THE IMPACT OF AGRICULTURAL POLICIES ON THE PERFORMANCE OF FUTURES MARKETS : AN EMPIRICAL INVESTIGATION OF THE LONDON WHEAT FUTURES MARKET

by

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Dedication

A mes Parents.

Abstract

One of the reason for the relatively slow development of agricultural commodity futures markets, when compared to the spectacular expansion experienced by the financial futures industry, can be found in the increasingly complex framework of agricultural policies.

While most of the literature has focused on the substitution between agricultural programs and futures markets with regard to risk management, little evidence, if any, can be found concerning the futures market performance operating within an agricultural policy. This thesis aims at contributing to this issue by analysing the performance of the London wheat futures market within the European Community (EC) wheat regime.

Chapter 1 outlines futures markets and the Common Agricultural Policy (CAP) characteristics, before introducing the hypotheses of the study. The hypothesis that the EC wheat regime has reduced the need for futures trading is tested in Chapter 2 where price risk in EC wheat markets is defined and assessed. A low but significant level of price risk is found which seems likely to be attributable to the CAP and particularly to the intervention system.

Chapters 3 and 4 explore the effect of these institutional factors on the risk-reduction function of the futures market. The basis performance is first investigated in Chapter 3 where the basis risk is calculated and identification of CAP-related economic factors influencing the basis behaviour takes place by econometric modelling. Chapter 4 focuses on hedging: the optimal hedging ratio and the hedging effectiveness are determined and assessed through various hedging strategies. Issues related to their stability and sensitivity to institutional factors are then addressed.

The influence of the CAP on the pricing performance is investigated in Chapter 5 where the forecasting function, the short-term price efficiency and the cost of trading of the futures market are examined. Results give some evidence of inefficiency in the pricing function of the market which are likely to be derived from the EC wheat regime arrangements. Yet, they do not appear to be strong enough to support the initial hypopthesis.

The informational role of the futures market in the wheat market price formation is explored in Chapter 6 where a commodity system of four markets, namely the wheat futures market, the UK forward market, the UK spot market and the French spot market, is analysed.

Interactions and informational links between these markets are empirically tested by various tests based on causality theory. Empirical findings suggest that the wheat futures market operates as a market leader in processing and generating information and do not support the initial hypothesis.

Conclusions and implications of the study are developed in Chapter 7. Evidence of significant alteration of the futures market performance due to EC wheat regime instruments are summarized. Consequences for policy-makers, economists and other agricultural operators involved in grain trading are finally reported.

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Abbreviations

AR	Autoregressive
BFE	Baltic Futures Exchange
CAP	Common Agricultural Policy
CBT	Chicago Board of Trade
EC	European Community
EMS	European Monetary System
HE	Hedging Effectiveness
HGCA	Home-Grown Cereals Authority
MA	Moving Average
MCA	Monetary Compensatory Amounts
OHR	Optimal Hedging Ratio
OLS	Ordinary Least Squares
RLS	Reverse Least Squares
SARIMA	Seasonal Autoregressive Moving Average
SUR	Seemingly Unrelated Regressions
SSR	Sum of Squared Residuals
SSE	Sum of Squared Errors
UK	United Kingdom

CHAPTER 1

Background to the Study

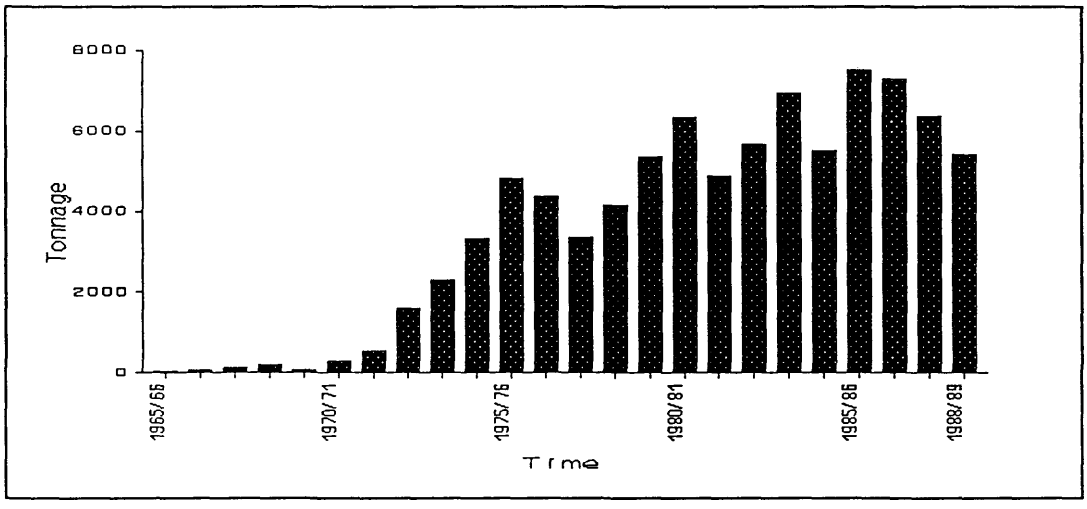
1.1 Introduction

Futures markets have witnessed a considerable expansion over the last decade, mainly in response to the rapid development of financial contracts. Nevertheless, agricultural commodities still account for nearly 25 % (Atkin, 1989) of the total volume of futures trading in the world and, as far as some commodities are concerned, prices quoted on futures markets are used as world price references. While the expansion of the futures industry took place in a relatively free market environment, agricultural commodity prices have been the subject of many regulation attempts. National and/or international intervention has constantly occurred. Agricultural policies and their effects in distorting market prices have made many agricultural commodity futures markets unviable. Yet little evidence exists on the compatibility between institutional or state intervention and futures trading. The reasons for this situation are twofold. The first reason is simple since some commodities operating under these conditions have ceased being traded, thus making any analysis impossible. The second reason comes from the nature and the origin of the futures market literature. Most of studies on futures markets have taken place in the USA and have focused on American futures markets whereas the impact of the American agricultural policy on prices was for many years somewhat different from that of agricultural policies, such as the Common Agricultural Policy (CAP), which affects more directly market prices. Operating within the framework of the CAP, the London wheat futures market offers a unique opportunity to examine the performance of a futures market dealing with a commodity whose marketing is highly regulated. This market has managed to survive and has even expanded throughout the 1980's, as shown in Figures 1.1 and 1.2, despite the full implementation of the CAP.

Chapter 1 introduces the general background to the thesis. It first describes futures markets, i.e. their organization and their mechanics, their functions and performance, the conditions of their successful development and finally their current state of development in the EC. A brief description of the CAP and the EC wheat regime is then given outlining the CAP

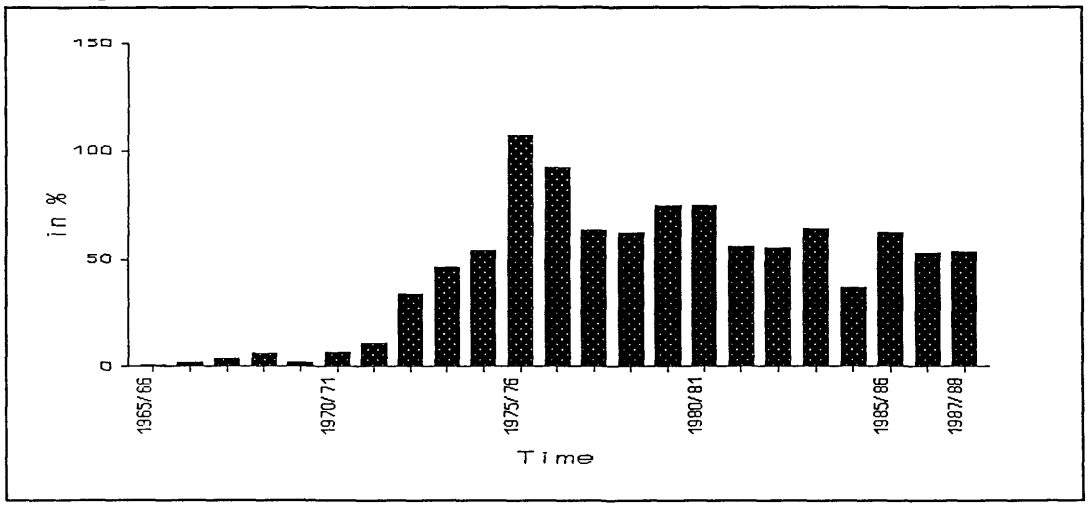
origin, objectives, mechanisms, achievements and recent developments. Then the EC wheat regime, the EC wheat market situation and the agri-monetary system of the CAP are briefly presented. Following these descriptions, the compatibility of futures markets and governmental intervention is discussed and a literature review is presented. This leads to the thesis plan and hypotheses.

Figure 1.1 Volume of trade on the London wheat futures market in '000 tonnes from 1965/66 to 1988/89.



Source: Grain and Feed Trade Association

Figure 1.2 Volume of trade of the London wheat futures market as percentage of Great Britain production from 1965/66 to 1988/89.



Source: Grain and Feed Trade Association

1.2 Introduction to futures markets

Markets have evolved in response to the necessity for trade and exchange of products. As pricing institutions, futures markets have been part of this constant development whose different stages have involved barter, cash (or spot or physical) markets and later forward markets. These markets have in turn developed into a highly institutionalized form referred to as futures markets.

1.2.1 Futures markets organisation and mechanics

Unlike other contracts involved in agricultural business, a futures contract does not involve the transfer of ownership of physical quantities of the underlying commodity, but rather the transfer of a commitment to make delivery of a standard quantity and of a standard quality at an agreed price during a given month in the future, the delivery month. Futures markets are essentially paper markets. Generally less than 5 % of the futures transactions leads to physical delivery. We must distinguish carefully between futures contracts and forward contracts; these two types of contract differ on at least two points: their formality and their performance as shown in Table 1.1. The diversity of traders represents one of the main factors of competitiveness of these markets. It is common practice to differentiate purely physical traders, known as hedgers, from those without any physical interest, known as speculators (Rutledge, 1972 and Cordier, 1984). Consideration of the membership of the Clearing House represents another way of classifying futures markets' participants.

