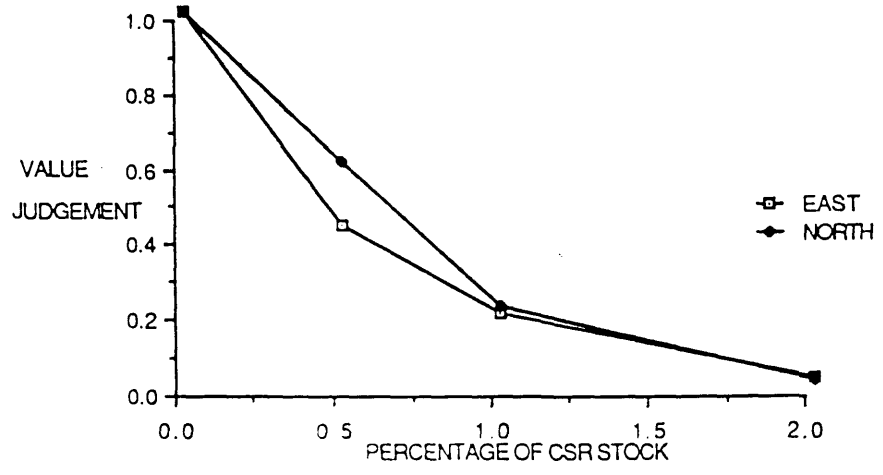


Fig D.32:The graph showing the value judgements for service measure17: "The percentage of CSR stock missing or broken."

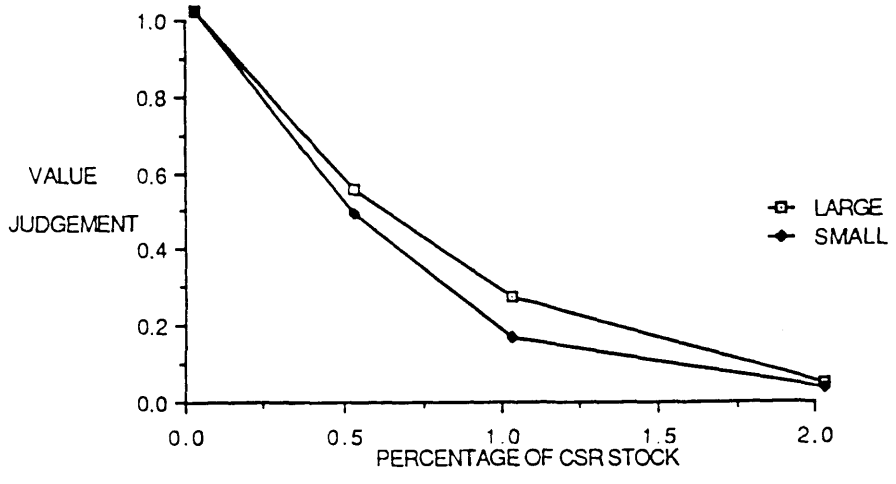
A) The overall mean judgement:



B) Regional differences:



C) Size differences:



further.

C) Trade-off areas:

1) The amount of warehouse space.

2) The number of warehouse pickers.

Against

1) The accuracy of the computer stock levels.

2) The level of lost sales.

3) The level of breakages.

D) Disturbances:

1) The warehouse workload.

E) Responses and response rates:

1) The amount of warehouse space. Hiring extra warehouse space had a medium response time, whereas, building a warehouse had a very long response time.

2) The number of warehouse pickers. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

Service measure 18: The percentage of CSR stock mispriced.

A) General discussion (see Fig D.33):

The level of CSR stock mispriced was felt to be affected by the CSR's picking rate. It was also felt to be affected by the relative positioning of the different priced stock in the CSR.

The repercussions on the store, of a low service level, were an increase in time spent repricing the stock.

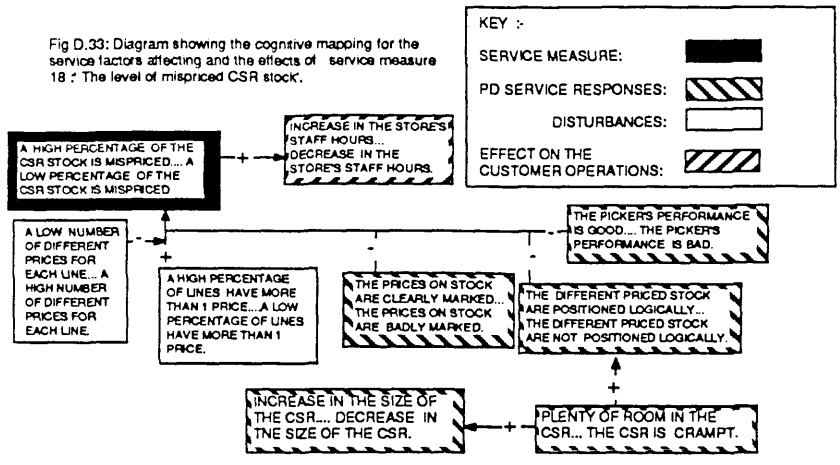


Fig D.33: Diagram showing the cognitive mapping for the service factors affecting and the effects of service measure 18 : The level of mispriced CSR stock'.

The questionnaire results indicated that the penalties, within certain limits, were linearly correlated with the level of disservice. Thus it is considered that the mean service level would have been a good service criteria to use.

B) Questionnaire results (see Fig D.34):

There were no regional or size differences. The K Mean cluster analysis results, (Appendix F) did not appear to produce segments that were more beneficial than the ones suggested by the company.

C) Trade-off areas:

1) The number of CSR staff.

Against

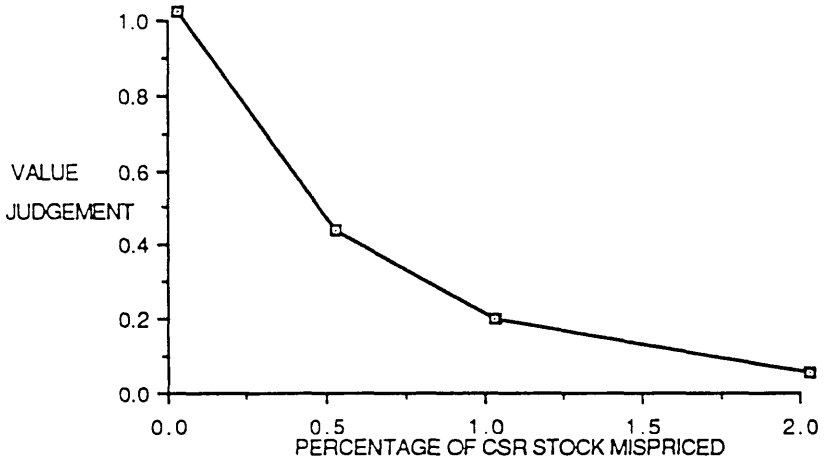
1) The time that was wasted at the store repricing stock (the number of store staff).

D) Disturbances:

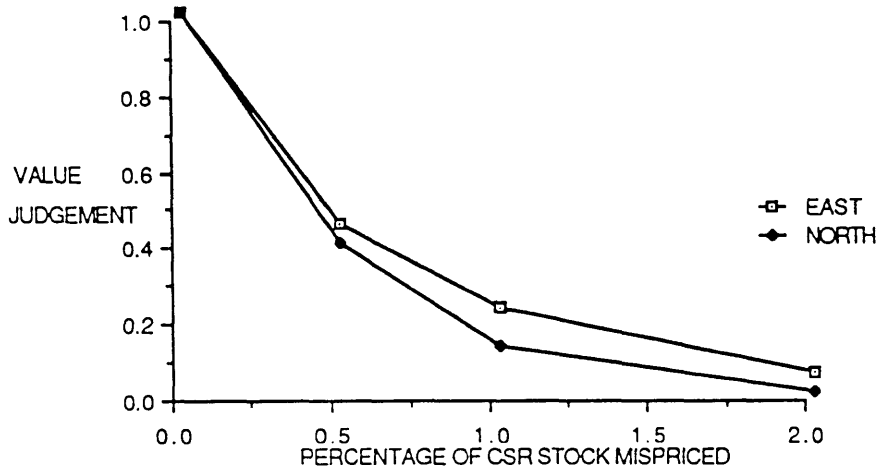
1) Amount of work to be done.

Fig D.34: The graph showing the value judgements for service measure18: "The level of mis-pricing in CSR stock."

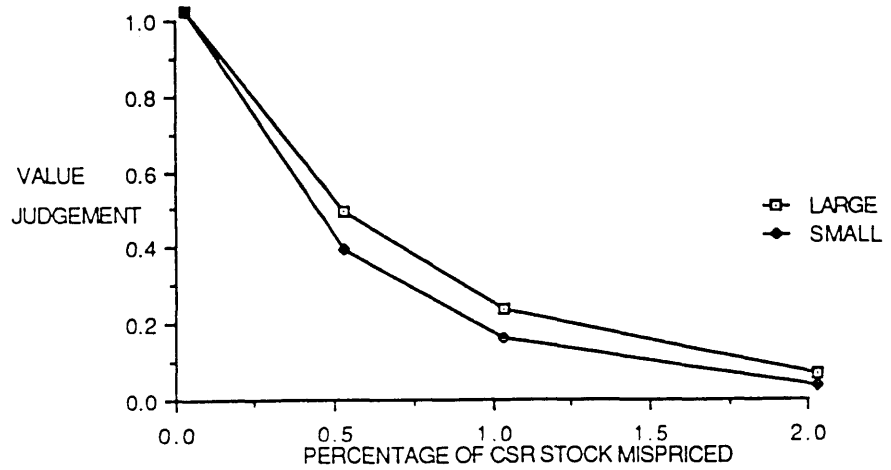
A) The overall mean judgement:



B) Regional differences:



C) Size differences:



E) Responses and response rate:

1) The number of CSR staff. Using overtime had a quick response time, whereas using full-time staff had a slow response time.

Service measure 19: The number of working days later that the invoices arrived after the associated stock arrived.

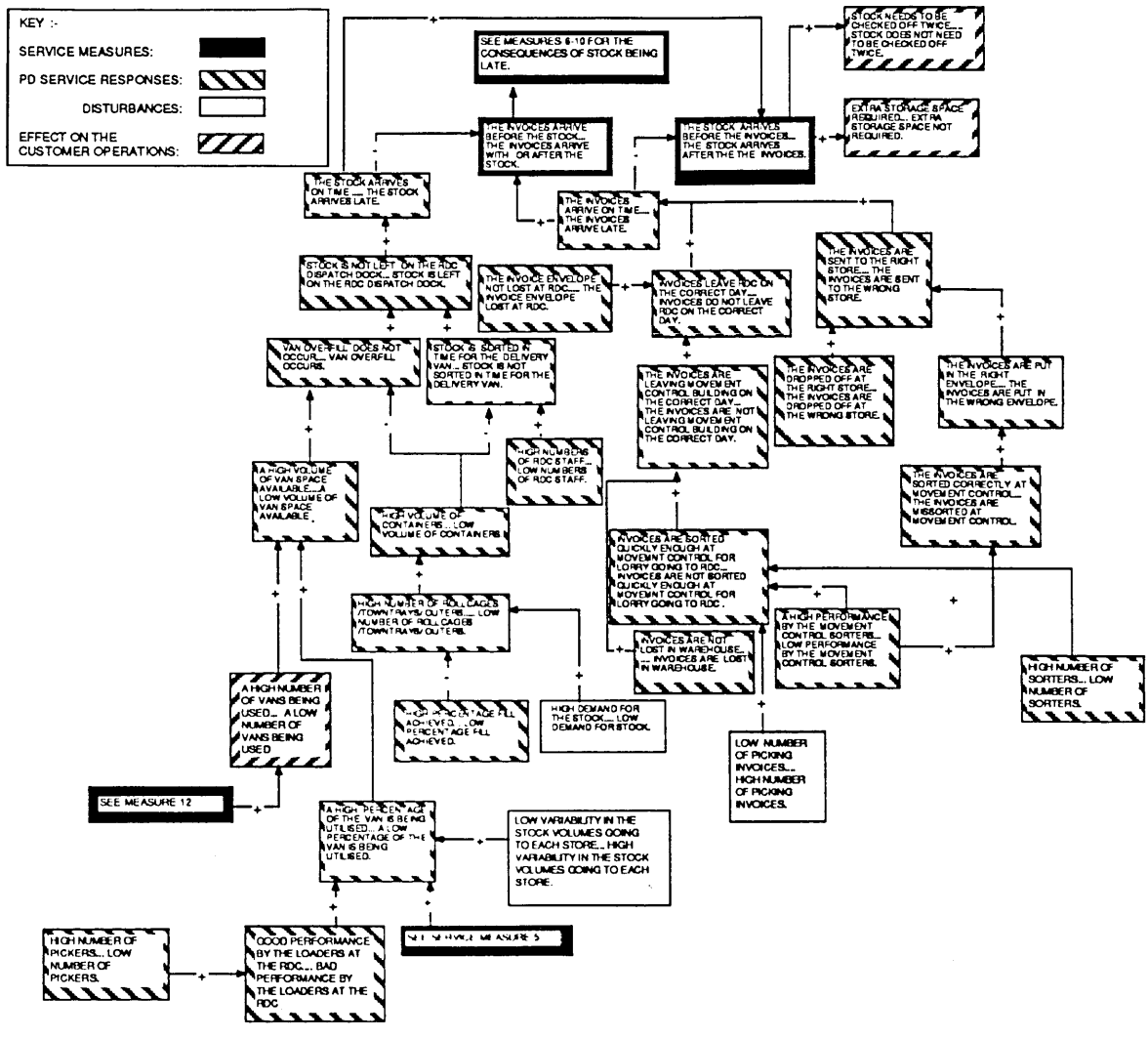
A) General discussion (see Fig D.35):

This service measure was concerned with the matching the arrival of invoices with the arrival of stock.

The arrival of stock has been discussed in service measures 6-8. However, it should be noted that, this service measure was only concerned with the time from which the stock was picked. The arrival time of the invoices was affected by the ability of the staff at the movement control building to sort the invoices out quickly enough for them to be loaded on the last lorry going to the RDC. This was dependent on the level of manpower and the level of workload at the movement control building.

The repercussions on the stores of an invoice arriving before the stock was quite minimal. However, if the stock arrived before the invoice, then either the stock had to be stored in the checking off area, or it had to be checked off twice (that is the stock information was written on a piece of paper and this piece of paper was then checked off against the invoice). Thus, stores generally preferred invoices to arrive before the stock rather than the other way round. As the questionnaire results are nonlinear it is proposed that the mean and variance should have been the criterion to monitor the service level.

Fig D.35: Diagram showing the cognitive mapping for the service factors affecting and the effect of service measure 19 :'The time difference between stock and invoices arriving.'



B) Questionnaire results (see Fig D.36):

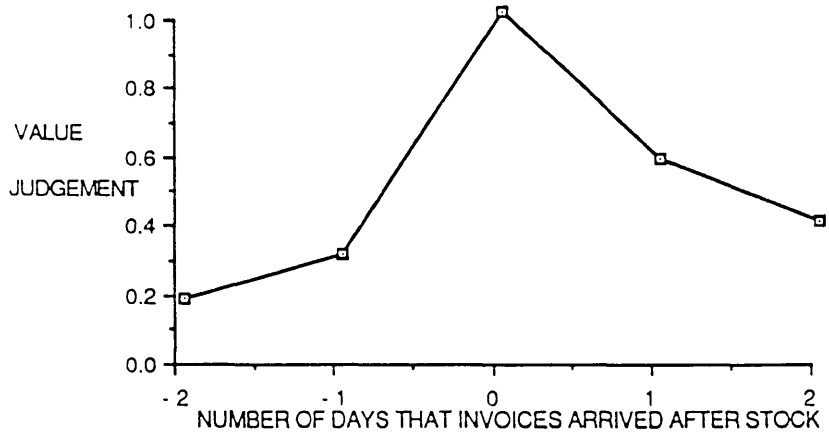
The questionnaire results supported the fact that, the store managers preferred the invoices to arrive before the stock. There were little regional or size differences. The K Mean cluster analysis results, shown in Appendix F, did not appear to produce segments that were more beneficial than the ones suggested by the company.

C) Trade-off areas:

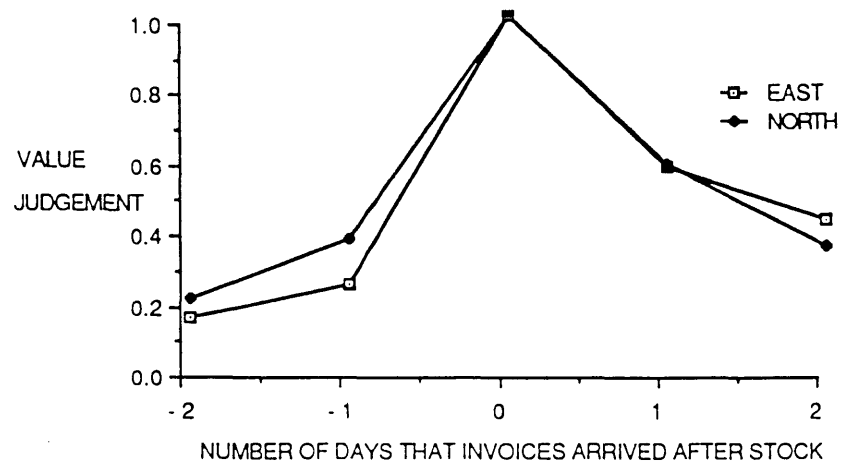
1) The number of staff that were being used at the movement control building, the

Fig D.36: The graph showing the value judgements for service measure 19: "The number of working days difference between stock and invoices arriving."

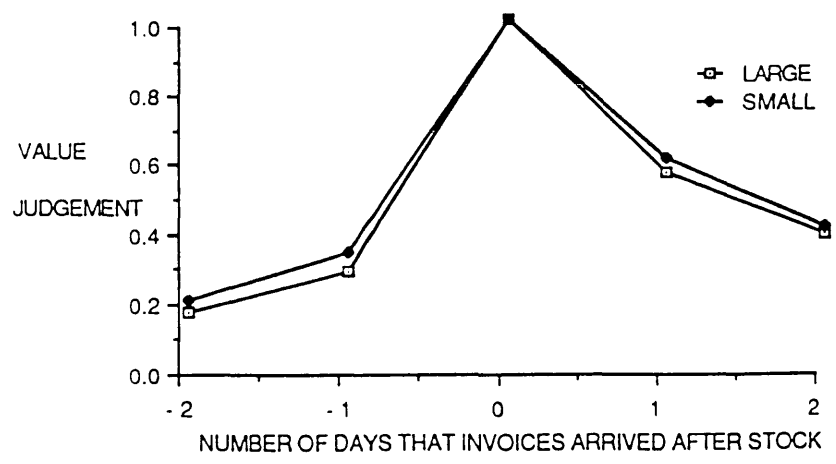
A) The overall mean judgement:



B) Regional differences:



C) Size differences:



RDCs and the warehouses.

2) The amount of lorries and vans being used.

Against

1) The amount of space in the store.

2) The amount of time wasted checking off twice (the number of store staff).

D) Disturbances:

1) The level of workload at the RDC.

2) The level of stock going to a RDC.

3) The level of stock going to the stores.

4) The number of invoices going to the stores.

E) Responses and the response rates:

1) The number of staff being used at movement control, the RDCs and the warehouses. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

2) The amount of lorries and vans being used. Hiring more vehicles had a quick response time whereas buying own vehicles had a long response time.