Trading takes place by direct confrontation of supply and demand and is conducted by either "open outcry" for most agricultural commodities, or through an electronic system (Prior Willeard, 1984). Futures prices fluctuate in accordance with transmitted orders. Regulations exist to prevent erratic fluctuations in price arising from manipulation or psychological phenomena. These include the system of deposit margins, the maximum daily permissible price change and volume trading limits imposed on some classes of traders, especially speculators (Gemmill, 1980). Futures contracts are guaranteed by the Clearing House. This institution ensures fulfilment of a contract by placing itself between the seller and the buyer, and that the market is in equilibrium, with equal numbers of contracts bought and sold, and the cash books balanced. Following the dichotomy in the operators classification, two operations on the futures markets are commonly defined: hedging and speculation. Although no precise definition exists, the traditional view of hedging describes this operation as the taking of a position in futures equal and opposite to an already existing or immediately

Table 1.1 Some characteristics of forward and futures contracts

	Futures	Forward
Standardization	Uniform quantity, quality, location and delivery time	Specifications tailorable to fit the needs of the contracting party
Liquidity	Commensurate with trading volume at organized exchange	Almost no fungibility
Integrity	Guaranteed by Exchange Clearing House	Same as any legal contract
Payment	Over the life of the contract via the margin mechanism (marking-to-market)	Lumps sum cash transfer at contract execution
Settlement	Cancellation through offsetting transaction	Spot delivery
Transaction costs	Brokerage fees and margin income (cost)	Possible legal fees

Source: Extract from Nelson (1985)

anticipated cash position (Hieronymus, 1971). Easy access to futures markets as compared to physical markets makes the former very attractive for speculators. Furthermore the relatively small deposit and low transaction costs, due to high traded volume and their profitability even in the case of price decrease, make futures markets very highly geared, i.e. high expected return associated with small investment.

1.2.2 Futures market functions and performance

Three main functions have commonly been recognized in futures markets (Atkin,1989 and Mackel, 1980).

1. A risk reducing function arising from hedging. This function has long been considered to be the first role of futures markets which facilitate the temporal allocation of seasonally produced commodities and enable agents to shift their price risks to speculators (Gray, 1960, Labeck, 1978 and Edwards, 1981).

2. A price discovery function. The open access of the market, the participation of well-informed traders, their important liquidity and their rapid information processing and generating ability have made such markets an efficient mechanism for price discovery

(Tomek and Gray, 1970 and Kofi, 1977).

3. The establishment of forward prices which fulfil an inventory-guidance role for storable commodities (Gray, 1972).

It is also claimed that futures markets reduce spot price volatility and consequently improve short-term marketing and long-term investment decisions (Working, 1963 and Goss and Yamey, 1976). This additional function of futures markets has not been separately identified above since it arises out of the three functions already listed.

The identification of economic functions of the futures markets directly leads to the examination of the success of futures markets in performing these roles. Analysis based on theoretical grounds and empirical studies have shown that futures markets are among the most efficient types of markets, provided a sufficient liquidity exists (Cox, 1976). Detailed examination of futures markets performance and of some specific issues relative to futures markets takes place in later chapters of this thesis.

1.2.3 Preconditions for a successful futures market

In order to understand the degree of compatibility between state intervention and futures trading, one must introduce the prerequisites for a successful futures market. Even if these are not sufficient, their definition within an analytical framework has always been a difficult and somewhat controversial issue (Goss and Yamey, 1976, Hieronymus, 1971, Sturgess and Ashton 1974 and 1975). Seven necessary preconditions are outlined as follows:

1. Price volatility. Price volatility caused by market forces such as production, consumption or stockholding is a major determinant in the viability of a futures market. Without price volatility there is no need to hedge and no perspectives of profits for speculators.

2. A competitive underlying market structure. There must be a large number of producers, consumers and traders of the commodity in order to avoid a monopolistic or monopsonistic conditions which could lead to lower price volatility and to market manipulation.

3. A large underlying market. A volume or value of trade large enough to support a futures market is needed to attract operators on the market, particularly speculators.

4. The commodity should be homogenous. Easiness for grading, standardization and classification are of major importance for the definition of a satisfactory contract.

5. Cooperation. Cooperation from the trade and generally by those involved in the underlying market is important. By neglecting the demand for futures trading some futures markets have failed to develop (for example the tea futures market). This aspect may be one of the greatest challenges for the futures industry if it is to expand.

6. Adequate and freely available market information. This is needed to enable trading to take place in optimal conditions and to avoid any situation of information monopoly.

7. Market and institutional conditions. These must be suitable and conducive to futures trading. Market conditions should not be distorted by state or institutional intervention on the market.

1.2.4 Development of futures markets in Europe

The first futures markets were set up in 1730 in Japan and in the last century in the United States (Kolb, 1988). Grain was the first commodity to be traded on an organized futures market, with rice traded on the Dojima Rice Exchange and cereals on the Chicago Board of Trade in 1865. There are now many futures markets throughout the world and particularly in the USA. However, and even though the implementation of such markets is rather old in Europe, these speculative markets are still little developed in Europe, apart from the financial futures markets: the MATIF (Marché à Terme International de France) in Paris and the LIFFE (London International Financial Futures Exchange) in London. The turnover of the four European agricultural futures markets (London, Paris, Lille, Amsterdam) represents a very small percentage of the total production of their respective commodity (Terwitte, 1987).

The main agricultural contracts traded on futures exchanges in the EC include: wheat, barley, soyabean meal, pigmeat, live cattle and potatoes, as well as sugar, Robusta coffee and cocoa. The UK futures trading in grain began in 1883 in Liverpool while the Baltic Futures Exchange (BFE) started trading in 1897. Closed down during the Second World War, it reopened in 1954, trading imported feedgrains. Early development, from 1965/66 to 1971/72, was slow owing to the price stability and institutional factors such as the Cereal Deficiency Payment scheme (CDP) and the Forward Contract Bonus scheme (FCB), which

gave little incentive to operators to use the market. The developments on the world market, combined with the phase-out of the CDP and the FCB schemes and the transitional period to entry into the EEC, has created uncertainty which has boosted market activity on the BFE (Mackel, 1980). Since the accession of the UK to the European Community, the role of the BFE has changed and it is still described as a market of minor and local importance (Debatisse, 1982 and Rees and Colenutt, 1976), despite a volume of trade representing more than half the British wheat production (Figure 1.2). The London wheat futures markets operates now within the framework of the CAP. Introduction to the CAP constitutes the subject of the next part of this chapter.

1.3 The Common Agricultural Policy

1.3.1 Objectives and achievements

The Common Agricultural Policy is a cornerstone of the European Economic Community. Its establishment was one of the major objectives of the Treaty of Rome. Article 39(1) of the Treaty of Rome laid down five objectives for the CAP :

" (a) to increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and the optimum utilization of the factors of production, in particular labour;
(b) thus to ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture;
(c) to stabilize markets;
(d) to ensure the availability of supplies;
(e) to ensure that supplies reach consumers at reasonable prices." (Commission of the European Communities, 1958)

In short, the major goal was to ensure a reasonable income for farmers. There are three different aspects to the income objective (OECD, 1987). First, agricultural incomes are supported in order to achieve parity with non-agricultural incomes, and second, to reduce the wide variation in incomes within the agricultural sector. Third, the policy aims at increasing the stability of farmers' income. The market and prices policies of the CAP are based on three fundamental principles. These are :

. the principle of Unity of Market

. the principle of Community Preference
. the principle of Financial Solidarity

The CAP has developed a diverse and complex panoply of measures aiming at providing support prices for farmers, coupled with import and export mechanisms to shield them from the world market. Every product, or group of products, is affected by a specific legislation.

The CAP continues to be a remarkable achievement to the extent that it has allowed farmers to increase their agricultural productivity and production dramatically, as shown in Table 1.2. Yet the price of this achievement has been high. The cost of the CAP, together with the accumulation of unwanted surpluses, has become economically burdensome and a cause of widespread criticism. The growth of stocks is a consequence of the gap between production and consumption within the EC. This gap has made the EC become an exporter for some crops such as cereals, sugar, dairy products, beefmeat.

Table 1.2 Self-sufficiency[+] in percentage, EC-10

Production	1973/74	1983/84	1987/88
Wheat	104	134	119
Barley	105	120	117
Grain/Maize	55	84	91
All meat	96	101	102
Wine	103	103	107
Butter	98	134	N/A

[+] Usable production as a percentage of domestic uses.
Source: EUROSTAT

This rise in self-sufficiency was the inevitable outcome of a price and market policy which has encouraged an increase in production by a high price support system, introduced principally in order to raise the agricultural revenue, while the technological and biological progress enabled farmers to greatly increase production. This sharp increase of supply has contrasted with a stagnant consumption held down within the Community by low population growth and a declining proportion of consumer expenditure on food.

Exporting these surpluses has become very expensive. The large difference between the World price and the EC Common price has led to very onerous exports refunds. The cost

of the CAP is threefold; first, a huge guarantee cost (95 % of the total CAP budget) which induces imbalance between the price policy and the structural policy; secondly, a constant need to increase price in response to price pressure from the depressive effect of the production increases; thirdly, a greater risk of international trade war.

1.3.2 The 1984/85 package

By 1985, the CAP had not achieved its stated objectives but still absorbed a growing share of the European budgetary resources. A reform package was then established[1]. This reform package marked a turning point in the CAP history. Within the Community of Ten and for the first time in fifteen years, the average increase in agricultural prices became negative. It was the beginning of a restrictive price policy which still prevails to the present day. However, one of the conclusions drawn from the 1985 consultations was that price policy was not sufficient to move production into line with demand. The Community failed to give market prices a greater role in guiding supply and demand within the Agricultural Policy and has since been drawn into a labyrinth of administrative measures for the quantitative regulation of production.

Some measures related to the intervention system and its quantitative and qualitative availability were taken in order to return the system to its original purpose: namely a safety net and not an artificial additional market outlet. Other measures such as the principle of co-responsibility for some products were introduced to make farmers contribute to the cost of disposal measures. However the price policy has been undermined by the agri-monetary system which allows Member States to modify the green conversion rates of EC institutional prices. This last system has been one of the most important constraints for any attempt to reform the CAP over the last ten years as it has provided an opportunity for national control.

1.3.3 The 1988 package

A new package of reforms was drawn up and adopted at the beginning of 1988. This package of measures aimed to provide the basis for controls on agricultural spending by establishing

[1] The Common Agricultural Policy, its performance and its evolution have generated an extensive literature (Tarditi, 1985) which has focused on three main issues : resource allocation, income distribution and other non-economic objectives. Most writers have formulated criticisms and concerns about the real goals and effects of the CAP. Apart from financial and social costs and benefits produced by sectoral policies, these studies also question the role of state intervention in agriculture.

production stabilising mechanisms, so-called stabilisers, for commodity regimes and to establish a new basis for financing the Community's budget. More specifically, it included production thresholds for cereals and oilseeds, plans for the setting aside of agricultural land and a new budget framework (Home-Grown Cereals Authority).