Service measure 20: The ASCOT service level:

A) General Discussion (see Fig D.37):

The ASCOT service level was an estimation of the service level, order fill-rate, given to the final customer. There were several factors which influenced this service level, such as the lateness of stock, the lead time, and the availability of stock in the warehouse for picking.

B) Questionnaire results (see Fig D.38):

The questionnaire results indicated that there were little geographical or regional preferences. It should be noted that, the K Mean cluster analysis results (shown in Appendix F) did not appear to produce segments that were more beneficial than the ones suggested by the company.

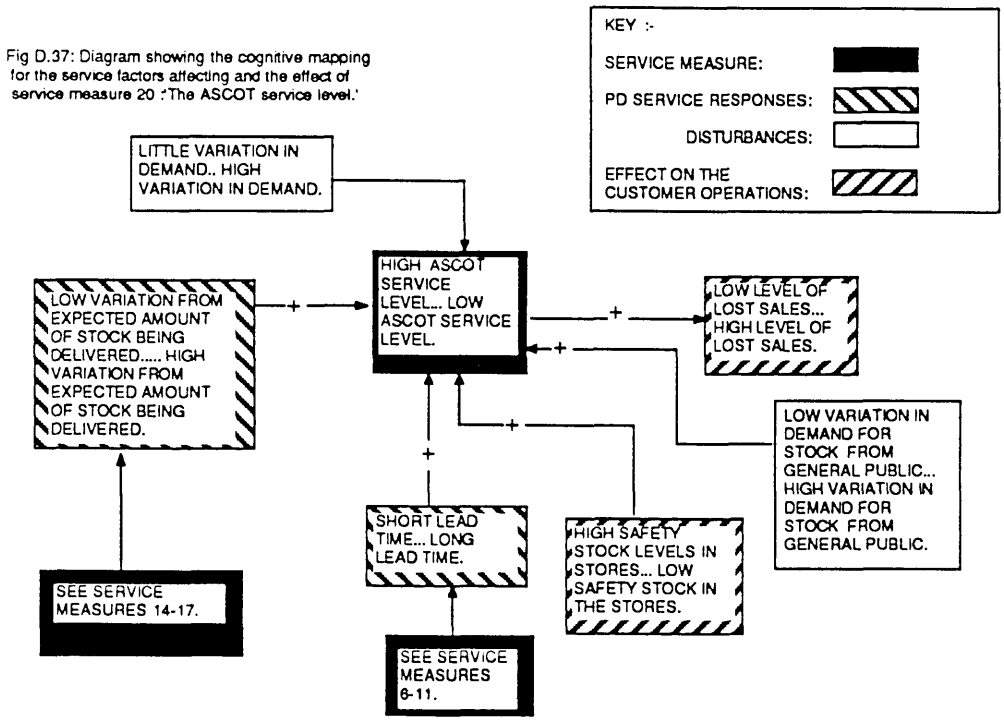


Fig D.37: Diagram showing the cognitive mapping for the service factors affecting and the effect of service measure 20 :'The ASCOT service level.'

C) Trade-off areas:

1) The number of staff in the warehouses.

2) The number of vans used.

3) The number of lorries used.

4) The amount of safety stock in the warehouses.

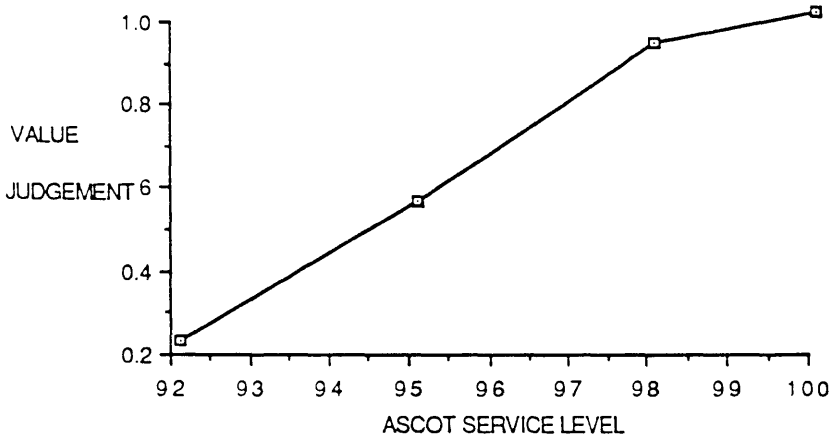
5) The amount of safety stock in the store.

Against

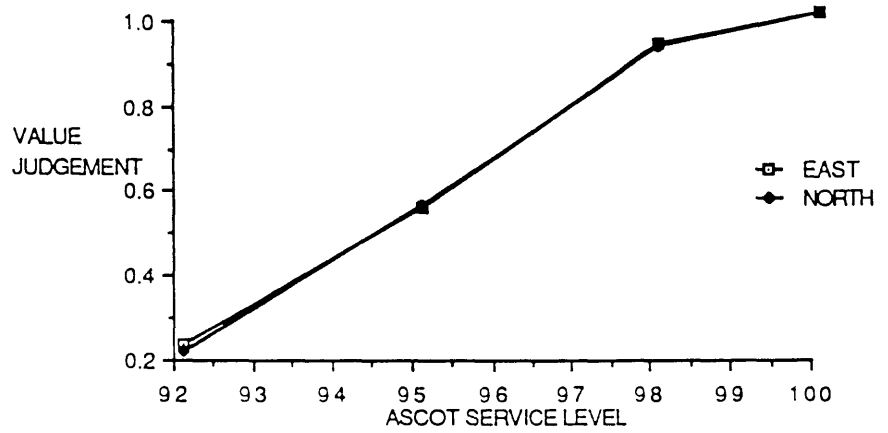
1) The level of lost sales.

Fig D.38: The graph showing the value judgements for service measure 20: "The ASCOT service level."

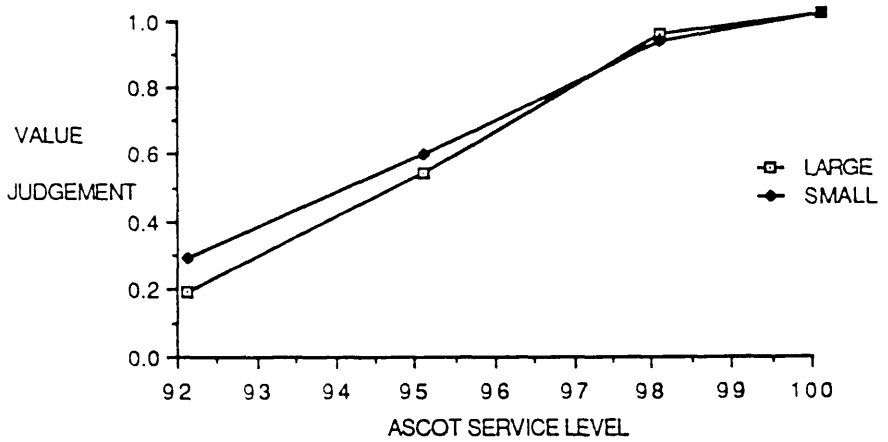
A) The overall mean judgement:



B) Regional differences:



C) Size differences:



D) Disturbances:

1) Variation in the amount of stock required by the general public.

E) Responses and response rates:

1) The number of staff in the warehouses. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

2) The number of vans/lorries. Hiring more vehicles had a quick response time whereas buying own vehicles had a long response time.

3) The amount of safety stock in warehouses. It was difficult to determine a figure for this response rate.

4) The amount of safety stock in the store. It was difficult to determine a figure for this response rate.

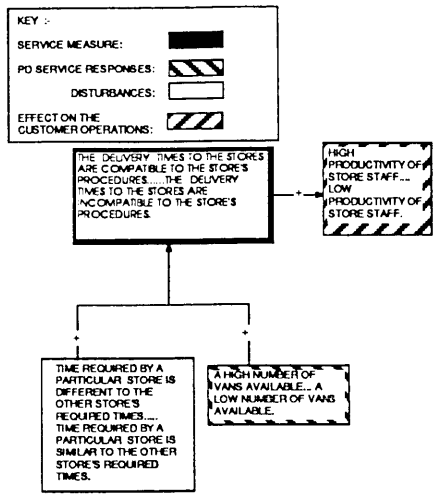
Service measure 21 The compatibility of the store's actual delivery time to the store's preferred delivery time.

A) General discussion (see Fig D.39):

The more freedom that the stores had, to choose their own delivery times, the more constraints that were being placed on any vehicle scheduling routines being used by the company. This meant that there would have been an increase in costs (reduction in the van fill or an increase in the mileage).

The benefits to a store manager of being able to dictate the delivery times were that staff were better utilised. It should be noted that, it proved impossible to actually determine what criteria should have been used.

Fig D.39: A diagram showing the cognitive mapping for the service factors affecting and the effect of service measure 21: 'The compatibility of delivery times to the stores procedures'.



B) Questionnaire results:

As only a value judgement was given on how good the present delivery time was, it proved hard to draw many conclusions from the questionnaire results for this measure.

C) Trade-off areas:

1) The van utilization/ the number of vans.

Against

1) The productivity of the stores staff.

D) Disturbances:

1) Store's required delivery times.

E) Response and response rate:

1) The van utilization/ the number of vans. Hiring more vehicles had a quick response time, whereas buying own vehicles had a slow response time.

APPENDIX E
DISCUSSION ON THE SUPPLY MANAGER'S SERVICE MEASURES.

This appendix includes the information that was generated by using the HASs in chapter 7 for the Supply Manager's service measures. The discussion for each service measure is divided into 4 parts:

1) General discussion on the service measure.

2) The trade-off areas for the service measure.

3) The disturbances affecting the service measure.

4) The service responses, and their response times, affecting the service measure.

Unfortunately, it was not possible to use questionnaire results to determine the market segmentation because of the low questionnaire return rate. However, where appropriate possible service segments, identified by other techniques, will be indicated.

Service measure 1 The amount of warehouse space that was actually available for a Supply Manager to use compared to the amount that is needed for the Supply Manager's stock.

A) General Discussion (see Fig E.1 and Fig E.2):

Each of the Company's Supply Managers regularly determined a budget stock flow proposal for their stock. These stock flow proposals were then used, by PD, to determine the volume of warehouse space that was required to cope with this expected demand. If either the stock flow proposals were inaccurate, or the translation of them into the amount of warehouse space required was inaccurate; then there was a possibility of some required stock not being accepted into the warehouses. This resulted in a decrease in the

Company's gross profits. To prevent this there was a need for a safety amount of warehouse space to meet these variances from the budget. However, this extra space had a associated cost, which was wasted if the space was not needed. This meant that a trade-off existed between the cost of having this extra warehouse space (more than that which was dictated by the stock flow proposal) and increase in the opportunities associated with being able to store more stock. Warehouse space was often hired to give PD extra flexibility. This meant the company had a quicker response time to meet the variations from the stock flow proposals and also helped in meeting the seasonal variations in the amount of warehouse space required. It is proposed that the mean and variance should have been used as the monitoring criteria as the service benefit curve is not linear (see Fig E.2).

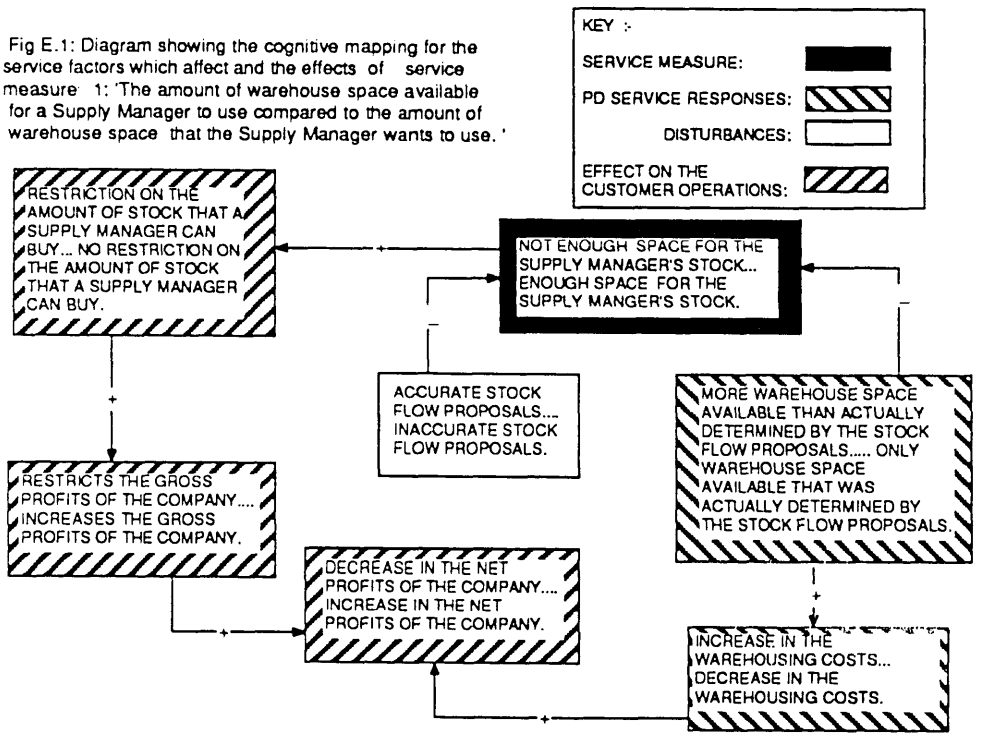


Fig E.1: Diagram showing the cognitive mapping for the service factors which affect and the effects of service measure 1: 'The amount of warehouse space available for a Supply Manager to use compared to the amount of warehouse space that the Supply Manager wants to use.'

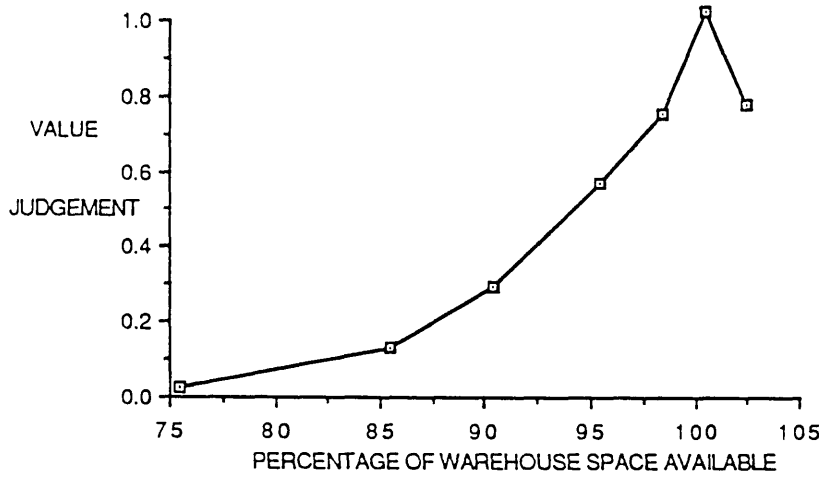
B) Trade-off areas:

1) The amount of warehouse space.

Against

1) The level of stock that can not be accepted by the warehouses.

Fig E.2: The graph showing the overall mean value judgement for service measure 1: "The amount of warehouse space actually available to the Supply Manager compared to the amount that is needed for the Supply Manager's stock."



C) Disturbances:

1) Unexpected stock flow not represented in the stock flow proposal.

2) The accuracy of translating the stock flow proposals.

D) Responses and response times:

1) The amount of warehouse space. Hiring extra warehouse space had a medium response time, whereas, building/buying a warehouse had a very long response time.

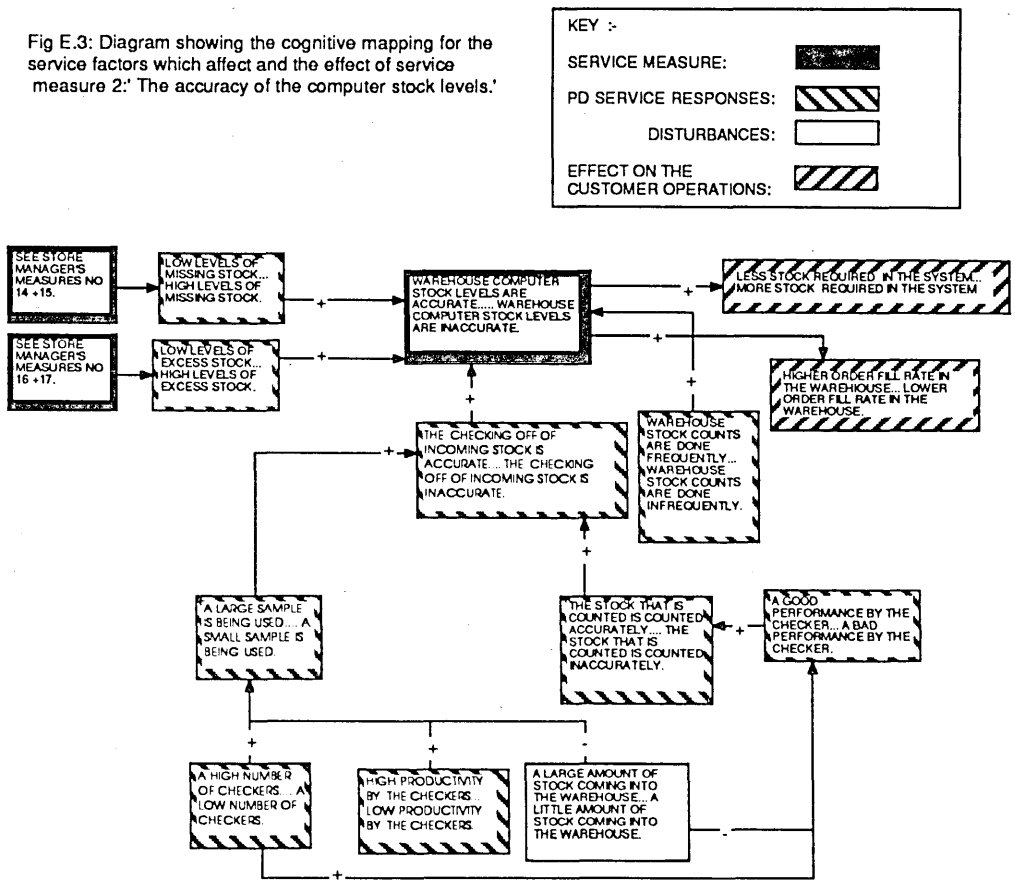
Service measure 2: The accuracy of the warehouse's computer stock levels.

A) General discussion (see Fig E.3 and Fig E.4):

If there was an overestimation in the computer stock levels, then there was a resultant

decrease in the level of stock ordered and hence a decrease in the order fill rate achieved in the warehouse. However, if there was an underestimation in the stock levels then there was an increase in the company's stock levels. (This was due to the computer ordering too much stock). Another effect of underestimating the stock levels, due to merchandise accounting system underestimating the level of stock that was available for picking,.was a reduction in the warehouse's order fill rate to the stores.

Fig E.3: Diagram showing the cognitive mapping for the service factors which affect and the effect of service measure 2:' The accuracy of the computer stock levels.'