Having outlined the main features of the CAP, we now focus on the wheat regime. The understanding of the objectives and of the workings of this regime is fundamental to the present study. Indeed, whilst the EC wheat regime was devised for relatively little official intervention in the market development, market prices levels have been increasingly dependent on EC decisions on matters such as the levels and the availability of export refunds, arrangements for intervention purchases and the agri-monetary policy[2].

1.3.4 The EC wheat regime and EC market situation

1.3.4.1 The EC wheat regime

The main features of the wheat regime involve a common internal pricing system and a regulated trading system with third countries. The regime consists of three basic components (Home-Grown Cereals Authority):

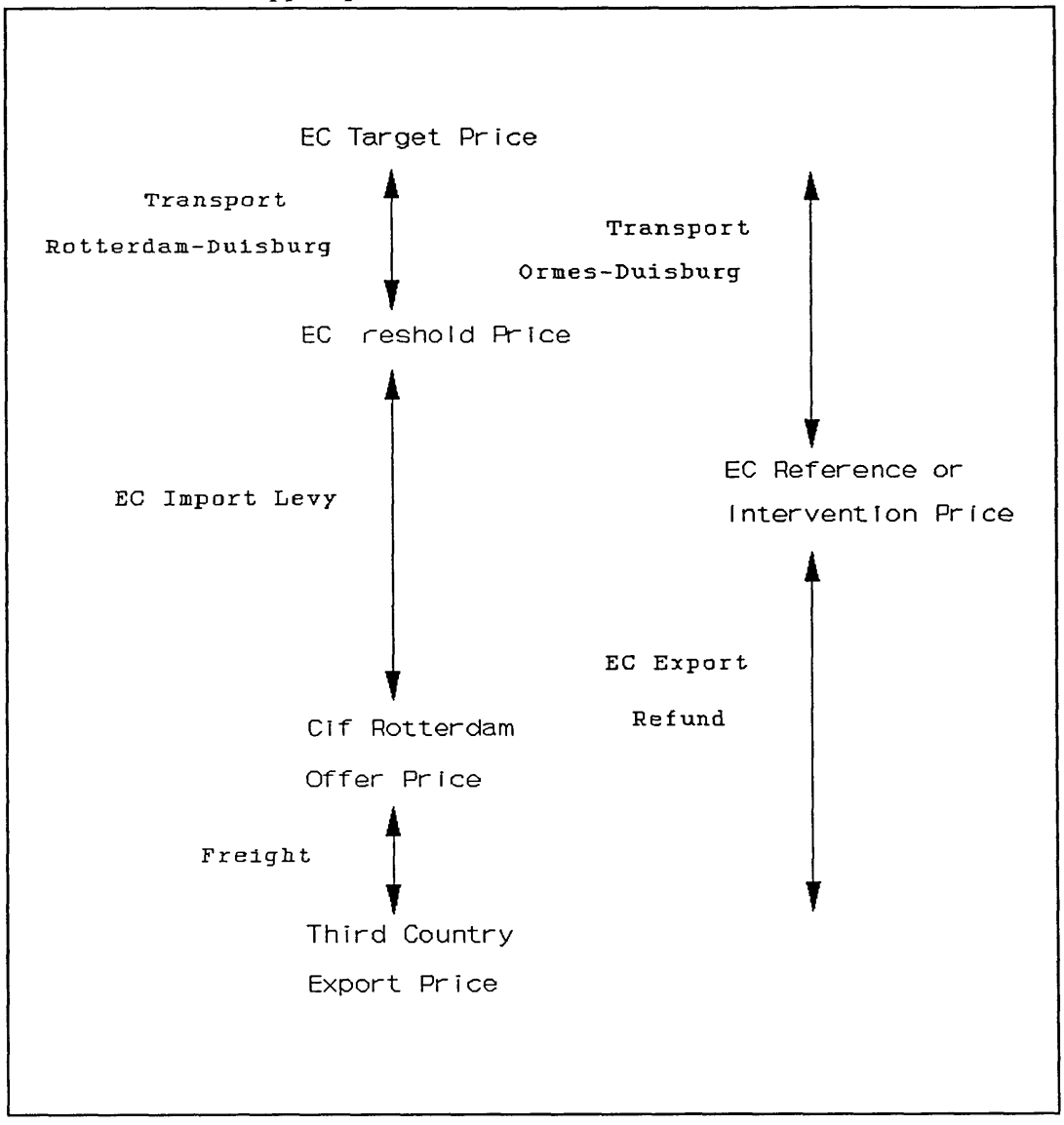
. the target price, which is the price, it is hoped, producers will receive in the area of greatest deficit in cereals, and from which the threshold price and the size of EC import levies are determined.
. the intervention price, at which Member States are obliged to buy grain offered to them.
. export refunds, the level and the amount of which are determined by the Commission and which enable grain to be exported on the world market if there is no market within the EC.

The relationship between these institutional prices is expressed below in Table 1.3. The marketing year for cereals starts in August and ends in July. However,from the start of the 1986/87 season the marketing year was brought forward by one month so that now it runs from July 1st to June 30th. Support prices during each season are increased by monthly increments. The rationale behind this measure is to ensure a continuous and orderly pattern of marketing over the year. The common prices of the cereals regime[3] are set each year at

[2] Detailed introduction to the agri-monetary policy of the EC is reported in Chapter 2 for it is at the core of the EC-intra wheat trade.
[3] The pricing and external trade systems are described in more details in Appendix 1-A.

the annual price-fixing review of the Council of Agricultural Ministers and apply for the following marketing year.

Table 1.3 Basic EC support price structure for wheat



Source: Home-Grown Cereals Authority

More recent developments have mainly affected the intervention system. Before the 1987/88 season the intervention price was the delivered-to-store price at which Community purchases were made (with adjustment for any variation in quality). Since then, a lower buying-in price has been set by the Commission at 94% of the basic July intervention price. At the start of the 1986/87 marketing season, restrictions on the availability of the intervention system were implemented. While offers for intervention could have been made

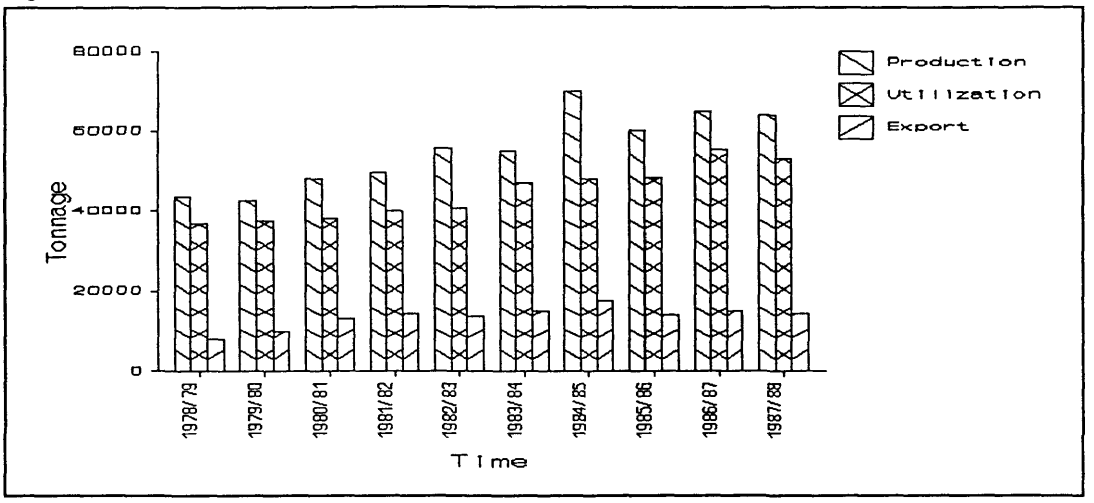
at any time in the season, (apart from bread-making wheat for which offers were limited from August to October and for a limited quota), stores were only opened at the beginning of September for Northern States, which includes the UK, with an extra delay of thirty days in payment in that month. For the 1987/88 and 1988/89 seasons, delivery into intervention was only allowed during the October-May period although the trigger price mechanism has been dropped. In 1989/90 the intervention period was reduced to the November-May period for the Northern States. Since the start of the 1987/88 season, increments have also been applied to the intervention price only during the November-May period while still added to the target and threshold price from August to May.

Grain is commonly traded on the open market at levels below the intervention price. The first reason for this situation comes from the very nature of the price since the intervention price is a delivered price, i.e. not an ex-farm price. The non-fulfilment of quality and quantity standards can lead to direct rejection of the grain or to price penalties. These requirements also put downward pressure on market prices. Since January 1984, a delay has been imposed on the payment for grain sold into intervention. Initially set at between 120 and 140 days after delivery of the grain, it was reduced to between 90 and 120 days in 1985/86 and 1986/87 and, since 1987/88, to between 110 and 115 days. These delays reduce the real intervention price received by farmers. Further reduction in the availability of the intervention system to a specified period within the marketing year has now removed the intervention price as an absolute price floor.

1.3.4.2 The EC wheat market situation

Growth in production (Figure 1.3) has occurred through the seventies but has shown a marked increasing trend in the eighties. This upwards trend has reflected a significant increase in yields resulting from high support prices relatively to input prices and better farm management (Harris et al., 1983). Yet the increase of production has favoured the development of low protein varieties unsuitable for milling. Furthermore the surge in production has not been matched by an increase in demand. The latter remained static throughout the whole period, associated with growing competition from imported grain substitutes, market saturation for food grain and improved output per unit of grain fed and feed composition in the livestock industry.