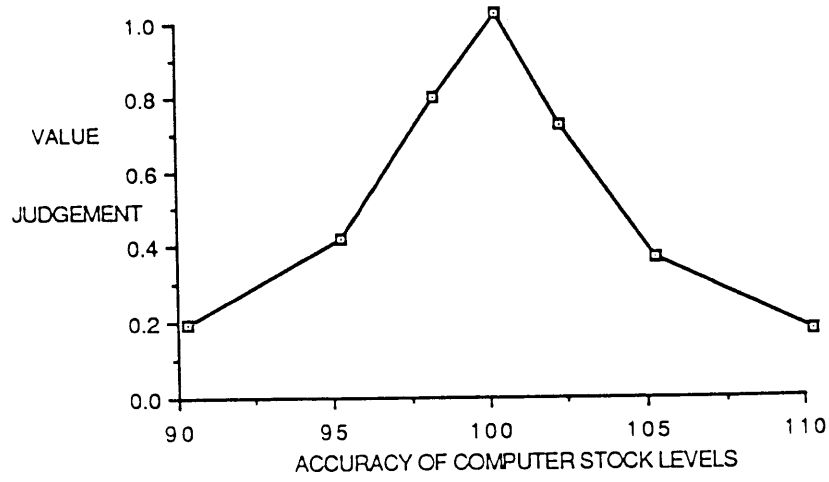


It should be noted that, the consequences of inaccurate computer stock levels were felt in 2 distinct ways:

1) The actual level of stock being ordered to bring the stock levels up to the correct level, was wrong.

2) The estimated stock demand, if calculated from these warehouse computer stock levels, was wrong.

Fig E.4: The graph showing the overall mean value judgement for service measure 2: "The accuracy of the warehouse's computer stock levels."



It was generally advantageous to the buyers if the stock levels were underestimated thus leading to having too much stock rather than not have enough. This bias was reflected in the questionnaire results where a higher value judgement was given to underestimating the stock levels (see Fig E.4).

There were many causes of these inaccuracies in the computer stock levels, below are indicated a few of these:

1) The level of stock entering the warehouse was recorded wrongly. The accuracy of this was dependent on the proportion of the stock actually counted and the accuracy with which this stock was counted. Both of these factors were dependent on the level of checking staff used and the level of workload.

2) The level of missings that occurred when picking stock. An increase in the missings lead to an overestimation in the stock levels. This was usually a short term problem, as the computer stock levels were adjusted back when the missings were

reported by the stores. However unless the stock ordering system took into consideration the level of missing stock that a particular store received, it could have overestimated the stock demand for that particular store.

3) The level of excess stock that was being picked in the warehouse. The consequence of excess stock was an overestimation of the warehouse's stock levels. It should be noted that, excess stock was less likely to be reported by a store manager than missing stock. Consequently this error was less likely to be adjusted for.

The errors in the warehouse's stock levels were reduced by regular counting of the actual stock levels, by the perpetual inventory department, and comparing this actual stock level against the theoretical computer stock levels. The more frequently these checks were done the more accurate the stock levels were. Consequently stock that was either more prone to these stock errors (determined by monitoring the errors) or were more crucial to have accurate stock figures should have been counted more frequently.

As the questionnaire graphs are not linear (see E.4) it is suggested that the mean and variance should have been used as the monitoring criteria.

B) Trade-off areas:

1) The level of checking off staff.

2) The level of picking staff.

3) The level of perpetual inventory counting staff.

Against

1) The level of stock outs.

2) The level of stock.

C)Disturbances:

1) The amount of stock flow.

2) The type of stock.

D) Responses and the response rate:

1) The level of warehouse staff. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

2) The level of perpetual inventory staff.

Service measure 3: The accuracy of the costing of storing stock in the warehouse.

A) General discussion (see Fig E.5 and Fig E.6):

The figure for the cost of storing stock in the warehouse was used to make the following two decisions:

1) Which delivery route the stock took.

2) Whether the company would stock a particular item or not. That is whether the stock was profitable.

If the same decision in the above two areas was still made, despite the costing inaccuracies then there was no effect on the company. Consequently, what mattered was the likelihood that a wrong decision would be made due to the cost inaccuracies. The greater were the inaccuracies the more likely that a wrong decision was being made. However, the likelihood that a wrong decision was being made, was also dependent on how clear cut the decision should have been. If the cost differences between alternative decisions were large it was less likely that the wrong decision was taken. Thus, the less likely that they were affected by the costs errors. However, the penalties associated with making a wrong

decision in this situation were greater.

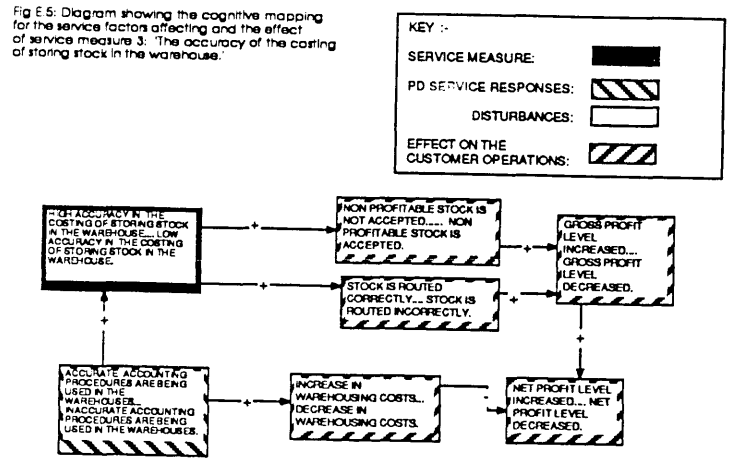
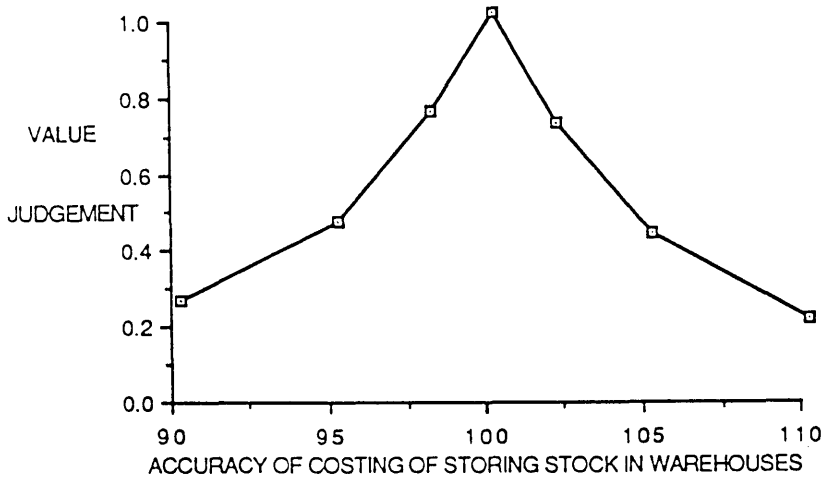


Fig E.6: The graph showing the overall mean value judgement for service measure 3 : "The accuracy of the costing of the storing of stock in the warehouse"



B) Trade-off areas:

1) The accuracy of the costing procedures used.

Against

1) The penalties of making a wrong decision.

C) Disturbances:

It proved impossible to determine what the disturbances are.

D) Responses/ response rate:

1) The accuracy of the costing procedures used. It proved impossible to determine a response rate here.

Service measure 4: The number of days it took for new merchandise stock to get to the store from the date that the Supply Manager requested that the stock should be delivered to the warehouse.

A) General Discussion (see Fig E.7 and Fig E.8):

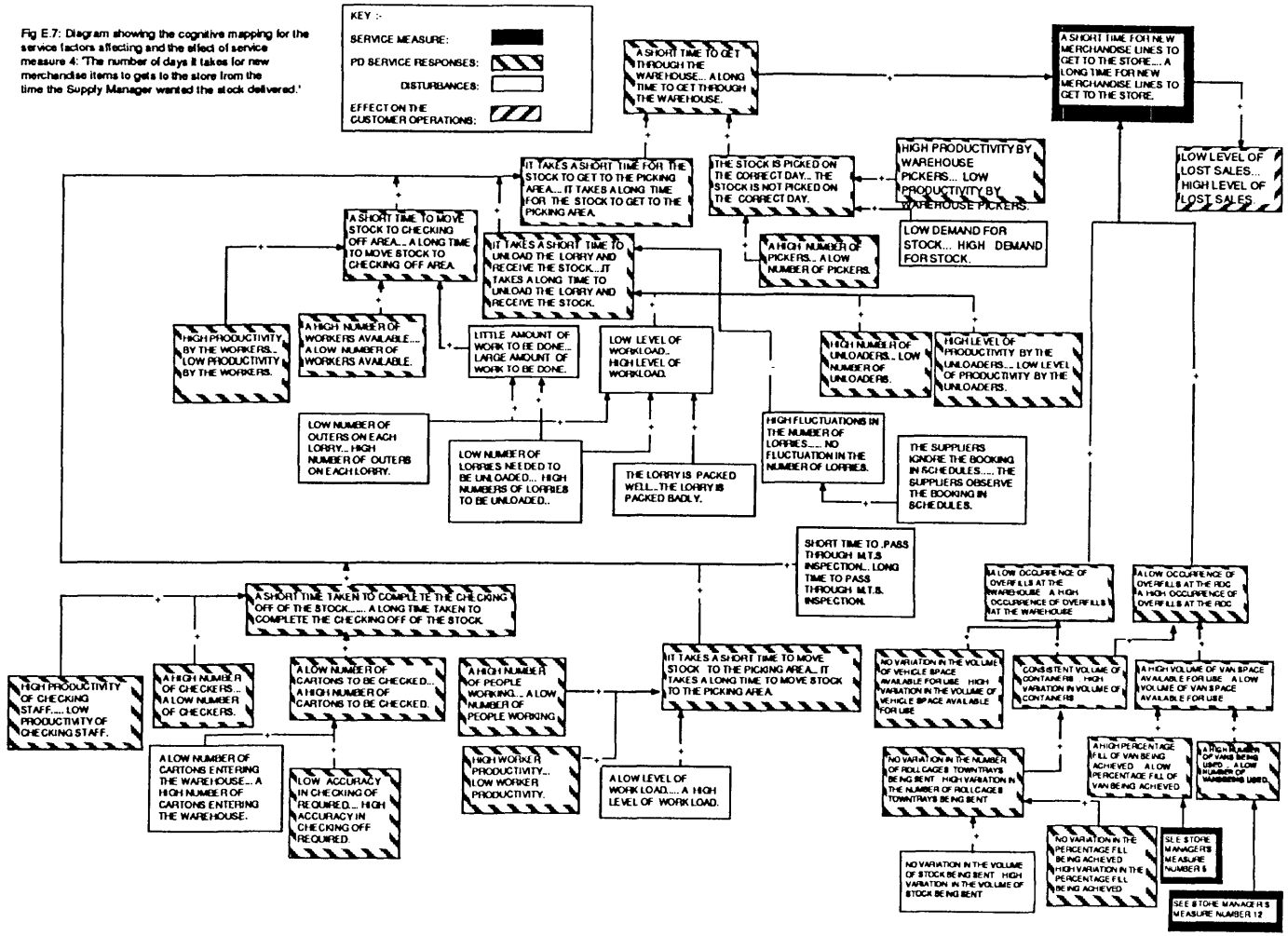
This service measure was designed to measure the swiftness with which PD could get stock to the stores. The influences on this measure were very similar to those on the store's service measures 6-8 (see Appendix D).

The time it took for new stock to get into and through the warehouses was dependent on several factors, influenced by PD:

1) The number of days suppliers had to wait before they could deliver their stock.
2) The time it took to check off incoming stock.
3) The time it took to move stock to the picking location.
4) The time it took for the stock to be picked.

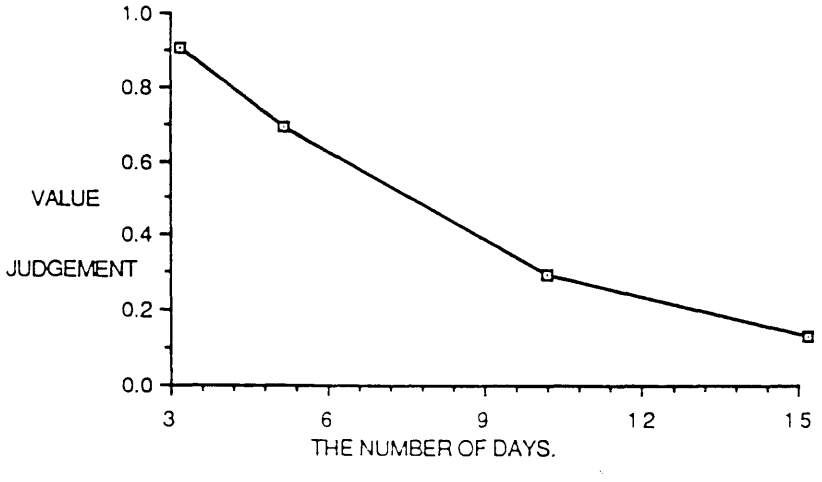
The number of days suppliers had to wait before they could deliver their stock was dependent on whether there was a free slot in the warehouse's booking in schedule. It would have been possible to reduce this problem by having slots reserved for urgent deliveries.

Fig E.7: Diagram showing the cognitive mapping for the service factors affecting and the effect of service measure 4: 'The number of days it takes for new merchandise items to gets to the store from the time the Supply Manager wanted the stock delivered.'



Each of the other 3 timings was dependent on the level of workload and the level of staff that was available to meet this workload. The greater was the variation in the workload the greater was the level of manpower required. The time taken was also dependent on howlong MTS (quality control) took to check the items and the time it took for the buyer to inspect the items. Consequently this indicates that there was a need for coordination between these various departments that affected this service measure.

Fig E.8: The graph showing the overall mean value judgement for service measure 4: "For new merchandise lines: The number of days it took for the stock to get to the store, from the time the Supply Manager requested that the stock should be delivered to the warehouse"



The time to get from the warehouse to the stores was dependent on several factors:

1) The time it took to get from the warehouse to the RDC.

2) The time it took to get through the RDC.

3) The time it took to get from the RDC to the store.

The value of the first and third of these factors was dependent on whether a lorry or a van overfill occurred at the warehouse or the RDC. These situations were influenced by the lorry/van fill and the variation in the amount of stock being sent. (This has already been discussed for the store's service measures 6-8, see appendix D). The value of the second factor was determined by the level of staff and the workload at the RDC.

As the graph (see Fig E.8) is almost linear it is proposed that the criterion that should have been used was the mean service level.

B) trade-off areas:

1) The level of warehouse/RDC staff.

2) The number of vans used.

3) The number of lorries used.

Against

1) The level of lost sales.

C) Disturbances:

1) The actual flow of stock into the warehouse.

2) The amount of stock that was being picked in the warehouse.

3) The variation in the amount of stock that was going to the RDC.

4) The variation in the amount of stock that was going through the RDC.

5) The variation in the amount of stock that was going to the stores.

D) Responses and the response rates:

1) The level of staff in warehouse/RDC. Using overtime had a quick response time whereas using full-time staff had a slow response rate.

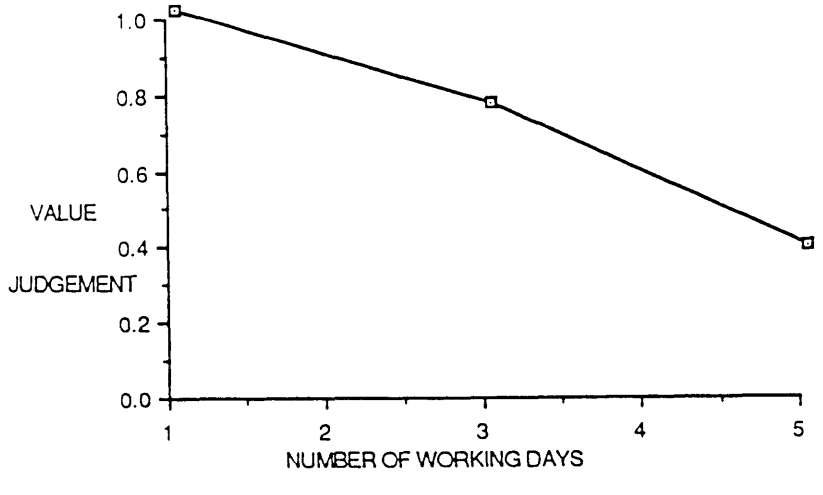
2) The number of vehicles being used. Hiring more vehicles had a quick response time whereas buying own vehicles had a long response time.

Service measure 5: The number of working days it took for an inter-store transfer to be completed.

A) General discussion(see Fig E.9 + Fig D.20):

It should be noted that, this service measure was identical to the service measure 11 for the store managers. Also by comparing Fig D.21 to Fig E.9 it can be seen that the questionnaire results were very similar. Thus, the customers could have been treated as being in the same service segment, consequently requiring the same service levels.

Fig E.9: The graph showing the overall mean value judgement for service measure 5: "The number of working days it took for an inter-branch transfer to be completed."



Service measure 6: The number of working days a store was out of stock whilst stock was available in the Physical Distribution system.

A) General Discussion (see Fig E.10+ Fig E.11):

This measure tried to reflect the influence which PD had on the level of stock outs that were occurring in the store. It should be noted that, it was not PD's fault (in the participating company situation) if a stock out occurred due to there not being enough stock in the warehouses. This situation was in fact a reflection on the Buyer's and the Supply

Manager's operations. By using similar argument it can be seen that the stock levels in the warehouses (excess stock) were not the responsibility of PD either. Thus, the actual stock turn over rate was not a fair measure of PD effectiveness in this particular company, but

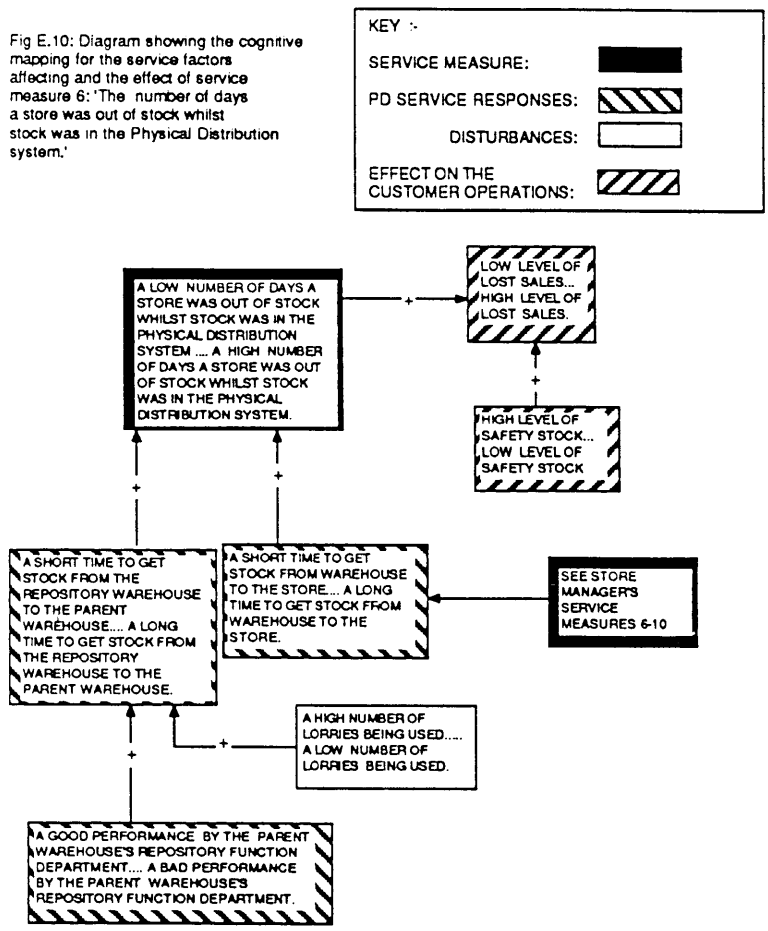
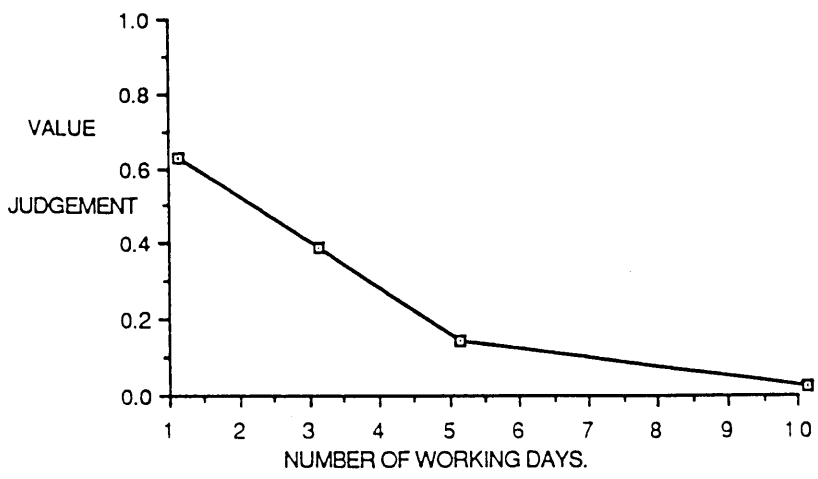


Fig E.10: Diagram showing the cognitive mapping for the service factors affecting and the effect of service measure 6: 'The number of days a store was out of stock whilst stock was in the Physical Distribution system.'

Fig E.11: The graph showing the overall mean value judgement for service measure 6: "The number of working days a store was out of stock whilst stock was available in the Physical Distribution system."



was more a reflection on the buyers and Supply Managers. Broadly there were two components to this service measure:

1) Making sure that stock was actually available in time. A failure to do this was usually caused by, either the lack of staff to move stock to the picking location or the stock being in the wrong warehouse- this was the responsibility of the warehouse's repository function.

2) Sending the stock to the store's as quickly as possible. This point has already been discussed in the store manager's service measures 6-10 (see appendix D).

Due to the high importance of achieving a consistently high service level on the customer it is suggested that a very tight criteria should have been adopted. Such a criteria could have been the mean and variance of the performance level plus the number of times stock was late.

B)Trade-off areas:

1) The number of lorries that were going from the repository warehouse to the parent warehouse.

2) The number of lorries that were going to the RDC.

3) The number of vans that were going to the stores.

4) The number of RDC workers.

5) The number of warehouse workers.

Against

1) The level of lost sales.

C) The disturbances:

1) The level of workload on the warehouses.

2) The level of stock being sent to the stores.

3) The level of stock being transferred between the warehouses.

D) Responses and the response rate:

1) The number of vehicles being used. Hiring more vehicles had a quick response time whereas, buying own vehicles had a long response time.

2) The number of warehouse/RDC workers. Using overtime had a quick response time, whereas using full-time staff had a slow response rate.

Service measure 7 The number of working days it took for returning stock to be ready for dispatch in the warehouse from the time it left the store.

A) General Discussion (see Fig E.12 and Fig E.13):

There were a number of components to this service measure:

1) The time it took for stock to get from the stores to the RDC.

2) The time it took for stock to get through the RDC.

3) The time it took for stock to get from the RDC to the central sorting area, D6.

4) The time it took for stock to get through the sorting area.

5) The time it took for stock to get from the sorting area to the warehouse.

6) The time it took to sort out the stock at the warehouse and to record the stock, on the computer, as being present.

Fig E.13: The graph showing the overall mean value judgement for service measure 7: "The number of working days it takes for returning stock to be ready for dispatch in the warehouse dfrom the time it left the store."

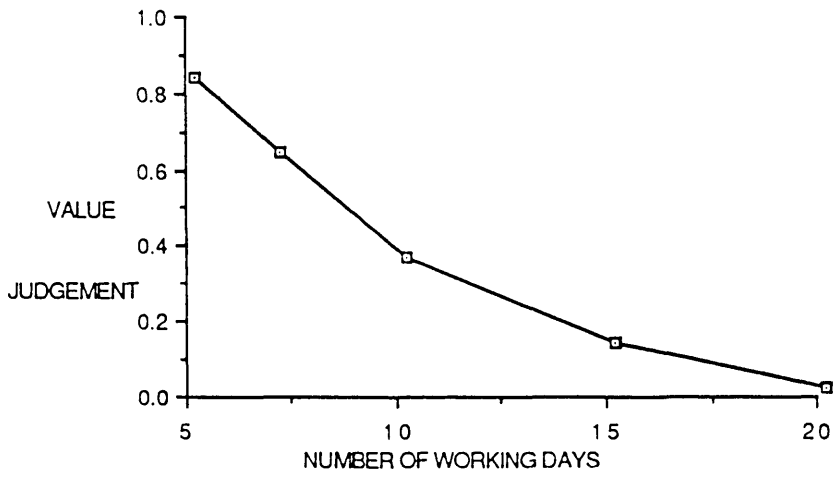
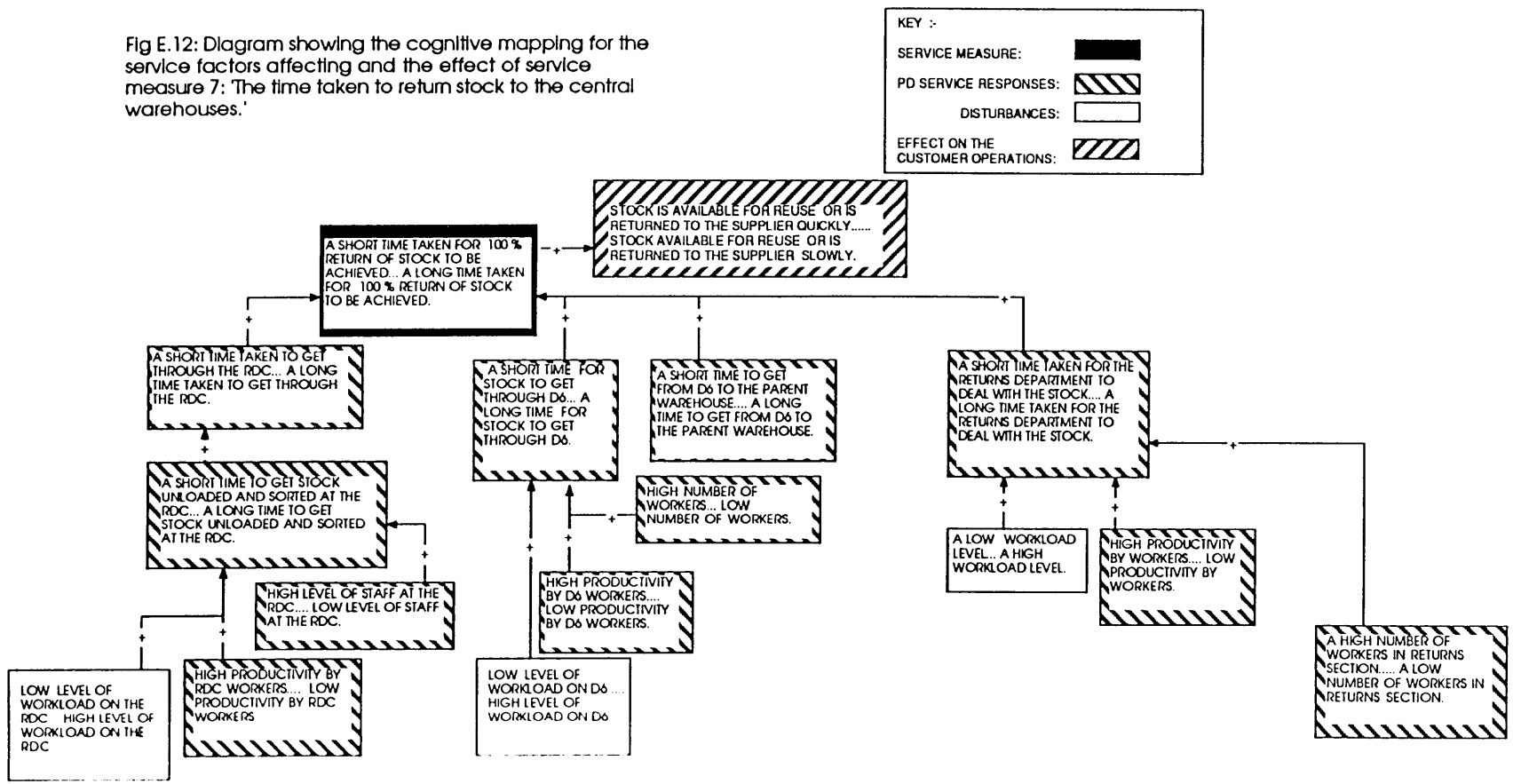


Fig E.12: Diagram showing the cognitive mapping for the service factors affecting and the effect of service measure 7: 'The time taken to return stock to the central warehouses.'



The first of these, along with the third, was determined by whether a vehicle overfill occurred at the store or at the RDC. Fortunately, this generally did not happen, as the level of stock being returned was, usually, less than the level being delivered.

The time it took for the stock to get through the RDC was dependent on the workload and level of staff being used. Fortunately, the peak in the level of returns was generally at a different time of year than the peak in the stock being sent out to the stores. Consequently, this meant that the peaks and troughs of these two separate RDC workloads had a tendency to even each other out slightly. This meant that there was less variation in the workload than there would have been if the workload peaks had occurred at the same time, thus, making it easier to react to the disturbance changes. The time it took for the stock to get through the central sorting area, D6, was also a function of the level of workload and the number of staff used.

With the warehouses, the peaks in workload for returning stock was at a different time of year from the peaks in workload caused by stock being dispatched. Thus staff could be transferred between the warehouse's picking location and the returns department of the warehouse. Also, it was important to get the stock onto the company's stock computer as soon was possible. This was because picking invoices were only produced for stock that was actually registered as existing on the company's computer.

It can be seen from the above that, there were numerous parts of PD affecting this service measure, thus there was a need for coordination of the trade-off between the different service responses.

The consequences of a decrease in the service level were two fold:

1) Stock was not ready for re-dispatch. This meant that there had to be more stock in

the system to meet the demand. However, this was not always the case as usually this demand would have been met by inter-store transfers.

2) With the stock being returned to supplier for credit there was an increase in the company's stock holding.

It is felt that the criterion that should have been used was the mean service level.

B) Trade-offs:

1) The level of RDC staff.

2) The level of D6 staff.

3) The level of warehouse staff.

Against

1) The stock turnover rates.

2) The level of frozen assets.

C) Disturbances:

1) The level of workload on D6.

2) The level of workload on the RDC.

3) The level of workload on the warehouse.

D) Responses and the response rate:

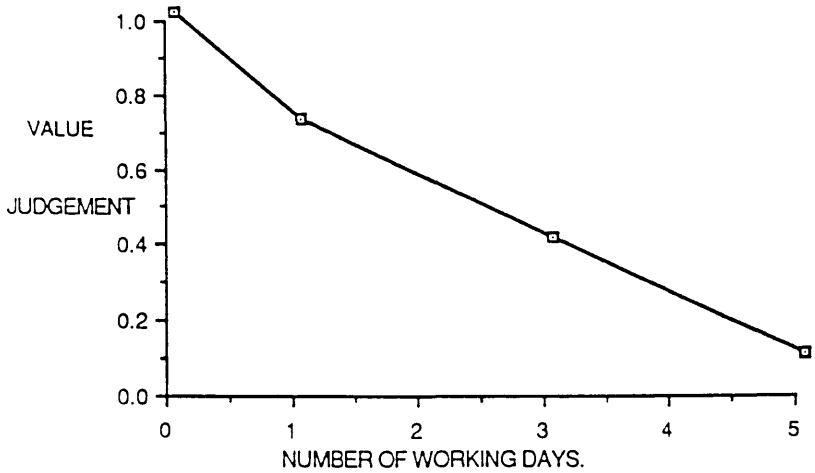
1) The level of staff at the RDC/ warehouse/ D6. Using overtime had a quick response time, whereas using full-time staff had a low response rate.

Service measure 8: For allocation stock, the number of working days after the expected delivery date that the stock arrives at the store.

A) General Discussion (see Fig E.14):

It should be noted that, allocation stock was always 2nd class stock, which has already been discussed as store managers service measure D. Also, the questionnaire results for the two customers, see Fig E.14 and Fig D.11 indicated very similar service judgements. Thus it is proposed that the two service measures could have been considered as being in the same segment and thus requiring the same service levels.

Fig E.14: The graph showing the overall mean value judgement for service measure 8: "For allocation stock, the number of working days after the expected delivery date that the stock arrives."



APPENDIX F
THE K MEAN CLUSTER ANALYSIS RESULTS FOR THE STORES.

This appendix looks at the advantages of using the market segments generated by using the k mean clustering technique compared to using the possible segments suggested by the company. These were the store's size and geographical location. It should be noted that the benefits of using the segments produced by using the K mean clustering technique have to be much greater than both of the other possible segments to make them worthwhile to use. This is due to the greater differentiating costs between the segments identified by using the K mean cluster analysis. It should be remembered that the benefits of using a particular segmentation policy is determined by the differences in the otimal service level for these different segments. Generally an approximation to this can be determined by looking at the differences in the benefits curves (service value curve). The greater the differences are, the greater are the advantages of using the proposed segmentation policy.

So as to maximise the differences, in the optimum service level, for different possible segments, the questionnaire data has been transformed as suggested, in section 6.3, before carrying out the analysis. This transformation affected the questionnaire results for measures 3,4,5,9,10 and 12.

It is assumed that the benefits of a service level are linearly correlated to the value judgement given. Thus, enabling the mean service value judgement of all the respondents in a grouping to be used to give an indication of the mean service benefits.

When looking at the differences between segments, more emphasise will be placed on the higher service levels, as it is assumed that the optimum service level has a relatively high value judgement associated with it.

It should be noted that when the results are represented graphically the service values are reduced by a factor of 6 so as to give a highest possible value judgement of 1.

Analysis for what type of service segmenatation should be used for service measure 1: "The number of minutes late that the RDC van is."

k mean clustering results for two groupings.

Group 1 consists of 21 respondents.
Group 2 consists of 13 respondents.

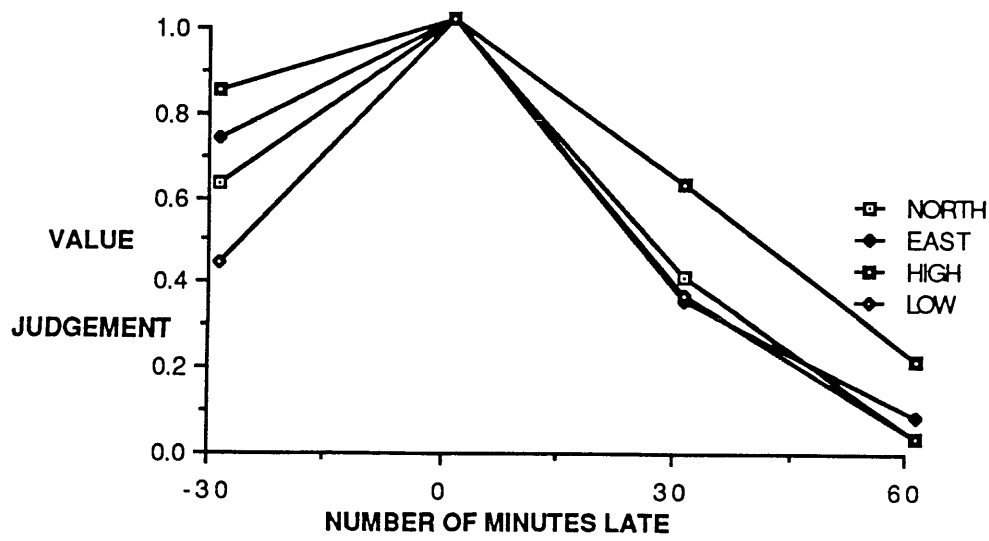
Group 1 MEMBERS		Group 2 MEMBERS	
04	20	01	19
05	22	02	21
06	25	03	23
08	26	07	24
09	27	12	28
10	29	15	31
11	30	18	
13	32		
14	33		
16	34		
17			

Aggregated results:

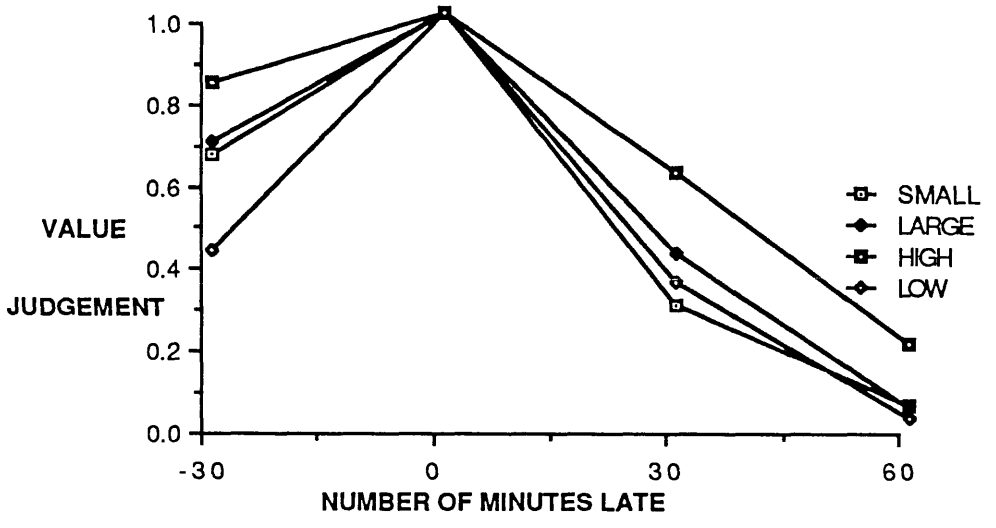
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
-30	4.029	1.47	4.952	0.97	2.539	0.66	3.667	1.23	4.316	1.60	3.938	1.44	4 111	1.53
0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6 000	0.00
30	2.147	1.10	2.191	1.17	2.077	1.04	2.333	1.23	2.000	1.00	1.750	1.13	2 500	0.99
60	0.235	0.55	0.333	0.66	0.077	0.28	0.067	0.26	0.368	0.68	0.250	0.58	0 222	0.55

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that it could be beneficial to use the market segmentation proposed by the K mean clustering. Thus, it may be worthwhile investigating the costs of differentiating more deeply.

Analysis for what type of service segmenatation should be used for service measure 2: "The number of minutes late that the CSR van is."

k mean clustering results for two groupings.

Group 1 consists of 22 respondents.
Group 2 consists of 12 respondents.