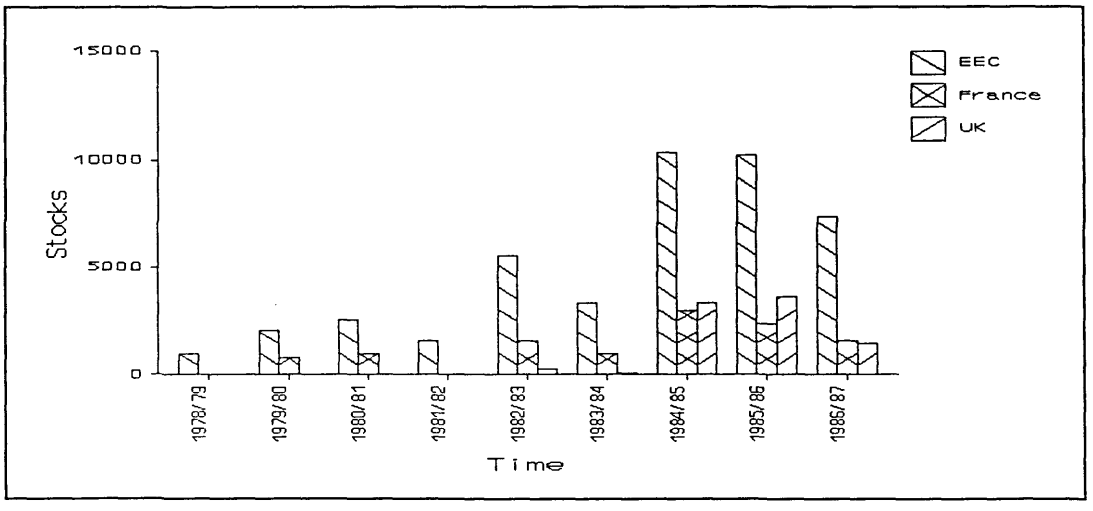
Figure 1.3 EC-10 Soft wheat supply balance in '000 tonnes from 1978/79 to 1988/89



Source: Home-Grown Cereals Authority

The amount of grain taken into intervention, though fluctuating from season to season, has thus shown an upwards trend with peaks during the 1982/83 to 1985/86 period. Lower harvests in the Community and active export markets have since then reduced intervention store levels (Figure 1.4). Situations of the EC wheat markets are shown in Figures 1-B.1, 1-B.2 and 1-B.3 in Appendix B with particular reference to the French and UK markets. These two countries have significantly increased their production as well as their exports of wheat over the last fifteen years, especially the UK after 1980/81 when it became a net exporter of wheat.

Figure 1.4 Wheat intervention stocks (closing stocks) in the EC, the UK and France, in '000 tonnes from 1978/79 to 1988/89



Source: Home-Grown Cereals Authority

1.4 The agri-monetary system of the EC

We now attempt to show the mechanism by which the agri-monetary system of the EC has created pricing distortions and hence may have had an impact upon the use and the effectiveness of the futures market. The principle underlying the application of the agri-monetary system is that trade into or out of a Community Member State should take place at a common price level (Agra-Europe). This level is assumed to be the appropriate support price level expressed in ECU and converted into national currencies using the market exchange rate. For agricultural purposes, the price is then translated into local currency using the green rate and not the currency central rate (initially assumed to be equal to the market exchange rate). France, for instance, has kept a strong green rate relatively to its central rate in order to avoid food price inflation. Hence, the effective intervention price in France is lower than the EC's Common intervention price. Such price differences across the EC would have led to artificial trade flows from one country to another. The EC has avoided this resource wastage by imposing a system of tax and levy on intra- and extra- EC trade. Known as the Monetary Compensatory Amounts (MCA) system, it aims to adjust the price of wheat traded between two countries. For a country such as France, a negative MCA offsets the gap between the internal EC Common price and the real Common price by acting as a tax on exports and a subsidy on imports. French traders can trade at the real Common price level while obtaining a lower internal price.

Though the underlying concepts of the MCA system are relatively straightforward, their translation into practice has created a complicated and rather expensive system. The practical application of the agri-monetary system to intra-EC trade has to obey several rules before the final calculation of the actual MCA. There is a number of specific arrangements which may undermine the application of the MCA system (Fulton, 1988)[4]:

1. the franchise or neutral margin
2. the non-cumulative rule
3. the minimum change rule
4. The MCA fixation delay
5. MCA calculation basis
6. Fluctuations of the market exchange rate around the central rate

[4] Detailed description of these specific arrangements takes place in Appendix 1-A.1.

Bearing in mind the recent increasing gap between intervention price and the market price, intra-EC trade no longer takes place at the support price level. The relation between the market prices of France and the UK for instance can be described as follows

$$PD_t - (MCA^{Fr} * P^{Fr}_{int}) + P^{Fr}_t = [P^{UK}_t - (MCA^{UK} * P^{UK}_{int})] * ER_t(£/FFr)$$

where MCA^{Fr} and MCA^{UK} are the MCAs for France and UK in percentage terms. P^{Fr}_{int}, P^{Fr}_t, P^{UK}_{int} and P^{UK}_t are the intervention price and the cash price for France and UK respectively. PD_t is the margin of fluctuation between prices prevailing on the French domestic market and the UK market, converted into FF under the agri-monetary system. PD_t must also incorporate wheat quality difference, transport cost between the two countries and marketing conditions relative to the contract formulation (insurance, etc).

1.5 Agricultural policies and futures markets

Literature has frequently focused on the opportunity for substitution between agricultural programs and futures trading (Petzel, 1985, and Randall, 1985). The role of agricultural policies and futures markets have then been compared with regard to their price risk management function. Yet, futures markets differ significantly from price-support programs such as the CAP in terms of their roles. Futures markets do not generate market prices different from those determined by supply and demand conditions while state intervention has frequently set market prices above long-run market-clearing prices. The price enhancement objectives of agricultural policies contrast with futures markets which provide agricultural operators with a risk management tool but do not alter market price equilibrium[5]. In fact, the relevant question here is whether these two mechanisms can be complementary. Futures markets are based on the notion of pure competition which includes the following four requirements: homogeneity of the product, the smallness of each buyer and each seller relative to the market, absence of artificial restraints, mobility of goods and perfect knowledge of the economy on the part of operators in the market (Chamberlain, 1933). The CAP has distorted market conditions by fixing a price floor, a price ceiling and an external trade policy. This may well affect the working of markets since prices are now highly dependent on political decisions rather than market conditions.

[5] The other main difference between price-support policies and futures markets have been their cost, as far as producers and consumers are concerned.

Indeed, Peck (1985) has claimed that futures markets and agricultural policies may only be substituted. She contended that, when price supports are above market-clearing prices, futures markets may have difficulty in operating efficiently and in fulfilling their functions referred to earlier. In that sense, agricultural programs and futures markets may be substitutes: a country may have either but may not have both. The CAP appears hardly compatible with futures trading since the former already fulfils the three primary functions of futures markets as listed in 1.2.2. By reducing price risk, the agricultural policy lowers demand for hedging. The function of establishing forward prices and the price discovery role of futures markets also become somewhat useless and redundant. Moreover the level of liquidity required by the market to achieve pricing efficiency may not be reached since speculators may be driven away from the market by the low level of financial opportunities on the market and the dominant position of institutional influence (Gray, 1960).

Yet the existence and the development of the London wheat futures market seems to contradict these arguments. The presence of a wheat futures market in London may possibly be due to the existence of price risk derived from the institutional complexities of the EC wheat regime and the erratic decision-making in the implementation of the program. Nevertheless, we may question the viability of such a futures market in efficiently performing its primary functions. The detrimental effect of governmental intervention on futures markets activity and performance is supported by the literature. Gray, in 1960 on the coffee market, in 1962 on the wheat market and in 1976 on the sugar market, and Yamey (1959) and Brand (1964), on the cotton market, have analysed the effects of institutional factors on futures markets. Mackel (1980), studying the London wheat futures market in the seventies and referring to the potential existence of an institutional price risk, writes "it has been argued that price uncertainty of this type will induce a bias into futures prices and reduce the effectiveness of its role of inventory regulation" (pp 42). It is the purpose of the present thesis to investigate the impact of these institutional factors on the performance of the London wheat futures market.

1.6 Hypotheses and plan of the thesis

The underlying hypothesis of the thesis is that the performance of the London wheat futures market in fulfilling its economic functions has been directly affected by the EC wheat regime. Analysis of the above hypothesis is elaborated by examination of several sub-hypotheses.

The first sub-hypothesis is that not only has the CAP removed most of the market price risk from EC wheat markets, but it has also generated an institutional price risk, thus justifying the existence of a wheat futures market. Analysis and test of this sub-hypothesis takes place in Chapter 2 where the concept of risk is defined and empirically assessed using data the UK and French domestic markets as well as data from intra-EC trade between these two countries.

The second sub-hypothesis is concerned with the fulfilment of the primary role of risk management by futures markets. We hypothesise that the effectiveness of the London wheat futures market in reducing price risk has been modified by the existence of the EC wheat regime. Examination and test of this sub-hypothesis is undertaken in Chapter 3 and 4 where study of the basis performance and of the hedging function, i.e. optimal hedging ratio determination and assessment of the hedging effectiveness, takes place.

The third sub-hypothesis refers to the pricing function of the futures market. We hypothesise that the pricing performance of the futures market, i.e. the trading cost, the forecasting performance and the price efficiency, has been detrimentally affected by the EC wheat regime. Investigation and test of this sub-hypothesis is reported in Chapter 5.

The fourth sub-hypothesis is related to the price discovery function of the futures market. It is hypothesised that the annual price-fixing and the implementation of institutional prices has altered the informational role of the futures market. This sub-hypothesis is tested in Chapter 6 where a system of four wheat markets, i.e. the UK forward market, the UK and French cash markets and the London wheat futures market, is examined.

The summary of the main findings and conclusions, their policy implications and opportunities for further research are finally developed in Chapter 7.

1.7 Limitations to the methodology

The analysis of the influence of the Common Agricultural Policy on the performance of the London wheat futures market does not take place within a comparative framework. Comparison of the performance of the London wheat futures market before and after the implementation of the CAP, or with another wheat futures market operating under a price support regime (eg in the US), might strengthen the results by highlighting the very specific features and characteristics derived from the establishment of the CAP.

Such a comparison was not attempted for the following reasons:

Firstly, the requirements, with regard to the amount and the quality of data, necessary for a pre-CAP/post-CAP comparison are not fulfilled since the 1964/75 period, not covered in this study, corresponds to the very early development of the London wheat futures market when data was scarce. In addition, there would likely be bias in the measurements of the performance of the market in its early stage because the establishment of the Deficiency Payment scheme and the Forward Contract Bonus scheme. These factors distorted the way the futures market operated in that early period, making any comparative analysis difficult and possibly misleading.

Secondly, the lack of recent analysis of wheat futures market performance using the methods here proposed prevents us from undertaking any direct comparative study. In addition, the concentration of this type of market in the USA, where the operation of the American agricultural policy is also very specific, does not provide a suitable framework of comparison.

While the absence of such comparisons does not affect the results themselves, it does constitute a limitation in the possible conclusions which may be drawn since, in some cases, the direct causal link between the CAP and the degree of futures market performance is difficult to identify formally.

Finally, as with many economic studies, our hypotheses are here tested by measuring some characteristics of the futures market performance and by assessing whether the empirical results are consistent with the initial hypothesis. Although this approach does not allow us unequivocably to accept or reject the four sub-hypotheses introduced above, it nevertheless can provide important insights on the way the CAP influences the performance of the wheat futures market.