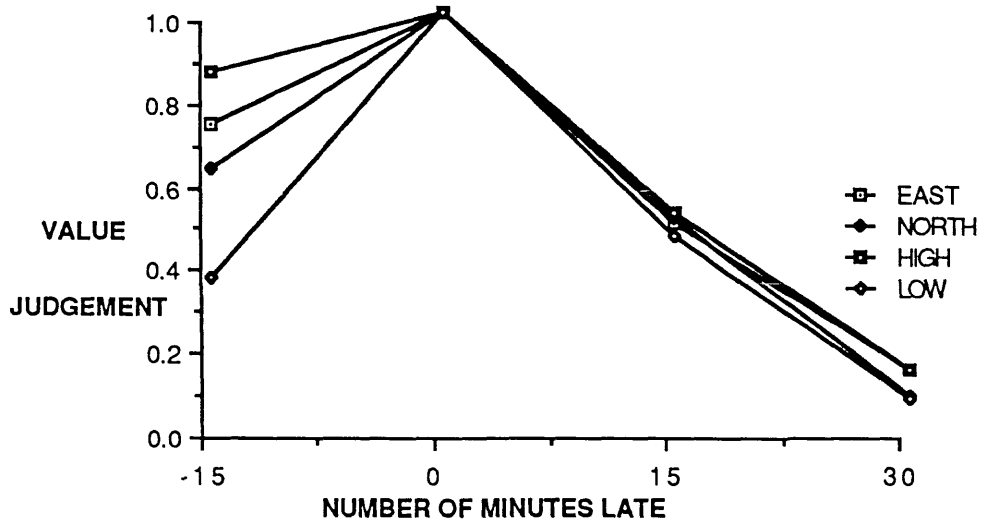
Group 1 MEMBERS		Group 2 MEMBERS	
03	16	01	23
04	17	02	25
05	20	07	26
06	21	09	28
08	22	18	31
10	24	19	32
11	27		
12	29		
13	30		
14	33		
15	34		

Aggregated results:

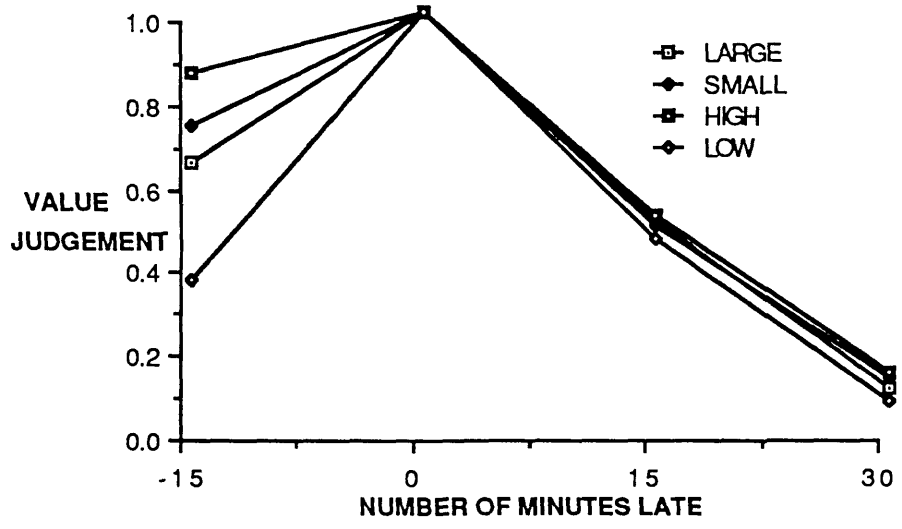
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
-15	4.088	1.68	5.136	0.83	2.167	0.94	3.773	1.62	4.368	1.71	4.375	1.36	3.833	1.92
0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
15	2.971	1.06	3.091	1.07	2.750	1.06	3.000	1.07	2.947	1.08	2.938	1.24	3.000	0.91
30	0.676	0.94	0.818	0.96	0.417	0.90	0.467	0.92	0.842	0.96	0.750	1.13	0.611	0.78

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is little evidence, to suggest it would be beneficial to use the market segmentations, proposed by the K mean clustering technique.

Analysis for what type of service segmenatation should be used for service measure 3: "The number of minutes to unload a RDC van."

k mean clustering results for two groupings.

Group 1 consists of 23 respondents.
Group 2 consists of 11 respondents.

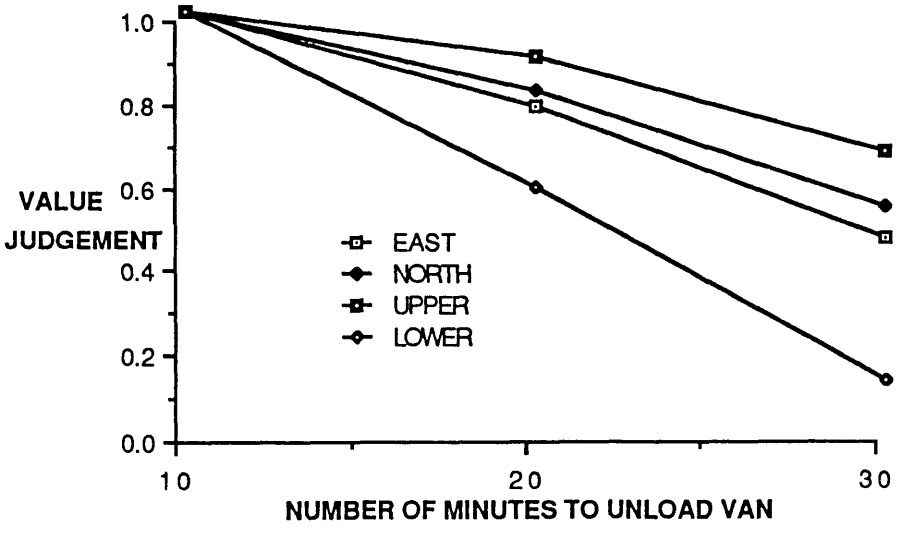
Group 1 MEMBERS		Group 2 MEMBERS	
01	23	02	12
03	24	04	14
06	25	05	16
07	26	09	20
08	27	10	31
13	28	11	
15	29		
17	30		
18	32		
19	33		
21	34		
22			

Aggregated results:

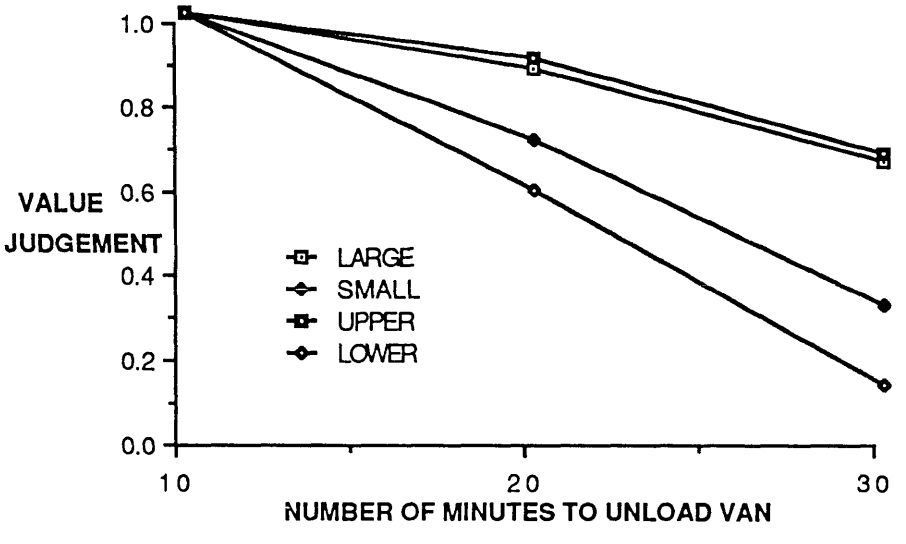
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
10	5.971	0.17	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
20	4.706	1.19	5.348	0.65	3.455	0.82	4.867	1.18	4.632	0.99	4.188	1.18	5.222	0.79
30	2.912	1.90	4.000	1.13	0.727	0.79	3.200	2.02	2.737	1.67	1.875	1.69	3.889	1.37

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is little evidence, to suggest it would be beneficial to use the market segmentations, proposed by the K mean clustering technique.

Analysis for what type of service segmenatation should be used for service measure 4: "The number of minutes to unload a CSR van."

k mean clustering results for two groupings.

Group 1 consists of 18 respondents.
Group 2 consists of 16 respondents.

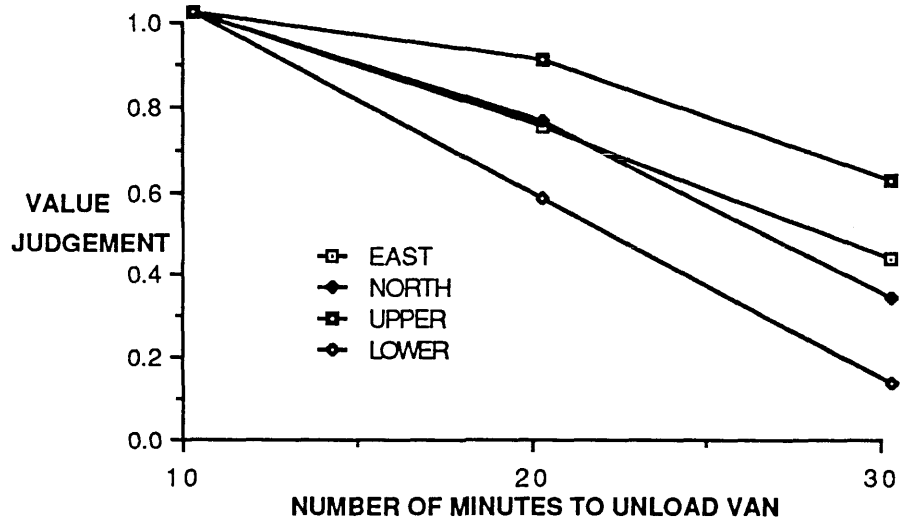
Group 1 MEMBERS		Group 2 MEMBERS	
01	25	02	14
06	27	03	16
07	28	04	17
08	29	05	20
13	30	09	21
15	31	10	22
18	32	11	24
19	33	12	26
23	34		

Aggregated results:

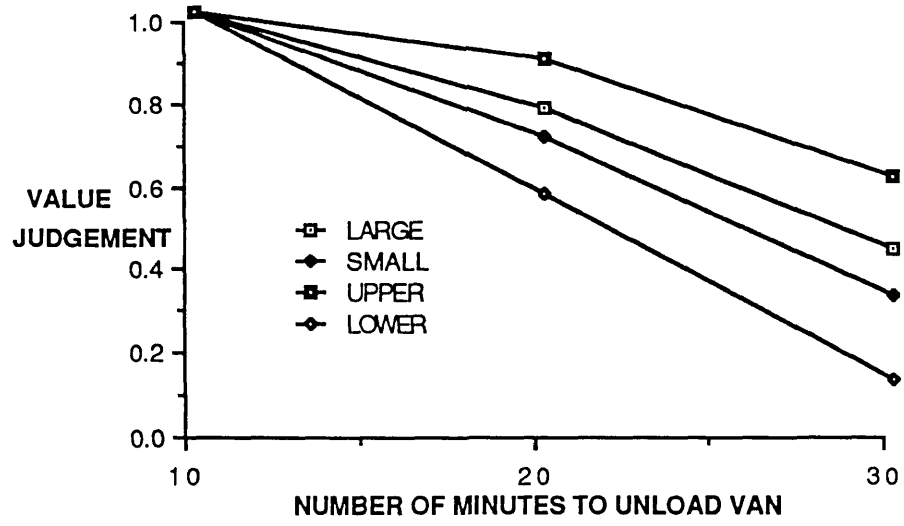
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
10	5.912	0.29	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
20	4.324	1.47	5.333	0.69	3.375	1.15	4.467	1.41	4.368	1.26	4.188	1.29	4.611	1.34
30	2.147	1.83	3.611	1.09	0. 688	0.79	1.933	1.83	2.474	1.73	1.875	1.76	2.556	1.64

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that it could be beneficial to use the market segmentation proposed by the K mean clustering. Thus, it may be worthwhile investigating the costs of differentiating more deeply.

Analysis for what type of service segmenatation should be used for service measure 5: "The number of working days warning that a store manager receives of a change in the arrival time of a RDC/CSR delivery van."

k mean clustering results for two groupings.

Group 1 consists of 17 respondents.
Group 2 consists of 17 respondents.

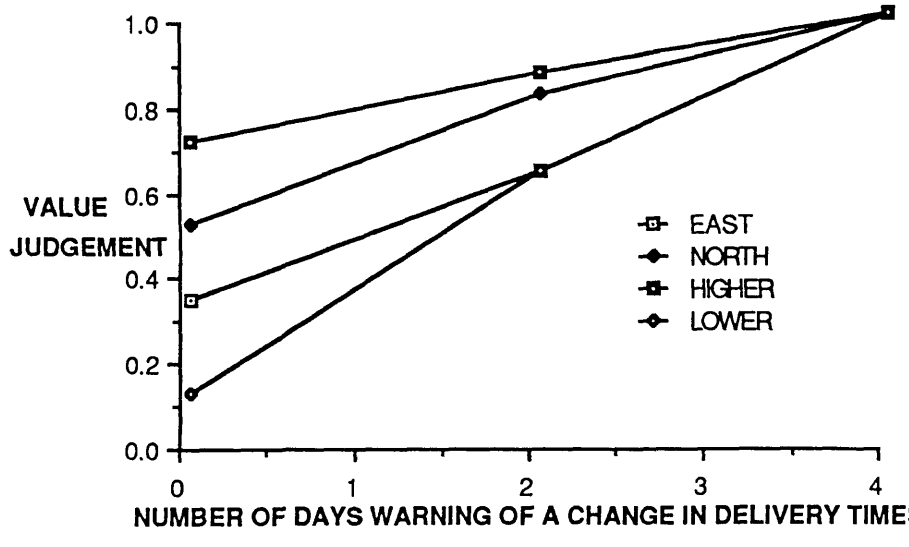
Group 1 MEMBERS		Group 2 MEMBERS	
01	19	05	25
02	20	10	26
03	21	11	28
04	22	13	29
06	23	14	30
07	24	15	32
08	27	16	33
09	31	17	34
12		18	

Aggregated results:

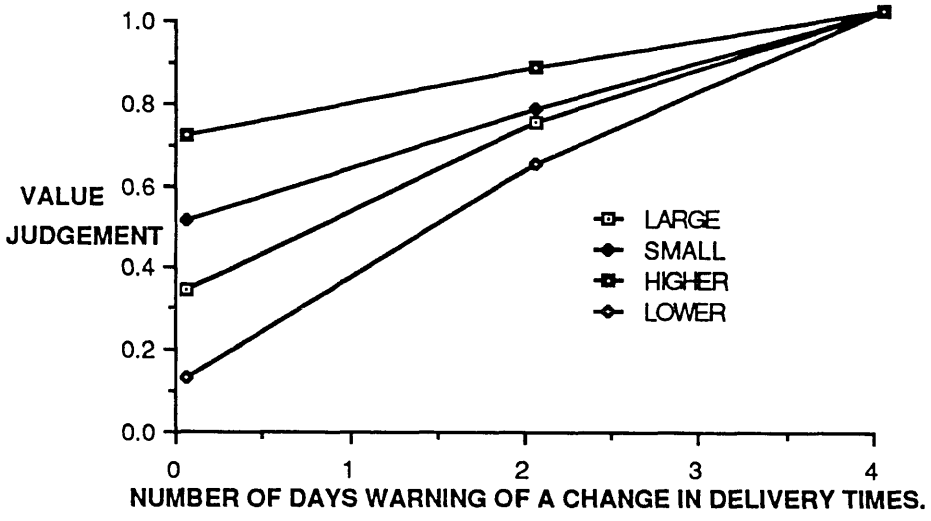
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0	0.206	1.04	4.177	1.07	0.647	0.79	3.000	1.85	1.947	1.38	2.973	2.05	1.944	1.81
2	2.088	1.58	5.177	0.64	3.765	0.97	4.867	1.06	4.158	0.89	4.563	1.06	4.389	1.06
4	3.441	2.09	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is little evidence, to suggest it would be beneficial to use the market segmentations, proposed by the K mean clustering technique.

Analysis for what type of service segmenatation should be used for service measure 6: "The number of working days after expected arrival day that 1st class stock arrived."

k mean clustering results for two groupings.

Group 1 consists of 16 respondents.
Group 2 consists of 18 respondents.

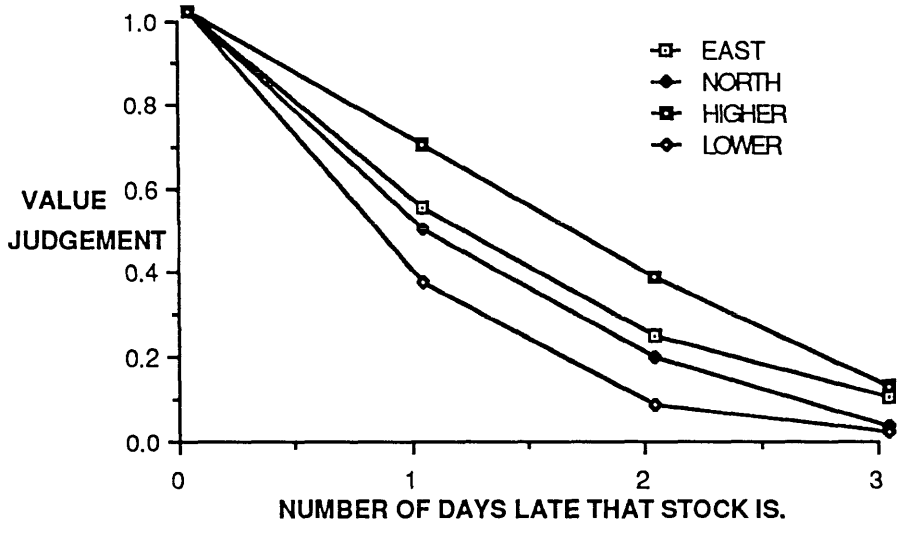
Group 1 MEMBERS		Group 2 MEMBERS	
04	22	01	18
05	23	02	19
06	24	03	20
08	25	07	21
10	29	09	26
12	32	11	27
13	33	15	28
14	34	16	30
		17	31

Aggregated results:

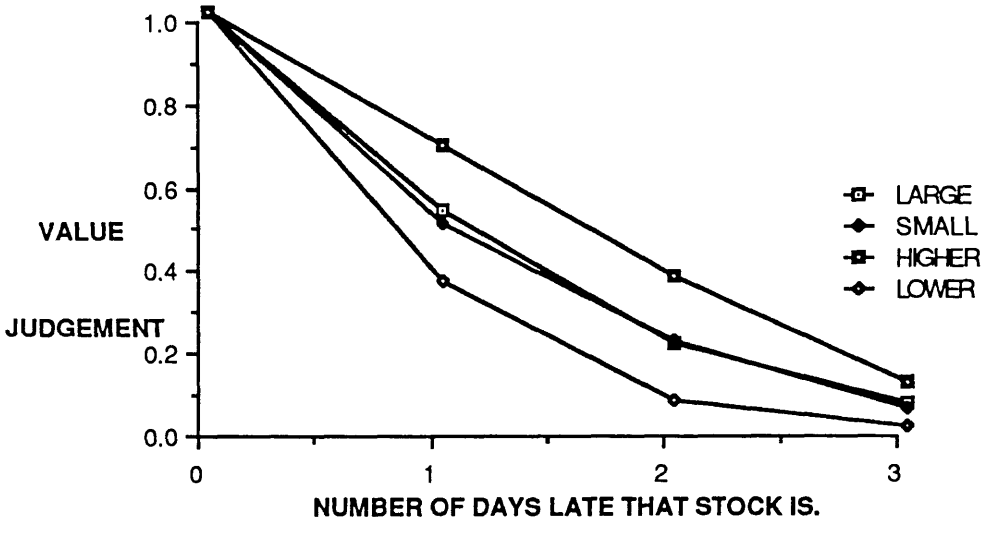
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
1	3.029	1.38	4.063	1.00	2.111	0.96	2.867	1.41	3.158	1.38	2.938	1.39	3.111	1.41
2	1.235	1.05	2.188	0.54	0.389	0.50	1.067	0.88	1.368	1.16	1.250	1.06	1.222	1.06
3	0.294	0.72	0.625	0.96	0.000	0.00	0.067	0.26	0.474	0.90	0.250	0.58	0.333	0.84

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that it could be beneficial to use the market segmentation proposed by the K mean clustering. Thus, it may be worthwhile investigating the costs of differentiating more deeply.

Analysis for what type of service segmenatation should be used for service measure 7: " The number of working days after expected arrival day that 2nd class stock arrived."
k mean clustering results for two groupings.

Group 1 consists of 6 respondents.
Group 2 consists of 28 respondents.

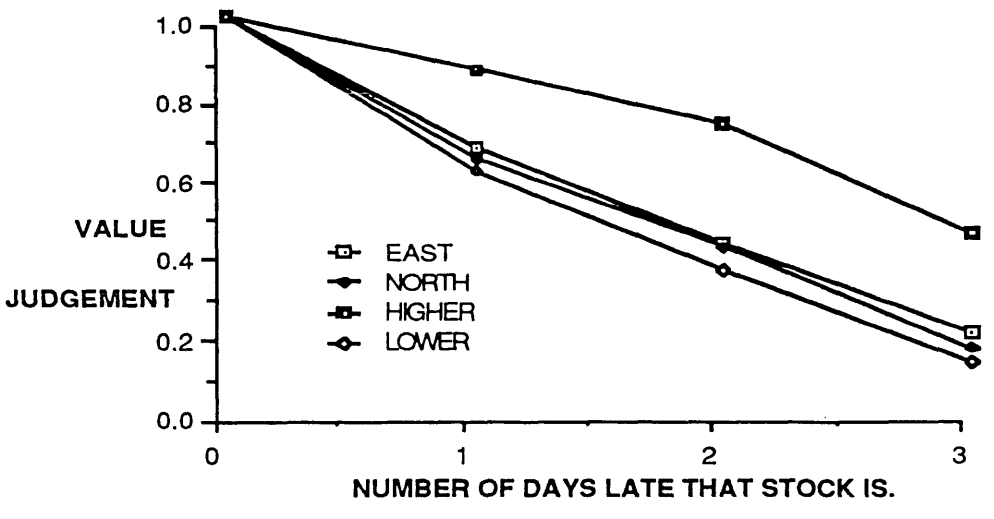
Group 1 MEMBERS		Group 2 MEMBERS	
08	25	01	18
13	33	02	19
15	34	03	20
25		04	21
33		05	22
34		06	23
		07	24
		09	26
		10	27
		11	28
		12	29
		14	30
		16	31
		17	32

Aggregated results:

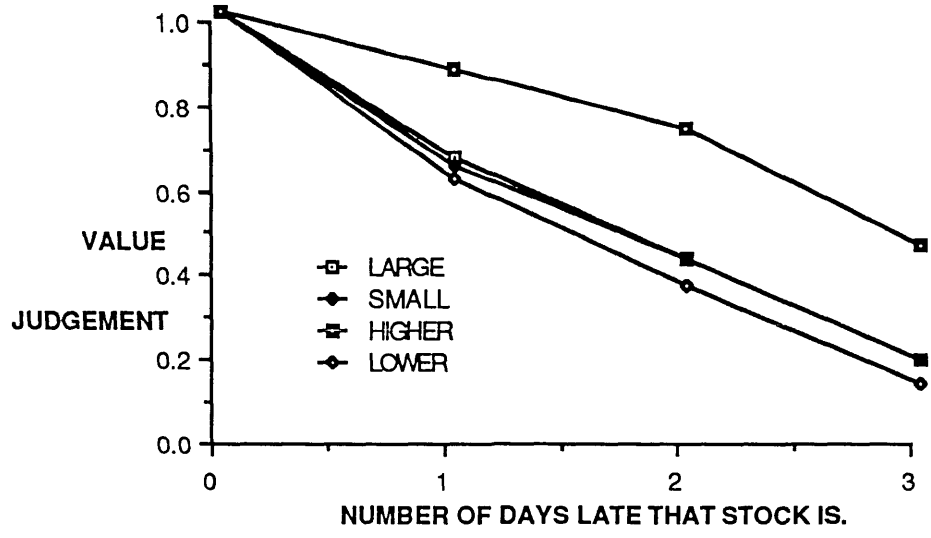
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
1	3.882	1.04	5.167	0.41	3.607	0.92	3.800	0.77	3.947	1.22	3.813	1.17	3.944	0.94
2	2.500	1.21	4.333	0.82	2.107	0.88	2.467	0.74	2.526	1.50	2.500	1.37	2.500	1.10
3	1.059	1.20	2.667	1.03	0.714	0.94	0.933	1.03	1.158	1.34	1.063	1.24	1.056	1.21

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that the market segmentation, proposed by the K mean clustering, should be used. However, the number of customers, in group 1, is rather small thus reducing the overall benefits of using the segmentations.

Analysis for what type of service segmenatation should be used for service measure 8: " The number of working days after expected arrival day that FOCUS stock arrives."

k mean clustering results for two groupings.

Group 1 consists of 8 respondents.
Group 2 consists of 26 respondents.

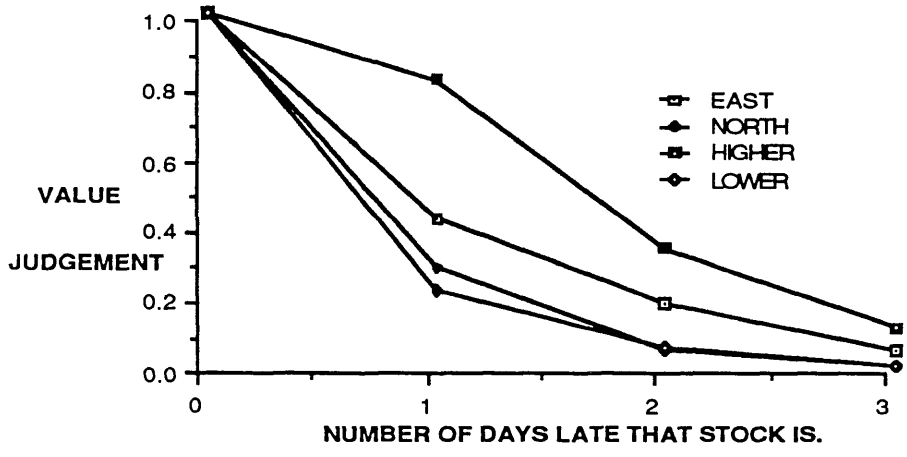
Group 1 MEMBERS		Group 2 MEMBERS	
06	24	01	18
10	29	02	19
13	33	03	20
14	34	04	21
		05	22
		07	23
		08	25
		09	26
		11	27
		12	28
		15	30
		16	31
		17	32

Aggregated results:

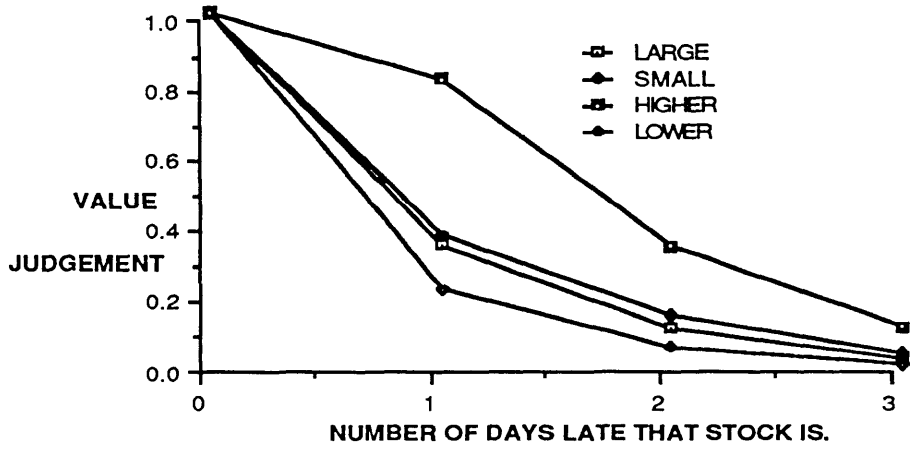
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
1	2.118	1.82	4.875	0.83	1.269	1.00	1.667	1.29	2.474	2.12	2.189	1.91	2.056	1.80
2	0.706	1.03	2.000	1.31	0.308	0.47	0.267	0.46	1.053	1.22	0.813	1.11	0.611	0.98
3	0.147	0.61	0.625	1.19	0.000	0.00	0.000	0.00	0.263	0.81	0.188	0.75	0.111	0.47

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that the market segmentation, proposed by the K mean clustering, should be used. However, the number of customers, in group 1, is rather small thus reducing the overall benefits of using the segmentations.

Analysis for what type of service segmenatation should be used for service measure 9: " The number of working days it takes for a delivery to occur after a hotline order has been phoned in."

k mean clustering results for two groupings.

Group 1 consists of 06 respondents.
Group 2 consists of 28 respondents.

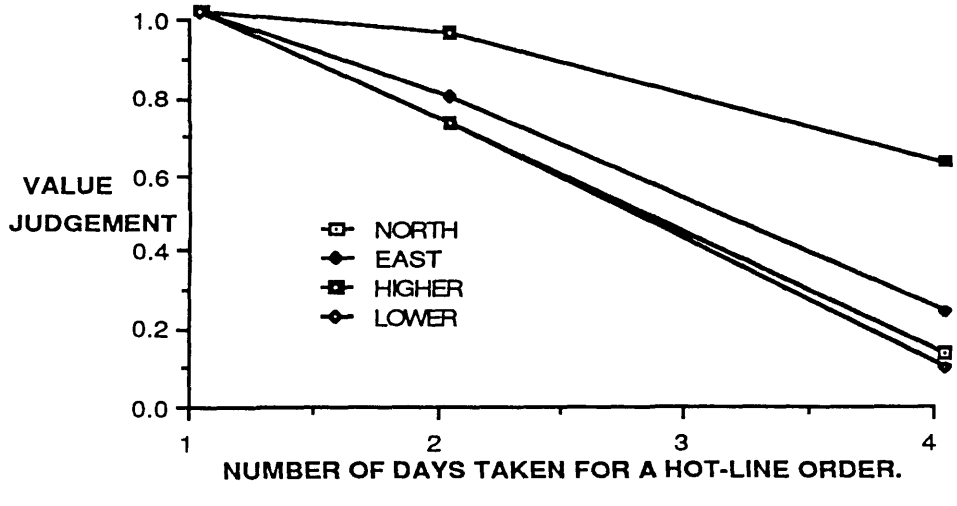
Group 1 MEMBERS		Group 2 MEMBERS	
08	26	01	17
12	29	02	18
19	30	03	20
		04	21
		05	22
		06	23
		07	24
		09	25
		10	27
		11	28
		13	31
		14	32
		15	33
		16	34

Aggregated results:

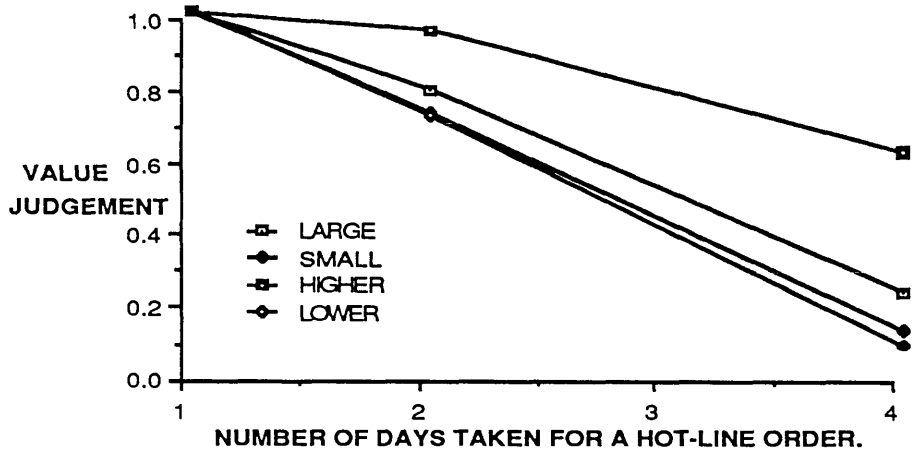
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
1	5.735	1.08	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
2	4.235	1.30	5.667	0.52	4.250	0.89	4.267	0.88	4.684	0.85	4.313	1.04	4.667	0.88
4	0.765	1.16	3.667	1.21	0.464	0.64	0.667	1.63	1.316	1.25	0.688	0.98	1.333	1.67

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that the market segmentation, proposed by the K mean clustering, should be used. However, the number of customers, in group 1, is rather small thus reducing the overall benefits.

Analysis for what type of service segmenatation should be used for service measure 10: "The number of working days it takes for a delivery to occur after a special order form has been sent in"

k mean clustering results for two groupings.
Group 1 consists of 16 respondents.
Group 2 consists of 18 respondents.

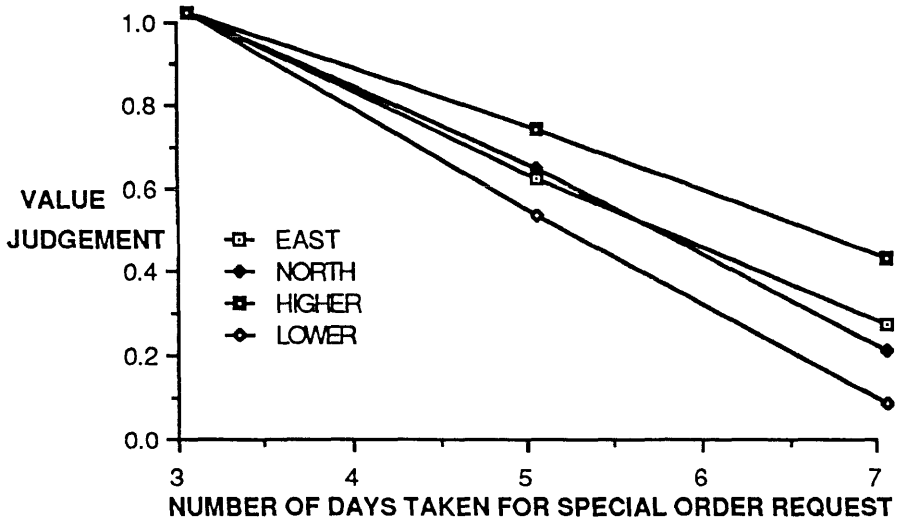
Group 1 MEMBERS		Group 2 MEMBERS	
01	18	02	20
06	19	03	21
07	24	04	22
08	28	05	23
10	29	09	25
12	30	11	26
15	31	13	27
17	32	14	33
		16	34

Aggregated results:

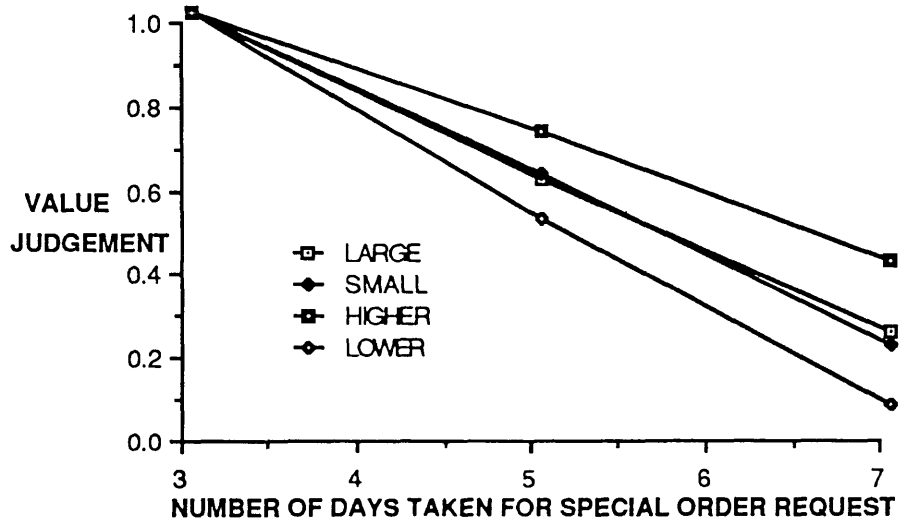
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
3	5.706	0.58	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
5	3.353	1.18	4.313	0.60	3.056	0.87	3.733	1.02	3.579	0.83	3.688	1.04	3.611	0.89
7	1.059	1.23	2.438	0.63	0.389	0.50	1.133	1.02	1.526	1.21	1.125	1.20	1. 444	1.12

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is little evidence, to suggest it would be beneficial to use the market segmentations, proposed by the K mean clustering technique.

Analysis for what type of service segmenatation should be used for service measure 11: "The number of working days it takes for a inter-branch transfer to be completed."

k mean clustering results for two groupings.

Group 1 consists of 16 respondents.
Group 2 consists of 18 respondents.

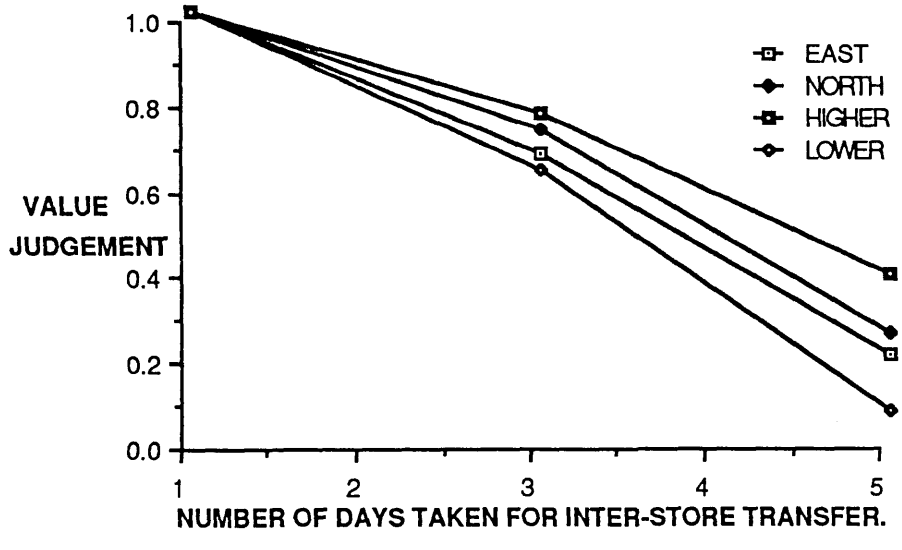
Group 1 MEMBERS		Group 2 MEMBERS	
03	18	01	22
05	19	02	23
06	20	04	25
10	21	07	26
12	24	08	27
15	28	09	30
16	29	11	31
17	33	13	32
		14	34

Aggregated results:

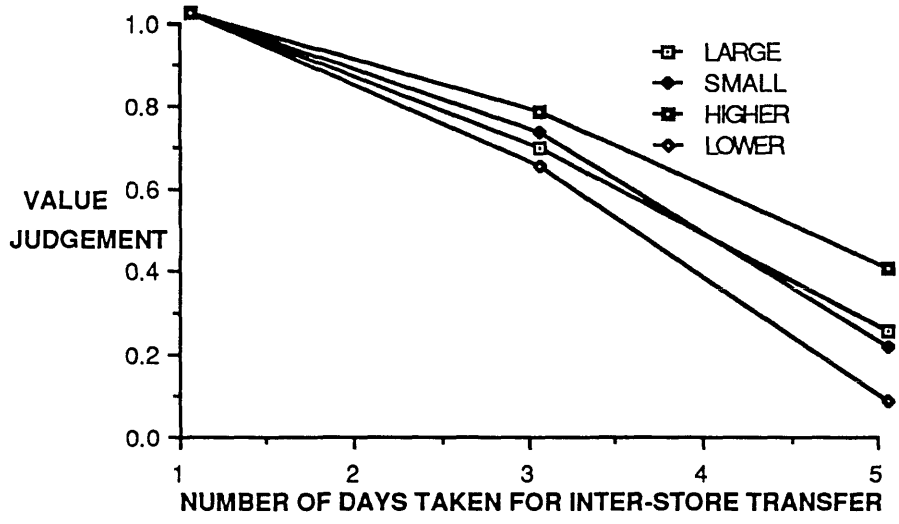
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
1	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6 000	0.00
3	4.147	0.96	4.563	0.89	3.778	0.88	4.333	0.98	4.000	0.94	4.250	1.13	4 056	0.80
5	1.294	1.09	2.313	0.48	0.389	0.50	1.467	1.19	1.158	1.01	1.188	0.98	1 389	1.20

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is little evidence, to suggest it would be beneficial to use the market segmentations, proposed by the K mean clustering technique.