The causal link between the CAP and the hypothesised results is only expected to be fully explained in the second sub-hypothesis. The empirical investigations carried out in this study can only reject the other stated sub-hypotheses but cannot unequivocably accept them. Testing a necessary link in the causal chain may provide an alternative and perhaps more conclusive approach. Yet, it remains very difficult to clearly identify and define.

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CHAPTER 2

Definition and assessment of spot price risk

2.1 Introduction

Chapter 2 tests and examines the first sub-hypothesis of the thesis which is that the CAP has not only strongly reduced market price risk from EC wheat markets but that it has also generated an institutional price risk. The first part of this chapter defines the concept of risk and identifies the framework within which analysis of decision-making under uncertainty takes place. It develops the theoretical foundations necessary for the study of agents' behaviour in futures markets. Sources of risk derived from the market and the EC wheat regime are then identified and discussed, with particular reference to the agri-monetary system which distorts intra-EC trade and the influence of the setting of export refunds. The third and last part of the chapter undertakes an empirical investigation of market price risk by considering the wheat price risk alone and within a portfolio of agricultural commodities. Examination of the wheat contribution to a total portfolio risk is derived from agricultural operators' strategies which frequently involve trading in several commodities.

2.2 The concept of risk

2.2.1 Definition of Risk, uncertainty and riskiness

'Certain' and 'uncertain' are adjectives used to describe events. Certain events are events that have only one possible outcome while uncertain events are events with more than one possible outcome. An event is said to be risky when its precise outcome is not known at the time when the decision must be taken (Webster, 1977). Fleisher and Robison (1985, pp 3) similarly propose a definition by asserting that "risky events are a set of uncertain events which alter the well-being of either a well defined class of decision makers or a single decision maker. Riskiness also results from the realization of possible events which are supposed to be uncertain or random and which define state of the nature." The authors here introduce the concept of well-being since it depends on the decision makers' attitude. Thus, the concept of riskiness depends on the preference of an individual or a class of individual

decision makers.

The definition of risk has always been difficult to elaborate. Knight (1921) associated objective probabilities with risk and subjective probabilities with uncertainty. More specifically, objective probabilities were generated from empirical observations or based on general principles (available information) while subjective probabilities, which he saw as not true probabilities, were ratios of perceived likelihoods (no available information).

Roumasset asserted that "in modern decision theory, uncertainty is a state of mind in which the individual perceives alternative outcomes to a particular action. Risk, on the other hand, has to do with the degree of uncertainty in a given situation"[6]. In our analysis, we reject the distinction between risk and uncertainty as well as the concept of well-being. Risk is assumed to be the unforeseeable and unpredictable component of any change of outcome derived from an uncertain event. Furthermore we make the assumption that risk can be measured by statistical parameters. This introduction to risk leads to the study of its effects on decision making in agriculture.

2.2.2 Analysis of decision making under risk

2.2.2.1 The decision problem

A decision problem must have more than one action choice available to the decision maker. The outcomes which may result from an action choice depend on unknown states of nature, to which the decision maker assigns a probability. To order all these outcomes is difficult and needs decision rules which incorporate individual beliefs, preferences of decision makers and, in part, their attitude towards risk.

2.2.2.2 Measures of risk by probabilities

The probabilist approach refers to the attribution of numerical expectation degrees to changes taking place in the value of variable components of a global calculation. Fleisher and Robison (1985) refute the distinction between subjective and objective probabilities arguing that, even for past events, probabilities are subject to human judgements, which can be

[6] Introduction to the proceedings of the Agricultural Development Council - CIMMYT conference on risk, uncertainty and agricultural development (1979).

different even with the same information. Decision makers take their decisions on the basis of their own ideas of probability (Savage, 1964). They estimate the risk of a variable once they know the probability distribution of this variable. The analysis of this distribution can be expressed by statistical parameters such as mean, variance and standard deviation. There exist many different parameters of risk measure and "a difficulty is that every decision-maker may have his own ideas as to what is to him the important parameter (Webster, 1977, pp 244)". Yet the probabilist approach just constitutes the first step of the consideration of decision making under uncertainty. We now need a theory of choice in order to explain choices or to base our reasoning on choice criteria in uncertainty.

2.2.2.3 The Expected Utility Hypothesis

There are generally two main categories of models of decision making under uncertainty (Fleisher and Robison, 1985). The first category refers to those in which the decision maker maximizes more than one objective or maximizes that objective subject to certain constraints. They are the safety-first models which include the maximax and minimax rules models, the safety-first models (focus-loss model) and the lexicographic ordering models. The second category in turn considers those in which the decision maker maximizes a single objective such as utility. It includes the Expected Utility Hypothesis models.

The second category of models has long included decision rules based on the weighting of outcomes according to their monetary value and on the selection of the action choice with the highest expected value. Their advantage over safety-first and lexicographic ordering rules lies in the use of a unidimensional preference index which allows homogeneous comparative analysis. Yet, many theorists argue that an expected profit maximization approach is not adequate for modelling decision making under uncertainty, because, as Bernoulli showed, the degree of satisfaction we can have from income is not a linear function of the amount of money. Bernoulli's analysis (1954) found an inconsistency between the expected value and the real decision makers' behaviour. He postulated that first, the real value of money depends on the wealth state of the decision maker and second that involved decision makers maximize expected utility expressed by the log function of outcomes rather than expected monetary value. However he did not address the issue of how to measure utility, nor why his expectation principle would be rational. From Bernoulli's statement, von Neumann and Morgenstern (1944) developed the Expected Utility Hypothesis (hereafter EUH) which incorporates the decision maker's utility for income and his attitude towards risk into a preference ordering rule. This approach now constitutes the basis of most of the

work on the economics of uncertainty.

The EUH asserts that if a decision maker's behaviour is consistent with four axioms of "rational behaviour" he will weight outcomes of action choices according to a personalized and unique function U(P) (Baumol, 1972, pp 548-551). The expected value of U(P) for each action choice provides the single valued index which orders action choices in accordance with the decision maker's preferences or attitudes towards risk.

The four axioms of "rational behaviour" which expected utility maximizers are assumed to follow are the axioms of ordering, transitivity, continuity and independence. In addition to the already introduced axioms, the EUH assumes that individuals respect a further two initial conditions: first they can identify a set of action choices, and second they can associate probability density function with the action choices. Alternative sets of axioms, resulting in the same general theorem, have been presented by Hernstein and Milnor (1953), Savage (1954), Pratt, Raiffa and Schlaifer (1964) and Fishburn (1970).
The EUH prescribes the following solution for an uncertain decision problem:

. identify the action choices and the possible states of nature under which the action choices may be experienced,
. assign probability weights to the states of nature consistent with the probability calculation,
. calculate the expected utility value of the consequences for each action choice,
. and implement the action choice with the highest expected utility.

The utility function is a device for attributing numbers or an index to possible outcomes of an uncertain prospect in order to help the decision maker to select from among a set of prospects. Schoemaker (1982, pp 538) reports nine normative variants of the Expected Utility model, differentiated by the treatment of utility and probabilities. We henceforth refer to von Neumann - Morgenstern theory when dealing with the Expected Utility Theory.

2.2.2.4 Conclusion

Although empirical tests of the model have not given it unconditional support (Haneman and Farnsworth, 1980), the expected utility hypothesis is considered by many decision theorists (Lin et al., 1974) to be the best available model of decision making under uncertainty. Schoemaker (1982) asserts that at the individual level, expected utility is more the exception

than the rule. He bases his critical judgement on the assessment of the four major perspectives in the Expected Utility model use, i.e. descriptive, positivistic, postdictive and, finally, prescriptive or normative. Yet by offering a framework for discussion, Expected Utility is and still remains, until richer models of rationality emerge, "a worthwhile benchmark against which to compare and towards which to direct behaviour" (Schoemaker, 1982, pp 556).

Our analysis considers that operators behave according to the Expected Utility Hypothesis. Under this assumption, agents act as though they have a utility function defined over the consequences of their choices, and choose the action which maximizes the expected value, not of the outcome, but of the utility of the outcome. Then, agents need to know only the consequences of their choices and their probabilities.

Risk aversion is an important concept in Expected Utility theory. If some gamble is less (or more) preferred than its monetary value for sure, the preference is said to be risk averse (or risk seeking). A concave utility function implies risk averse preferences within the range of concavity. The individual's attitude towards risk is considered in the following paragraph.

2.2.3 Local measures of attitudes towards risk

We can measure risk aversion either by the coefficient of absolute risk aversion or by the coefficient of relative risk aversion, or by the coefficient of partial risk aversion. The first one is the Arrow-Pratt coefficient of Absolute risk aversion, defined as follows,

(2.1) $R(Y) = -U''(Y) / U'(Y)$

with U the utility function and Y the level of wealth, and which measures behaviour as wealth increases and scale of gamble remains the same (Arrow, 1951 and Pratt, 1964).

The Arrow-Pratt coefficient of Relative risk aversion measures the elasticity of the marginal utility of wealth. It is defined as

(2.2) $Rr(Y) = -Y.U''(Y) / U'(Y)$

and measures behaviour as both wealth and scale of gamble increase. Both coefficients are positive for risk averse individuals, zero for risk neutral individuals and negative for risk

loving individuals.

The coefficient of Partial Relative risk aversion is interesting owing to its simplicity of calculation. Developed by Menezes and Hansen (1972) and Zeckhauser and Keeler (1970), it aims at measuring behaviour as size of gamble increases and wealth remains the same. Note should be taken of the distinction between risk aversion "in the small" and "in the large" (Pratt, 1964). But evidence (Fleisher and Robison, 1985) shows that these measures are local measures and cannot justifiably be used to order individuals according to their attitudes towards risk "in the large" as it is currently practised in the empirical studies of decision under uncertainty. Moreover there exists a distinction between two concepts measured by the utility function : the attitude towards risk and the strength of preference for the consequences under uncertainty.

2.2.3.1 Utility functions

We limit our field of study to unidimensional utility. A utility function may be elicited by the gathering of points of indifference between two gambles (Anderson et al., 1977). An algebraic representation of the utility function is needed to permit the utility value of any outcome to be computed and to ease calculation of the function's derivatives for analytical decision procedures. For that purpose, a variety of functional forms are available. We generally distinguish three main types of utility function:

. the utility function with constant relative risk aversion coefficient (e.g. semi-log and log linear utility function)
. the utility function with constant absolute risk aversion coefficient (e.g. exponential utility function)
. the polynomial function (e.g. the quadratic)

The quadratic form of the utility function is the most widely used as it provides a concave function, in line with the risk averse individual's requirement, and great ease of utilisation. Critics (Arrow, 1965 and Pratt, 1964) have pointed out an important weakness of the quadratic form since it increases regularly with wealth, while one may intuitively expect it to decrease. In a research context, much of choice behaviour under uncertainty is characterized by the absolute risk aversion coefficient. The functional form of the utility function is important as it carries important implications in terms of behaviour. Some evidence shows that attitudes towards risk are not stable over time and wealth levels, or

across situations (Markowitz, 1952 and Love and Robison, 1984).

2.2.3.2 Mean-Variance analysis

This approach is popular as it enables the analysis of the effects of risk on welfare and behaviour simply in terms of the expected values and variance of the probability distributions of outcomes. But like most convenient models, it makes strong assumptions which may prejudge the answers to important questions. It assumes that the distribution of risky outcomes is normal. Agricultural output may not be normally distributed (Newbery and Stiglitz, 1981). For such decisions, mean-variance analysis may be seriously misleading. This hypothesis also suffers several other shortcomings since the decision-maker may be concerned about higher moments of its outcome probability distribution and since profits are considered as the only action-outcome in the utility function. As Young (1979) notes, by assuming a mean-variance model, the variance (or any related statistical measure of dispersion) represents the appropriate "measure of risk". Criticisms include Rotschild and Stiglitz (1971) and Meyer (1974).

Three special cases illustrate the advantages of the mean-variance analysis.
1. The Constant Absolute Risk Aversion coefficient depends only on the standard deviation and not on the mean of income. Yet it follows from this assumption that a change in wealth does not affect the choice of a risky portfolio which seems improbable. However, since it is almost impossible to reach an equilibrium solution with general utility functions, the constant absolute risk aversion case, by separating out the risk and wealth effects, offers a simple methodology.

In this case the certainty equivalent Y^c can be described as:

$$(2.3) \qquad Y^c = E(Y) - \tfrac{1}{2}.(A.Var(Y))$$

with A the absolute risk aversion parameter, E(Y) the expected level of income and Var(Y) the variance of the income. Portfolio choices, in which assets are jointly normally distributed returns, satisfy this condition. The comparison of two decision-makers' attitudes towards risk can be inferred from the risk premium calculation using this method.

Portfolio choice takes place in two stages:
. first, find the best pattern of risky assets given the returns of all assets (efficient portfolio)

. then, decide on the amount of the risky asset pattern in his total portfolio. Only this second decision is affected by his attitude to risk. We thus can refer to it as the "optimal" portfolio for risky assets.

2. The combination of constant relative risk aversion R, with a log-normal distribution of income, in which the log of income is normally distributed, also illustrates the advantages of the mean-variance analysis under a more plausible specification. If we assume constant elasticities and multiplicative risk, log normality is the appropriate functional form to adopt. Moreover if quantity and price are log-normal, so will be the output. Unfortunately the previous portfolio analysis cannot be used here for the sum of two log-normal distributions is not log-normal.

3. Analysis under a quadratic utility function is often presented in terms of mean-variance (or E-V) analysis. The utility function can be described as :

$$(2.4) \qquad E(U) = E(Y) + b.E^2(Y) + b.Var(Y)$$

and implies a utility surface in three dimensions (U,E,V) (Anderson et al., 1977). But this usage requires the adoption of some very strong assumptions as noted above.

2.2.4 Conclusion

Although theoretical, the analysis undertaken above is very important. It provides a framework for the individual's attitude towards risky decision making. It constitutes the basis of the agricultural operator's strategic behaviour analysis when using risk management tools such as futures or forward markets. We henceforth assume that risk represents the unpredictable component of any change of an outcome derived from uncertain events. The operator's behaviour is assumed to follow the Expected Utility Hypothesis, and his decision-making process may be represented in a mean-variance framework, bearing in mind the caveats made earlier.

2.3 Spot price risk in EC agricultural markets

Causes of price variability and price risk for agricultural commodities, with particular reference to wheat, are now identified. Variability and risk on EC domestic markets are first considered, while discussion and detailed analysis of risk involved in intra-EC trade are later

exposed. No account is taken here of extra-EC trade price risk derived from the EC export refund/import levy system.

2.3.1 Market variability

As far as the production of agricultural commodities is concerned, two kinds of variability, i.e. a systematic and a non-systematic variability, can be distinguished. The distinction between these two types of variability lies in their predictability, as systematic variability is supposed to be foreseeable (Newbery and Stiglitz, 1981). The general price level is exogenous for operators as an individual operator cannot exert any kind of influence on it. Agricultural agents are then considered as price takers. In competitive markets movements in prices are attributed to both shifts and anticipations of shifts in either demand or supply. These movements in prices, on both sides of the market, arise from various sources of variability. They are described in Tables 2.1 and 2.2:

Table 2.1 Demand variability

Demand Variability	
Systematic	Non-systematic
. Income variability . Price inelasticity . Expectation of future inflation and exchange rate (impact on stock holding policy)	. Changes in taste . Changes in technology

Table 2.2 Supply variability

Supply Variability	
Systematic	Non-systematic
. Production conditions (weather) . Price inelasticity . Tariffs, taxes and exchange rate (impact on import and export) . Price of inputs . Variability in price expectations	. Production conditions . Changes in technology

To complete this list of sources of price variability, we must add the role of governmental intervention which, within the CAP, is a major cause of price variability. Governmental

decisions may also represent a major cause of market price volatility since they can affect both supply and demand through policies on market taxation, market regulations, national income or, merely, by a price stabilization scheme. They may be considered as contributing to non-systematic price variability since they are so difficult to anticipate.

2.3.2 CAP-derived Price variability

2.3.2.1 Domestic price variability

The present section discusses CAP-derived price variability. Although particular reference is made to the EC wheat regime, the underlying principles are common to most commodities affected by CAP regulations. The contribution of the sources of spot price variability listed above to the price variability on EC markets is strongly limited and restricted by the operation of the CAP. As described in Chapter 1, EC wheat prices fluctuate within a well-defined range between the threshold price and the intervention price. Yet, the EC market situation of overproduction and the implementation of high institutional prices, relative to long-run market-clearing prices, have given the intervention price a deterministic role in the market price formation. Empirical assessment of price variability, for a range of agricultural commodities, shown in Appendix 2-A.1, confirms the low level of price variability. However, evidence (Mackel, 1979, Mac Laren, 1980 and Burrell, 1985) shows that the panoply of politically-determined complex arrangements relative to the availability of the intervention system with regard to quantity, quality and temporal requirements, combined with an external trade system and the agri-monetary policy, have created market uncertainty. This risk, referred to as institutional risk has been strengthened by the nature of the decision-making in the EC. Established every year by the Council of Ministers, following Commission proposals, the definition of the EC wheat regime may be characterized by a slow decision-making process[7], the absence of long-term objectives[8] and problems of interpretation[9]. While spot price variability is much lower than under free-

[7] Price packages should theoretically be adopted by the Council of Ministers before planting time. However long delays have always been the rule and exceptionally in 1985/86, the Commission took it upon itself to fix the wheat institutional prices since no price package had been agreed at harvest time.

[8] The political nature of decision-making, and the consequent compromises achieved, have contributed to induce systematic annual changes in the marketing arrangements which have turned their application into a difficult exercise of readjustment of market parameters.

[9] Decisions are often difficult to interpret and may require the Commission's clarification. This is common for the agri-monetary system and additional measures such as the coresponsibility levy gradual phase-out in 1990.

market conditions, spot price risk, derived from the complexity of the EC wheat regime and from the political and institutional nature of its decision-making, is still expected to be significant.

2.3.2.2 Price variability affecting intra-EC trade

The spot price risk discussed above concerns EC domestic market conditions. When intra-EC trade is involved, an additional risk derived from the agri-monetary system of the EC, and in particular the MCA system, has to be considered along with the domestic spot price risk and exchange rate risk inherent in the nature of the transaction. A MCA change may arise for four reasons :

. a change in the Common support price, i.e. the intervention price,
. a change in the green rate at which the institutional prices are converted in national currencies,
. a change in the value of the agricultural ECU,
. a change in the exchange rate of one of the floating currencies or in the central rate of one of the EMS currencies.

Most MCA variability arises from exchange rate variability. Green currencies and the MCA system may create a price difference between countries which are not market-induced but institutionally- and politically-induced[10]. If there were no green currencies, price risk would be due mainly to fluctuation around the intervention price in the importing country and exchange rate risk for the gap between intervention and market prices in the importing country. Indeed, the intervention price set up in ECU at the beginning of each marketing year would fluctuate along with EC national currencies. Traders throughout the EC would be assured of the same intervention price in ECU throughout the marketing year and across

[10] An MCA export levy merely acts to offset the increased competitiveness that a country with a depreciated currency would get in relation to other Member States. In fact, the Franchise system does not fully compensate exporters from appreciated currency countries (positive MCA's) and the competitive advantage gained by exporters from a weak-currency country (with negative MCAs) is not fully offset by the MCA system. This under-compensation is greater for a weak-currency country (1.5 % v. 1 %). But we should not forget that the franchise represents a political compromise reached at each price-fixing negotiation. This works also for imports if we follow the same rationale. One major effect of the MCA system seems to have insulated EC grain markets from fluctuations that would have arisen from currency movements should the MCA system not be there.

the different EC Member States. The object of the MCA system was to maintain the same support price at fixed exchange rate for wheat over the EC. But, because of the specific arrangements discussed in Chapter 1, this does not occur. With the current system, operators trading across the EC still face an exchange rate risk, on the gap between the intervention price adjusted by the MCA system and the market price in the importing country, and an MCA risk. The latter exists since the actual MCA system does not completely fill the gap between the green rate and the market exchange rate on the full Common intervention price.

The European Community has recognised that operators involved in external trade with third countries face MCA risk since the size of the MCA prevailing at the time of the export/import cannot be predicted with certainty. Hence it is now possible to prefix MCA for trade between a Member State and a third country. Yet this opportunity is not available for intra-EC trade. The Commission has assumed that fluctuations in exchange rates are roughly offset by the MCA applicable. To contravene this intra-EC trade risk, an opportunity is given to traders to achieve a similar effect by placing grain under 'Customs clearance' within a month prior to export. If traders forecast an adverse MCA development, they can fix their level by clearing their merchandise at custom store.