Analysis for what type of service segmenatation should be used for service measure 12: "The number of working days notice given, to the store manager, of an extra van arriving."

k mean clustering results for two groupings.

Group 1 consists of 7 respondents.
Group 2 consists of 27 respondents.

Group 1 MEMBERS		Group 2 MEMBERS	
01	15	02	20
05	21	03	22
07	33	04	23
10		06	24
		08	25
		09	26
		11	27
		12	28
		13	29
		14	30
		16	31
		17	32
		18	34
		19	

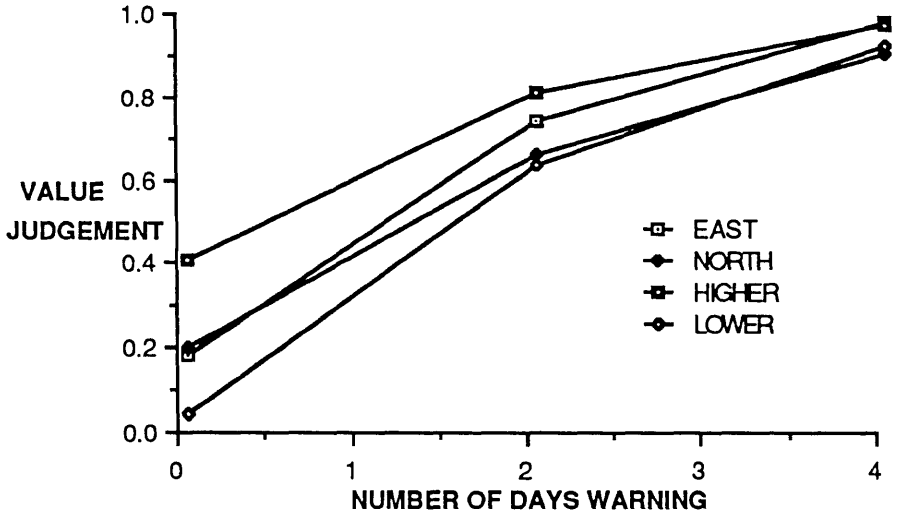
APPENDIX F

Aggregated results:

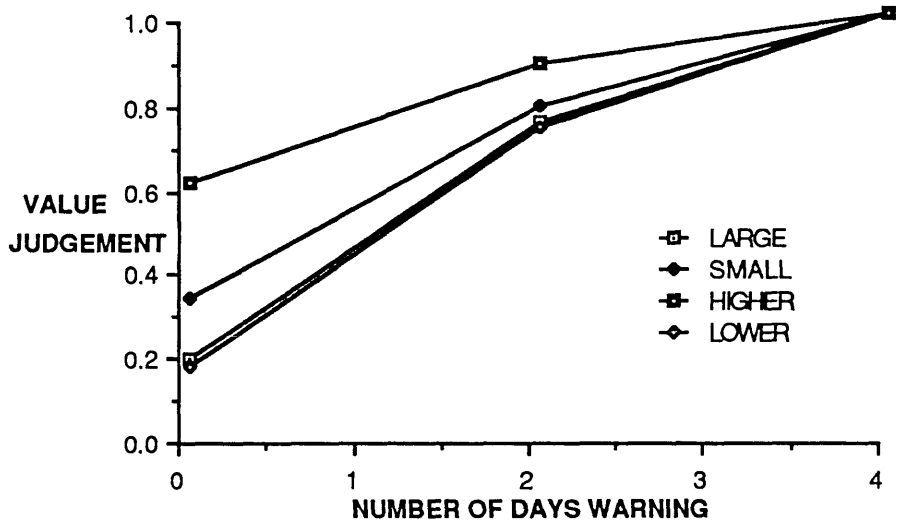
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0	1.000	1.26	3.571	1.13	0.926	0.83	1.800	1.57	1.211	1.13	1.938	1.44	1.056	1.18
2	4.088	1.16	5.286	0.76	4.370	0.84	4.533	0.79	4.579	0.93	4.688	0.92	4.444	0.83
4	5.529	0.79	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that the market segmentation, proposed by the K mean clustering, should be used. However, the number of customers, in group 1, is rather small thus reducing the overall benefits of using the segmentations.

Analysis for what type of service segmenatation should be used for service measure 13: "The number of minutes spent filling out M & E forms."

k mean clustering results for two groupings.

Group 1 consists of 18 respondents.
Group 2 consists of 16 respondents.

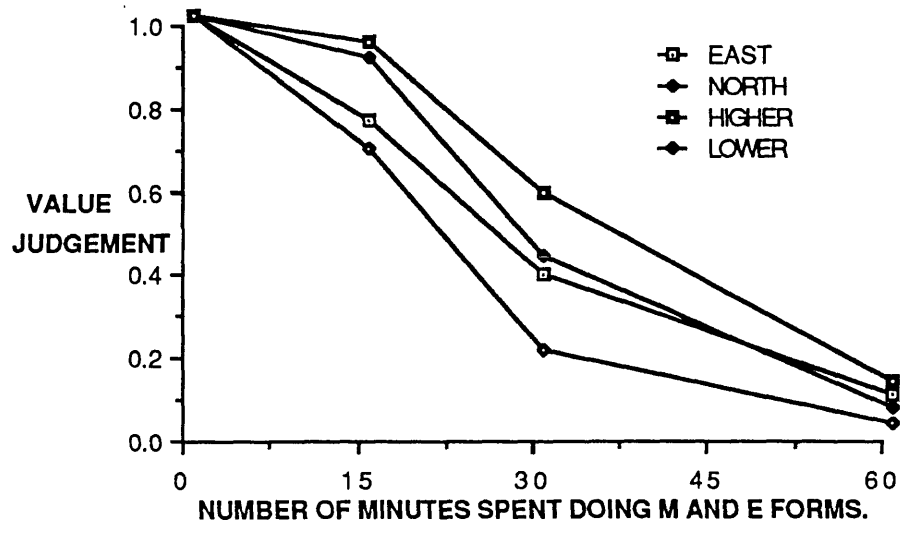
Group 1 MEMBERS		Group 2 MEMBERS	
03	21	01	15
05	23	02	16
06	24	04	20
08	25	07	22
11	29	09	26
14	31	10	27
17	32	12	28
18	33	13	30
19	34		

Aggregated results:

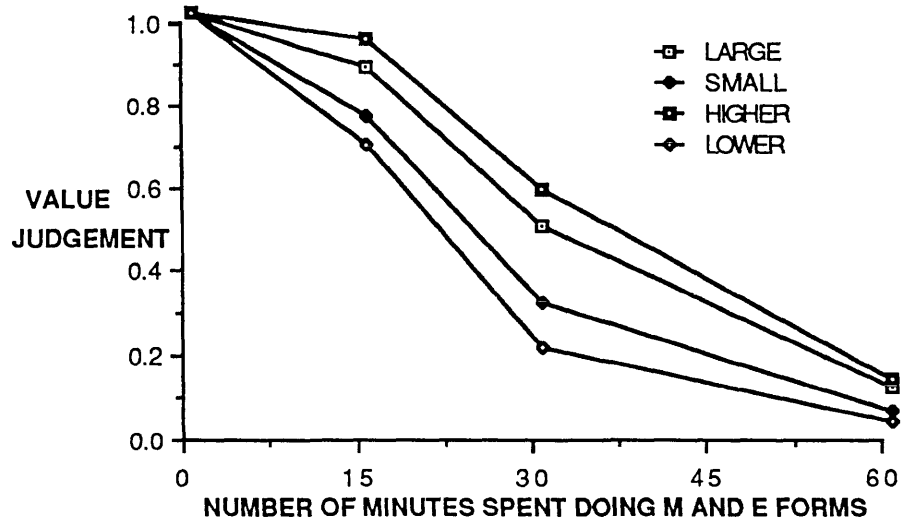
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0	1.000	1.26	3.571	1.13	0.926	0.83	1.800	1.57	1.211	1.13	1.938	1.44	1.056	1.18
2	4.088	1.16	5.286	0.76	4.370	0.84	4.533	0.79	4.579	0.93	4.688	0.92	4.444	0.83
4	5.529	0.79	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is little evidence, to suggest it would be beneficial to use the market segmentations, proposed by the K mean clustering technique.

Analysis for what type of service segmenatation should be used for service measure 14: "Percentage volume of excess RDC stock."

k mean clustering results for two groupings.

Group 1 consists of 24 respondents.
Group 2 consists of 10 respondents.

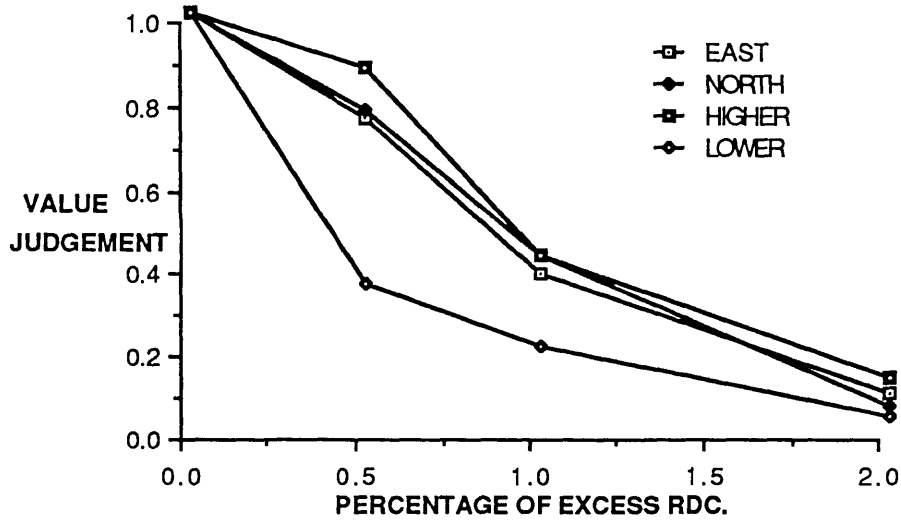
Group 1 MEMBERS		Group 2 MEMBERS
01	17	06
02	18	07
03	20	09
04	21	14
05	23	19
08	24	22
10	25	26
11	29	27
12	31	28
13	32	30
15	33	
16	34	

Aggregated results:

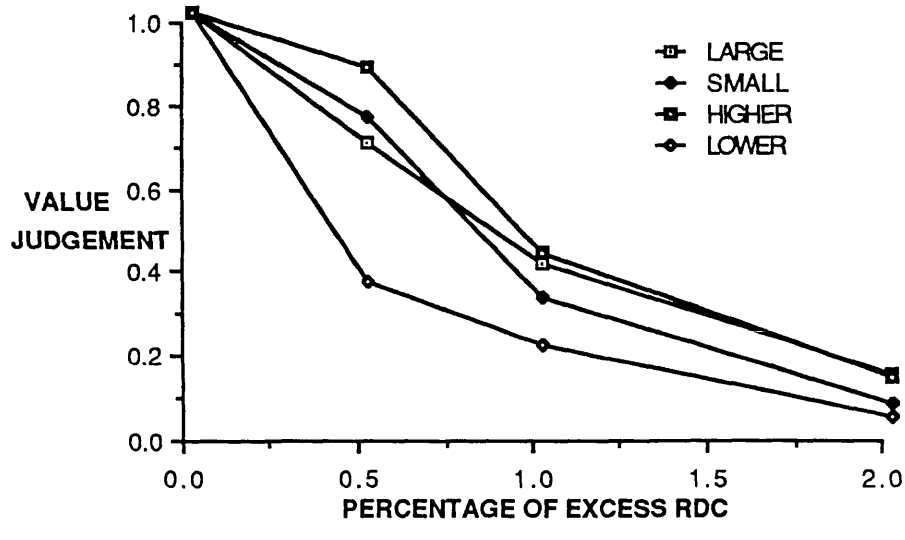
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0.0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
0.5	4.294	1.62	5.208	0.72	2.100	0.88	4.600	1.35	4.053	1.81	4.500	1.37	4.111	1.84
1.0	2.147	1.21	2.542	1.18	1.200	0.63	2.200	1.26	2.105	1.20	1.875	1.15	2.389	1.24
2.0	0.588	0.86	0.750	0.94	0.020	0.42	0.600	0.99	0.579	0.77	0.375	0.50	0.778	1.06

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that it could be beneficial to use the market segmentation proposed by the K mean clustering. Thus, it may be worthwhile investigating the costs of differentiating more deeply.

Analysis for what type of service segmenatation should be used for service measure 15: "Percentage volume of excess CSR stock."

k mean clustering results for two groupings.

Group 1 consists of 17 respondents.
Group 2 consists of 17 respondents.

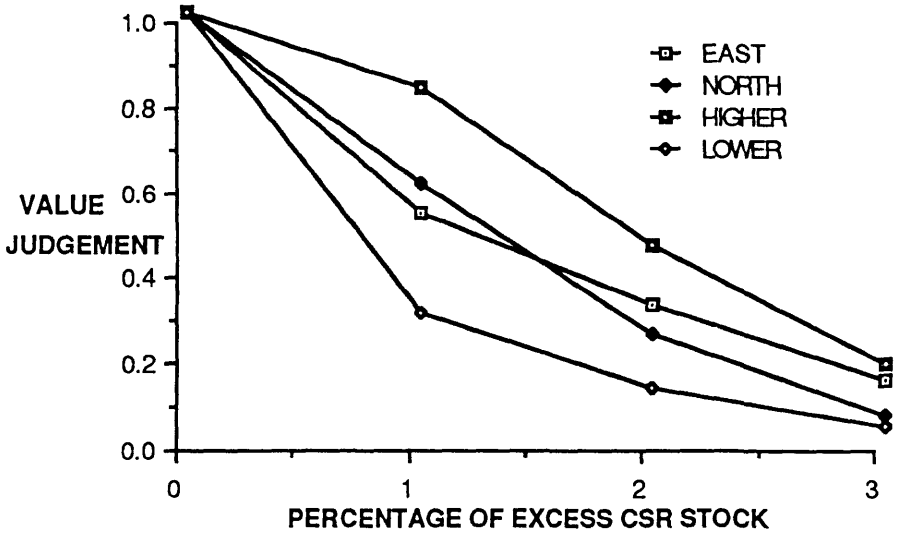
Group 1 MEMBERS		Group 2 MEMBERS	
01	23	02	15
03	24	04	19
07	25	05	20
11	29	06	21
12	31	08	26
16	32	09	27
17	33	10	28
18	34	13	30
22		14	

Aggregated results:

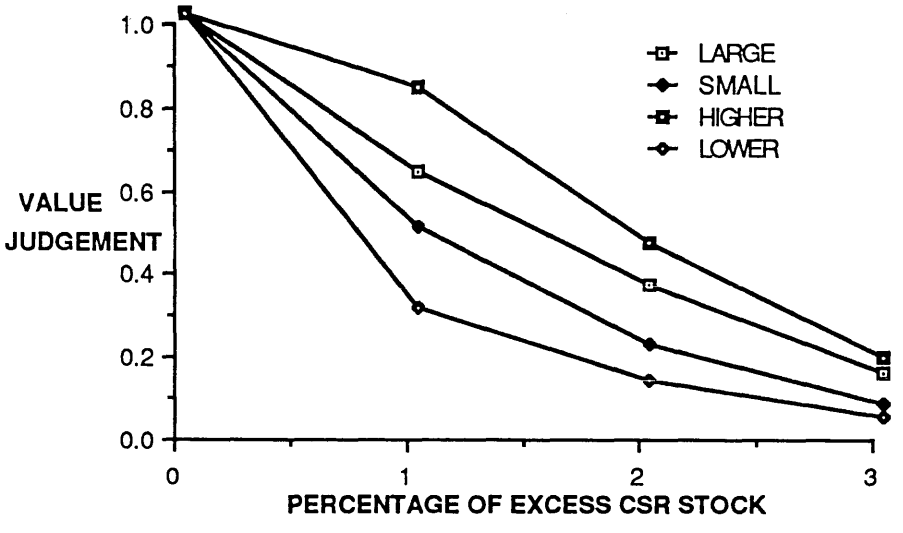
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
1	3.353	1.87	4.941	0.83	1.765	1.09	3.600	1.84	3.158	1.92	2.938	1.84	3.722	1.87
2	1.706	1.38	2.706	1.16	0.706	0.69	1.467	1.41	1.895	1.37	1.250	1.06	2.111	1.53
3	0.618	0.92	1.059	1.08	0.177	0.39	0.333	0.90	0.842	0.90	0.375	0.62	0.833	1.10

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b)size of stores:



Comment:

There is some evidence, to suggest that it could be beneficial to use the market segmentation proposed by the K mean clustering. Thus, it may be worthwhile investigating the costs of differentiating more deeply.

Analysis for what type of service segmenatation should be used for service measure 16: "The percentage of RDC stock missing or broken."

k mean clustering results for two groupings.

Group 1 consists of 15 respondents.
Group 2 consists of 19 respondents.