2.4 Empirical analysis of price risk

Price risk for wheat alone and within a portfolio of agricultural assets is examined. Since the methodology used is similar, the differences between the two applications will only be discussed when the data is described.

2.4.1 Definition of a methodology for price risk assessment

We are interested in the price risk faced by agricultural operators. Our analysis measures operators' exposure to price uncertainty through each of the commodities they trade. The principle described below can be applied to any operator in the wheat chain. Operator k's output O_k can be expressed in vector notation as follows :

(2.5) $$O_k = P'.X_k$$

where :

. X_k is the vector of yield for operator k, with each element corresponding to a different commodity (in the case of producers with production uncertainty).

. P is the random vector of national commodity price, the elements of which can be decomposed into a systematic or foreseeable component and a random component which will be denoted $p^{\sim}$.

The output O_k is a weighted sum of random economic variables. The risk associated with each of the random economic variables of which the output is composed will be measured as the difference between a statistical best guess of its value, versus the actual value prevailing in a given time period. Therefore, the price risk is defined as the part of any price change which is unforeseeable or which is caused by stochastic variables. It then refers to the relative price forecast error $E_f(P_t)$:

(2.6) $E_f(P_t) = [F(P_t) - P_t] / P_t$

with $F(P_t)$ the price forecast and P_t the realized spot price, and is measured by the standard deviation of this forecast error.

By considering that the uncertainty of each price time series is measured by the standard deviation of a relative forecast error, our approach makes a sharp distinction between variability, which includes expected and foreseeable changes in prices, and uncertainty which does not. This approach to uncertainty is based on the existence of stochastic variables in a price function. This concept has been described by Gordon et al. (1984), Terwitte (1987) and Herrmann and Kirschke (1988) and represents a new methodology when compared with the earlier literature on instability measurement (Parikh, 1971, Edwards and Parikh, 1976, and Edwards, 1977). Price risk takes account of the link existing between the different price uncertainties of the commodities comprising the operator's portfolio. Then, it can be expressed as

(2.7) $R_1O_k = (Y'_k.C.Y_k)^{½}$

with

. C the Variance-Covariance matrix of the individual commodity price uncertainty expressed by the $E_f(P_t)$.

. Y_k the vector of the weight of each product in the total portfolio.

R_1O_k represents the measure of the overall exposure of operator$_k$'s portfolio to agricultural commodity price uncertainty. More precisely, it is the standard deviation of the relative

forecast error of his portfolio output, assuming that there is no quantity risk. It is possible to isolate the impact of each commodity on the output overall risk measure. The operator's exposure to individual commodity price uncertainty is assessed as the amount that the individual commodity contributes to the total uncertainty of the agricultural output. In vector notation, this contribution can be represented as follows

(2.8) $I_{ik} = (Y_k'.C.R_{ik})/(Y'_k.C.Y_k)$

R_{ik} is a vector of zeros in all but the ith element where it equals Y_{ik} , the weight of the "i" commodity in the total output of operator$_k$. Then, the contribution of the "i" commodity to the total is equal to the weighted sum of its own price variance plus its covariance with other commodities. It is worth noting that if a commodity's covariance is large enough and negative, its contribution can potentially be negative. It can be used to reduce the agricultural portfolio price risk. Comparison between individual price risk and the portfolio risk, when no account is taken of potential interaction between products, is also realized. Attention is now focused on the forecast model since we have assume the forecast model adopted by individuals.

2.4.2 Choice of the forecasting model

Forecasting models are commonly divided into two main groups, the empirical and the fundamental models. Most forecasting models can be found in the first group. Univariate forecasts are made on past observations of a given time series by fitting a model to data and extrapolating. These models range from the naive expectation model to other simple models whose prediction is based on the trend curve forecast either by linear trend (the least squares method), or by filters (such as moving average) or by a combination of trend and seasonal variation. Smoothing methods are methods based on empirical extrapolations whose common feature is to give more weight to recent observations. We distinguish simple, double and triple smoothing methods from their prediction function which is either linear, or exponential or sinusoidal. Brown and Holt-Winters methods follow the procedure of updating the model coefficients. Finally, the Box-Jenkins forecasting procedure is based on fitting an auto-regressive integrated moving average (ARIMA) model to a given set of data. We determine the model of the price time series in a first period and apply this structure in an extrapolation to the next time period. By applying this method several times, we readjust the structure and improve the performance. Although straightforward for the smoothing methods, it becomes heavy and time-consuming in the case of the Box and Jenkins approach.

The computerization of the model is impossible and the choice of the model is mainly subjective (there is no one appropriate model specification).

The second group of methods relates to multivariate procedures which provide forecasts by taking into account observations from other variables. Multivariate models which are sometimes called "causal" or "prediction" models, are either multiple regression models or Box-Jenkins methods[11].

When facing the choice of forecasting procedure, many factors need to be considered. As far as our study is concerned, the degree of accuracy required constitutes the principle choice criterion[12]. Evidence concerning the performance of these forecasting procedures raises several issues. The econometric models have often had poor predictive powers (Naylor at al, 1972). Gourieroux and Monfort (1983) try to explain the better performance of Box-Jenkins models as compared with the econometric models in term of forecasting power by considering their forecast error magnitude (Cooper, 1972; Evans-Haitovsky-Treiz, 1972). They obtained a result inconsistent with the previous empirical evidence. But their conclusion relies on the hypothesis of perfect specification of the econometric model which is most unlikely. The Box-Jenkins model, if well identified, appears indirectly to integrate the relationships neglected by the econometric model. Reid (1975) and Newbold and Granger (1974) show that the Box-Jenkins method tends to give more accurate forecasts than simple automatic univariate procedures.

Price uncertainty cannot be measured objectively since it depends on the agent considered, his information level, and the point in time. We assess the deterministic part of the price function by an ARIMA model based on the past price time series, but we must remember that a unique, objective measure of the degree of risk does not exist. We will assume that

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[11] Futures or forward prices can also be used as forecasts if we consider the forward pricing function of forward and futures markets (Kahl and Tomek, 1986). Terwitte (1987), who based his opinion on evidence from Just and Rausser (1981), and Carter and Rausser (1983), argues that futures markets provide similar, if not better, forecasts than other forecasting models. The use of these markets in the definition of price risk is here inappropriate since we aim to investigate the wheat futures market performance. We seek to choose a forecasting method susceptible to provide us with an "objective" assessment of price risk, relatively to any futures market influence. Furthermore no study has tested the London wheat futures market forecasting performance.

[12] There is a risk inherent in the choice of the forecast model. We can call this type of risk the estimation risk which is due to subjective assessment of risk by market participants (Bawa, Brown and Klein, 1979 study this risk in a Bayesian framework).

market price expectations are based on ARIMA models. These models provide a means of constructing quite efficient forecasts with very low information requirements and relatively low modelling costs.

2.4.3 Methodology

2.4.3.1 General methodology

The general Auto Regressive, Moving Average (ARMA) approach has been developed by Box and Jenkins as an iterative method for modelling the dependence among the observations in a time series. The autoregressive models (AR) were first introduced by Yule (1926) and later generalized by Walker (1931). Slutzky (1937) first used the moving average models (MA) while Wold (1954) developed the theoretical foundations for a combined ARIMA process. The model is reassessed if any deficiency proves to exist. The process follows an iterative approach. When the model is found to provide an adequate description of the data (usually done by examination of the residuals), it then proceeds to the forecasting of future observations. In case of non-stationarity differencing has to be operated. The AR, MA or mixed model may then be fitted and is then called an Integrated Model (ARIMA). Furthermore, the possibility of an annual seasonal component is taken into account by the development of a general multiplicative seasonal model in the form of (with a seasonality of s)

$$(2.9)\quad \phi_p(B).\Phi_P(B^s).(1-B)^d.(1-B^s)^D.Y_t = \Theta_q(B).\Theta_Q(B^s).\epsilon_t$$

where B denotes the backward shift operator, ϕ_p, Φ_p, Θ_q, Θ_Q are polynomials of order p, P, q and Q respectively, and ϵ_t and Y_t the random component of the price series, with $E(\epsilon_t) = 0$ and $E(\epsilon_t.\epsilon_{t+sk})=0$ for k not equal to 0[13].

For an efficient use of the Box and Pierce test, we set the number of lags slightly above the seasonal lag. Box and Jenkins (1970) describe a portmanteau lack-of-fit test. This approach consists in looking at the residuals' autocorrelation coefficients for the first K values (K lags number), and in estimating the Q variable as defined by

[13] This and similar models are discussed in the scalar case in Box and Jenkins (1968, 1970) Chatfield and Prothero (1973), Ansley, Spivey and Wrobleski (1977), Granger and Newbold (1977) and in the multivariate case in Box, Hillmer and Tiao (1976).

(2.10) $Q = T.\Sigma_{i=1}^{i=k} r_i^2$

with T total number of observations and k number of lags. This test does not work well even for moderately large sample sizes. Various alternative statistics (Ljung and Box, 1978) have been proposed but they still appear to give poor quality results (Davies et al., 1979).

The main stages in setting up a Box-Jenkins forecasting model can be described as follows:

. choice of data
. model identification
. estimation
. diagnostic checking (estimation of forecast errors, the basic characterization of the price uncertainty and calculation of the price Variance-Covariance matrix, by the residuals of ARIMA models).
. consideration alternative models, if necessary.

We estimate the variance-covariance matrix of residuals from price expectations determined by ARIMA models. This matrix will enable us to determine the price risk of each commodity through the variances and the potential risk diversification effects between commodities through the covariances.

2.4.3.2 Wheat price risk

SARIMA models, built on an initial time period of four years, are used to forecast over a twelve-week horizon. Short-term price risk is then assessed from the standard deviation of these twelve forecast errors. The next four weeks are then added to the initial sampling period before proceeding with the same calculation. We thus obtain thirteen price risk assessments per year as well as the annual average of forecast errors over a four-week, eight-week and twelve-week period. An annual or medium-term price risk is also assessed and defined as the standard deviation of the relative forecast errors over the whole marketing year (or 52 weeks).

Since the intervention price does not constitute an uncertain component in the price determination, we examine price risk on the difference between the spot price and the intervention price. This allows us to avoid the artificial shift occurring in the beginning of each year due to the price fixing. This shift as well as the emergence of a new price trend

in 1984 may have jeopardized the initial hypothesis of stationarity of the time series and cast doubt on the feasibility of the Box and Jenkins method. As highlighted by Chatfield (1984), the variation of the systematic part of the time series would have affected the results since the effectiveness of the ARIMA model is then mainly determined by the initial differencing operations and not only by the fitting of an ARIMA model.