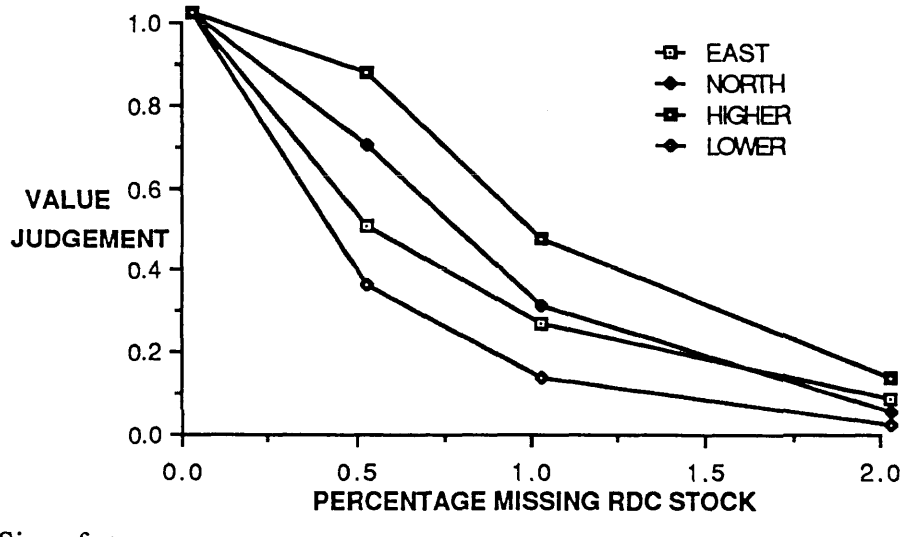
Group 1 MEMBERS		Group 2 MEMBERS	
01	23	04	15
02	24	05	19
03	25	06	20
11	29	07	22
16	32	08	26
17	33	09	27
18	34	10	28
		12	30
		13	31
		14	

Aggregated results:

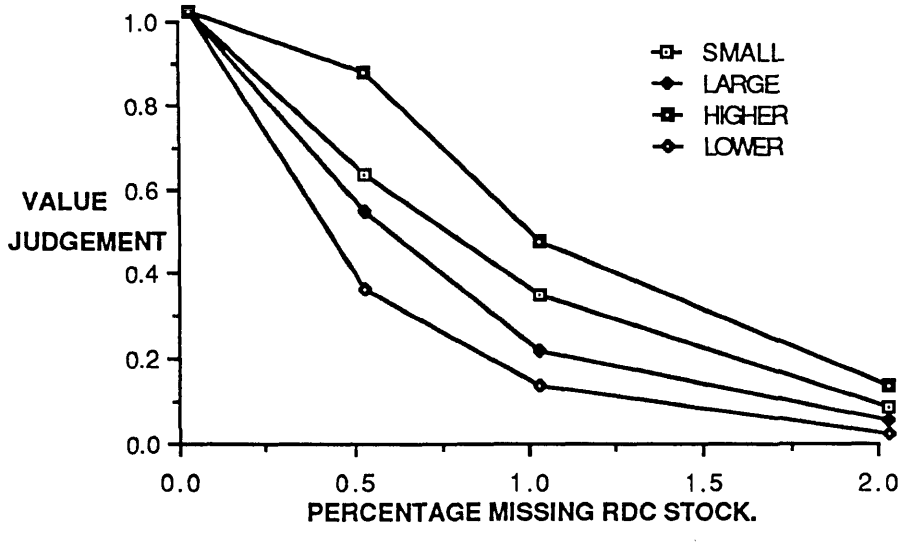
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0.0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
0.5	3.412	1.78	5.133	0.64	2.053	1.03	4.067	1.62	2.895	1.76	3.125	1.50	3.667	2.00
1.0	1.588	1.28	2.733	0.88	0.684	0.67	1.733	1.28	1.474	1.31	1.188	1.22	1.944	1.26
2.0	0.294	0.63	0.667	0.82	0.000	0.00	0.200	0.41	0.368	0.76	0.188	0.54	0.389	0.70

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that it could be beneficial to use the market segmentation proposed by the K mean clustering. Thus, it may be worthwhile investigating the costs of differentiating more deeply.

Analysis for what type of service segmenatation should be used for service measure 17: "The percentage diference for missing and breakages in RDC stock."

k mean clustering results for two groupings.

Group 1 consists of 13 respondents.
Group 2 consists of 21 respondents.

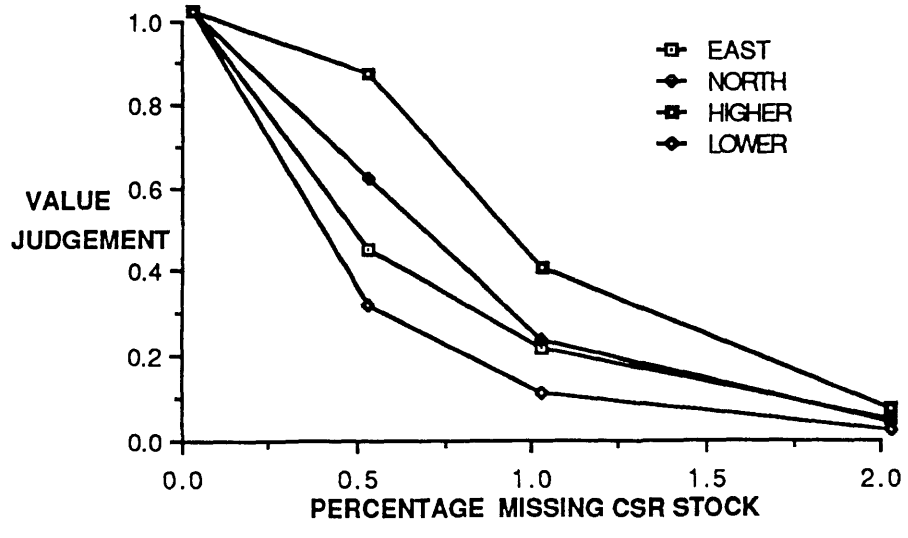
Group 1 MEMBERS		Group 2 MEMBERS	
01	24	04	19
02	25	05	20
03	31	06	21
11	32	07	22
16	33	08	23
17	34	09	26
18		10	27
		12	28
		13	29
		14	30
		15	

Aggregated results:

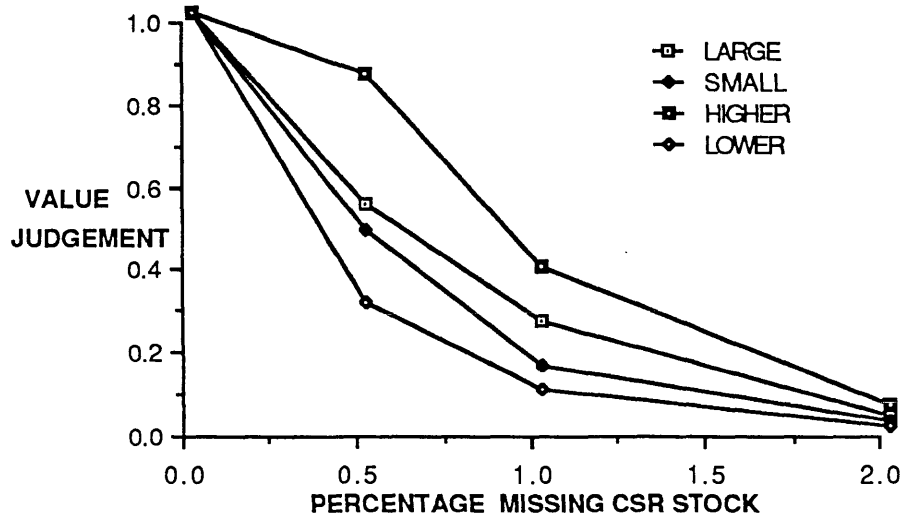
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0.0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
0.5	3.029	1.87	5.077	0.64	1.762	1.04	3.600	1.88	2.579	1.77	2.813	1.76	3.222	1.99
1.0	1.206	1.23	2.308	1.03	0.524	0.75	1.267	1.28	1.158	1.21	0.875	1.09	1.500	1.29
2.0	0.118	0.41	0.308	0.63	0.000	0.00	0.067	0.26	0.158	0.50	0.063	0.25	0.167	0.51

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that it could be beneficial to use the market segmentation proposed by the K mean clustering. Thus, it may be worthwhile investigating the costs of differentiating more deeply.

Analysis for what type of service segmenatation should be used for service measure 18: "The level of mispricing in CSR stock."

k mean clustering results for two groupings.

Group 1 consists of 11 respondents.
Group 2 consists of 23 respondents.

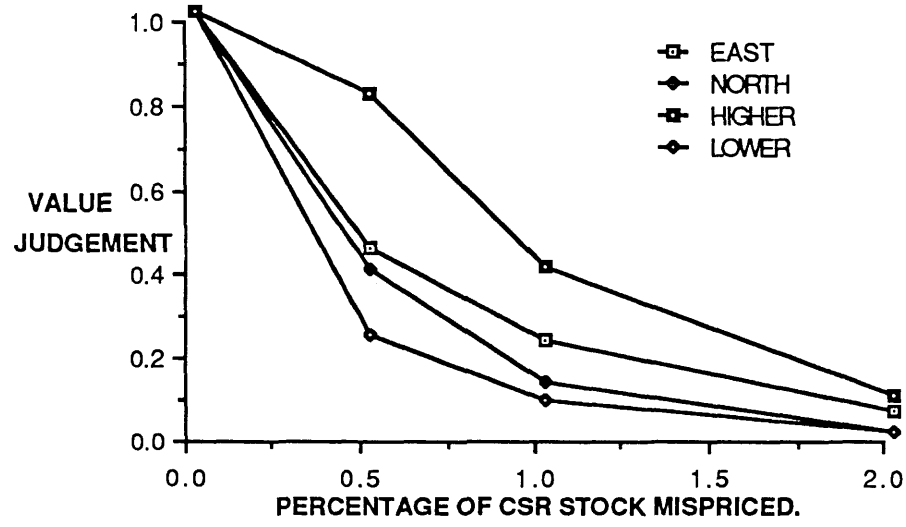
Group 1 MEMBERS		Group 2 MEMBERS	
03	28	01	18
07	29	02	19
12	31	04	20
16	32	05	21
17	33	06	22
24		08	23
		09	25
		10	26
		11	27
		13	30
		14	34
		15	

Aggregated results:

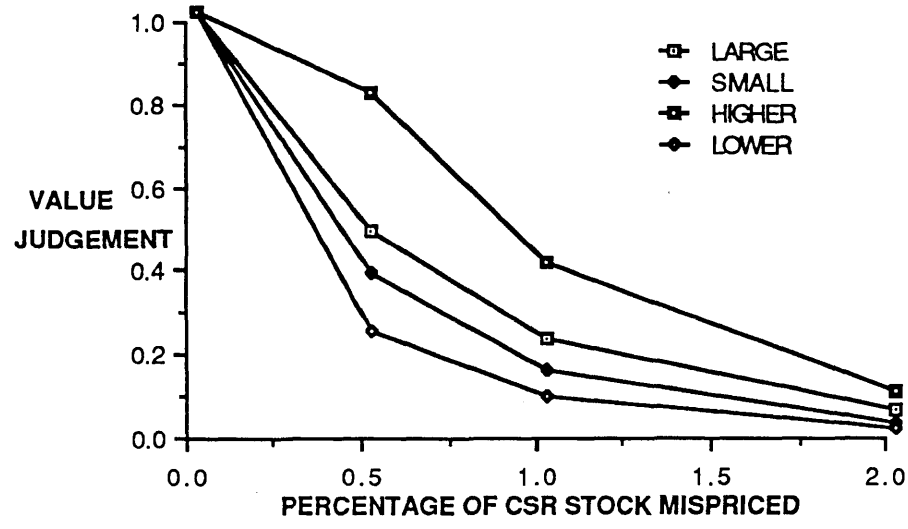
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
0.5	2.500	1.94	4.818	0.87	1.391	1.16	2.333	1.76	2.632	2.11	2.125	1.82	2.833	2.04
1.0	1.059	1.13	2.364	0.92	0.435	0.51	0.733	0.70	1.316	1.34	0.813	0.91	1.278	1.27
2.0	0.176	0.46	0.546	0.69	0.000	0.00	0.000	0.00	0.316	0.58	0.063	0.25	0.278	0.57

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is some evidence, to suggest that the market segmentation, proposed by the K mean clustering, should be used. However, the number of customers, in group 1, is rather small which thus reducing the overall benefits of using the segmentation policy.

Analysis for what type of service segmenatation should be used for service measure 19: "The number of working days difference between stock and invoices arriving."

k mean clustering results for two groupings.

Group 1 consists of 20 respondents.
Group 2 consists of 14 respondents.

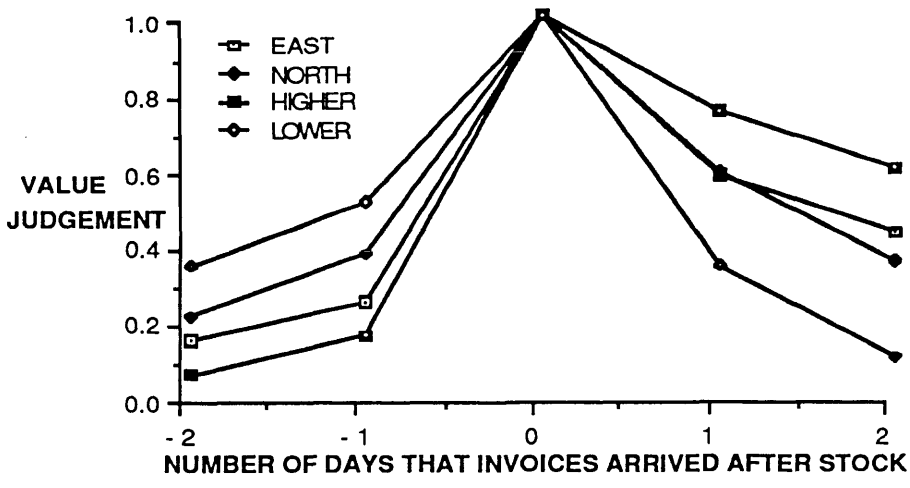
Group 1 MEMBERS		Group 2 MEMBERS	
02	17	01	22
06	18	03	23
08	19	04	24
09	20	05	25
10	27	07	26
11	29	16	28
12	31	21	30
13	32		
14	33		
15	34		

Aggregated results:

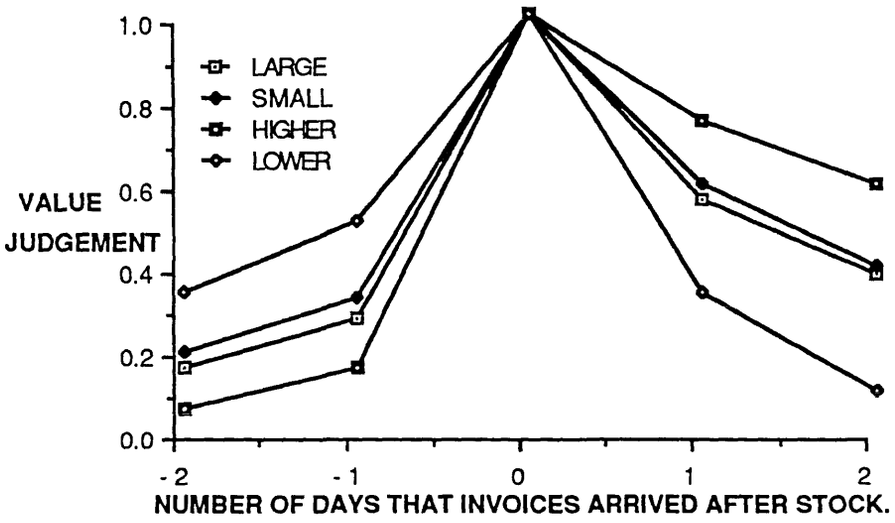
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
-2	1.000	1.69	0.300	0.57	2.000	2.21	1.200	1.61	0.842	1.77	1.125	1.54	0.889	1.84
-1	1.765	1.71	0.900	0.91	3.000	1.84	2.200	1.70	1.421	1.68	1.938	1.73	1.611	1.72
0	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
1	3.441	1.71	4.450	1.05	2.000	1.41	3.467	1.73	3.421	1.74	3.563	1.79	3.333	1.68
2	2.324	1.87	3.550	1.32	0.571	0.85	2.067	1.71	2.526	2.01	2.375	1.67	2.278	2.08

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is little evidence, to suggest it would be beneficial to use the market segmentations, proposed by the K mean clustering technique.

Analysis for what type of service segmenatation should be used for service measure 20: "The ASCOT service level."

k mean clustering results for two groupings.

Group 1 consists of 12 respondents.
Group 2 consists of 22 respondents.

Group 1 MEMBERS		Group 2 MEMBERS	
02	10	01	23
03	14	04	24
05	16	08	25
06	21	11	26
07	29	12	27
09	31	13	28
		15	29
		17	30
		18	31
		19	32
		20	33
		22	34

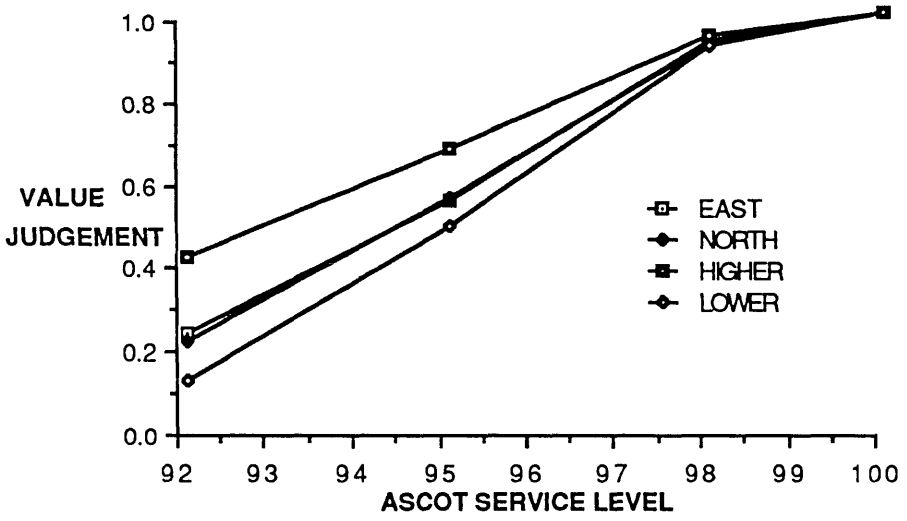
APPENDIX F

Aggregated results:

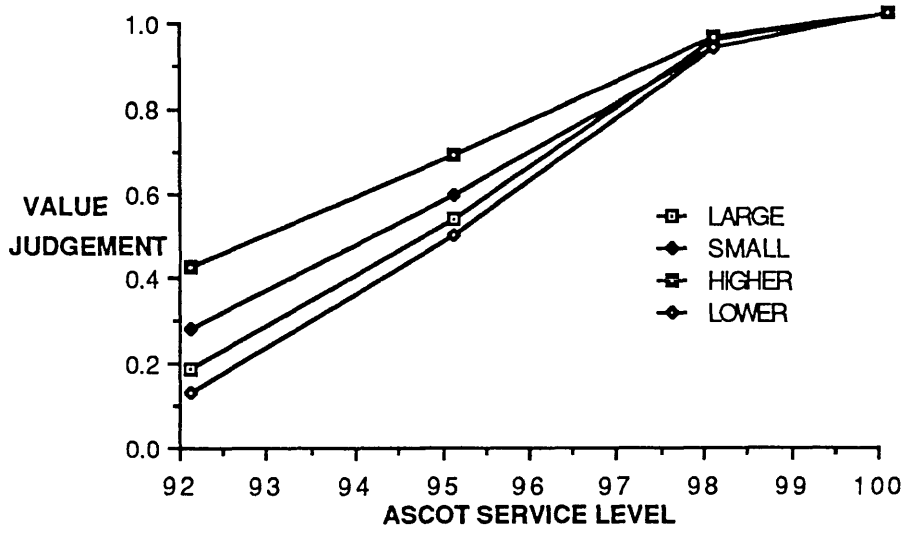
VALUE	TOTAL		GROUP1		GROUP2		NORTH		EAST		SMALL		LARGE	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
100	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00	6.000	0.00
98	5.559	0.56	5.667	0.49	5.500	0.60	5.533	0.64	5.579	0.51	5.500	0.63	5.611	0.50
95	3.265	1.05	4.000	0.60	2.864	1.04	3.267	1.16	3.263	0.99	3.438	1.03	3.111	1.08
92	1.265	1.05	2.417	0.79	0.636	0.49	1.200	1.15	1.316	1.00	1.563	1.26	1.000	0.77

The graphs showing the differences between segments produced by using company's market classifications and the segments produced by K Means clustering analysis.

a) Geographical regions:



b) Size of stores:



Comment:

There is little evidence, to suggest it would be beneficial to use the market segmentations, proposed by the K mean clustering technique.

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