In the study of price risk over a period of time covering two different marketing years, we differentiate price risk coming from year-to-year uncertainty and within-year uncertainty. Wheat market price risk can be split into two distinct elements. One comes from the risk of price level determination, while the other relates the risk arising from fluctuations around the price level over the marketing period. Since we limit the forecast horizon to 12 weeks, most forecasts are intra-marketing year forecasts, i.e. when the price level is known. Furthermore, since EC price-fixing decisions take place long before the beginning of the marketing year, generally at least more than 12 weeks generally, the risk of price level determination is expected to be very low. In the analysis of wheat price risk, we set X_k and Y_k, defined in 2.4.1, constant[14].

2.4.3.2 Portfolio price risk

A similar methodology is applied to the study of price risk for a commodity portfolio, including wheat, barley, egg, pigmeat and beefmeat. For products benefiting from an EC market regime based on an intervention price, examination is also undertaken of the price gap between the market price and this intervention price. It mainly concerns grain commodities included in this portfolio, namely barley and wheat. The weight of each agricultural commodity in the total portfolio, expressed by Y_k in equation (2.7), is set equal to 20%.

2.4.4 Data

Wheat price risk is analysed with weekly data while assessment of the portfolio price risk is operated with monthly data. All prices are deflated and refer to the 08/1978 to 07/1987 time

[14] However, simulations of the farm cropping pattern will be possible by varying values of X_k and Y_k. Our approach allows the assessment of R_1O_k to be undertaken every year, over a longer period of time or for a particular period of time (just before harvest, after harvest). The period of time studied also depends on the availability of data. From these periods of time, different kinds of simulation can be realized such as ex-post simulation or ex-post forecast.

period. We choose to study three different wheat prices. The two wheat price series refer to domestic prices prevailing in the UK and in France, while the third wheat price series refers to the import of French wheat into the UK. Such a choice enables us to investigate domestic market and intra-EC price risk[15]. The time period corresponds to the end of the 1973/78 transitional period of entry of the UK into the EC. The portfolio price risk is only analysed on British and French domestic markets. Characteristics of data sources are displayed in Appendix 2-A.2.

2.4.5 Results

The full results of wheat price risk and portfolio risk are listed in Appendices 2-A.3 and 2-A.4 respectively, while their respective forecast models are described in Appendices 2-A.5 and 2-A.6.

2.4.5.1 Wheat price risk results

Table 2.3 shows that levels of risk associated with wheat prices are very low[16]. Average price risks over the 1982/87 period are .0192 and .0286 for the UK and France respectively. That means that, over this period, the standard deviation of the forecast errors, when expressed as a percentage of the price realized, was around 2% and 3% for these two countries. The results given in Table 2.3 appear to confirm our initial sub-hypothesis that the CAP has reduced price risk since greater price risk might be expected under free-market conditions. Nevertheless, detailed analysis of these figures reveals interesting features. As expected, the inter-marketing year price risk is higher than the intra-marketing year price risk. Risk involved in the price determination between marketing campaigns is about twice as high as price risk relative to intra-marketing year. While the price risk has remained fairly constant in the UK, fluctuating between .01 and .02, it has constantly increased in France during the 1982/87 period, from .021 to .033 (Figure 2.1). A similar trend is found when examining the price risk involved in wheat export from France to the UK.

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[15] The case of the import of wheat into the UK from France is hypothetical since both countries are self-sufficient in wheat. It may however come from the demand in the UK for wheat of a quality not grown in the UK or inter-branch trade by multinational firms influenced by logistical or pricing considerations.

[16] See Gordon et al (1984) and Ray et al (1985). Sources of data used may contribute to low levels of price risk since the empirical assessment is undertaken with average prices of soft wheat from nine major areas for France and the HGCA weekly average ex-farm spot prices for the UK. Prices for specific locations could have given more accurate and certainly higher values for local operators.

Table 2.3. Annual average of monthly price risk and annual assessment of price risk for the UK domestic market, the French domestic market and the French export market to the UK*.

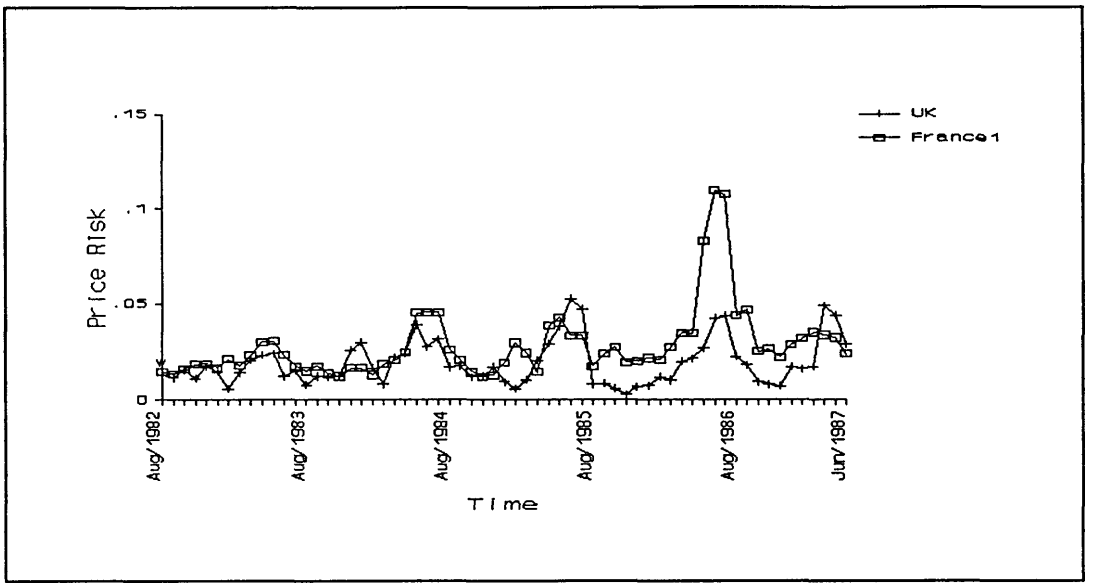
Price risk	Short-term price risk				Medium-term risk		
Intra-year	UK	France1	France2	UK/ France1	UK	France1	France2
1982/83	.0159	.0207		.7769	.0223	.0241	
1983/84	.0203	.0199	.0294	1.0544	.0449	.0339	.0588
1984/85	.0174	.0231	.0207	.8231	.0341	.0273	.0430
1985/86	.0106	.0256	.0307	.3938	.0194	.0627	.0916
1986/87	.0209	.0328	.0382	.6308	.0365	.0434	.0518
1982/88	.0165	.0244	.0297	.7262	.0314	.0382	.0613
Inter-year	.0289	.0421	.0541	.8128			
Overall** (1982/87)	.0193	.0286	.0355	.7454			

* France1 and France2 refer to the French domestic markets and French export to the UK respectively.
** Average of intra- and inter-marketing year price risk over the 1982/87 period.

Constantly increasing from .021 to .038, it is higher when assessed over a time period across two different marketing seasons. It is systematically higher than French and UK domestic price risk (Table 2.3). Apart from the 1984/85 season, it is almost twice as high as the UK domestic price risk.

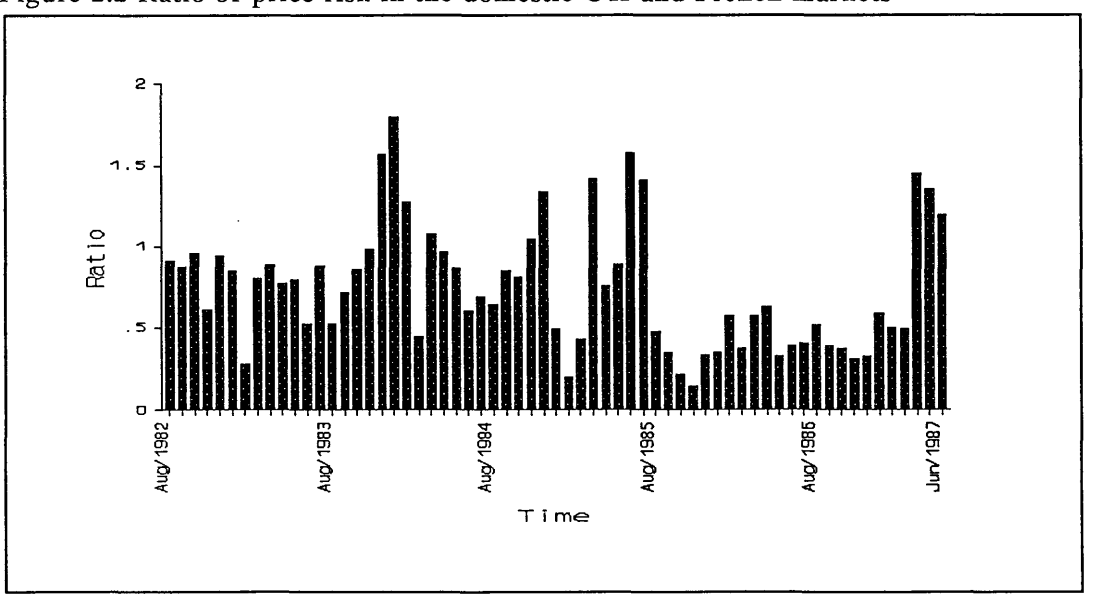
This assessment refers to short-term price risk since forecasts are undertaken over a twelve-week time period. When a medium-term price risk, expressed as the price risk calculated at the beginning of each marketing year over the whole year, is considered, we obtain higher measures. They range from .019 to .045 in the UK and from .024 to .062 in France. Price risk involved in French export to the UK is again also higher, fluctuating between .043 to .092. These results confirm early expectations, since forecast errors and price risk refer to a 52-week horizon rather than to a 12-week horizon for short-term price risk. While price risk is always higher in France than in the UK for the short-term horizon (Figure 2.2), results for the medium-term horizon are mixed since UK price risk is higher during the 1983/85 period and lower during the 1985/87 period as compared with France (Table 2.3). The EC market situation of overproduction and the setting of the intervention price above long-term market-clearing prices may have been expected to reduce price risk to a level

Figure 2.1 Short-term price risk of wheat in the domestic UK and French markets, from 1982/83 to 1986/87.



close to zero. The results appear to suggest that price evolution around the intervention price is increasingly difficult to predict owing to the weakening of the EC intervention system. Indeed market prices, in both countries, seem to fluctuate below the EC intervention price.

Figure 2.2 Ratio of price risk in the domestic UK and French markets

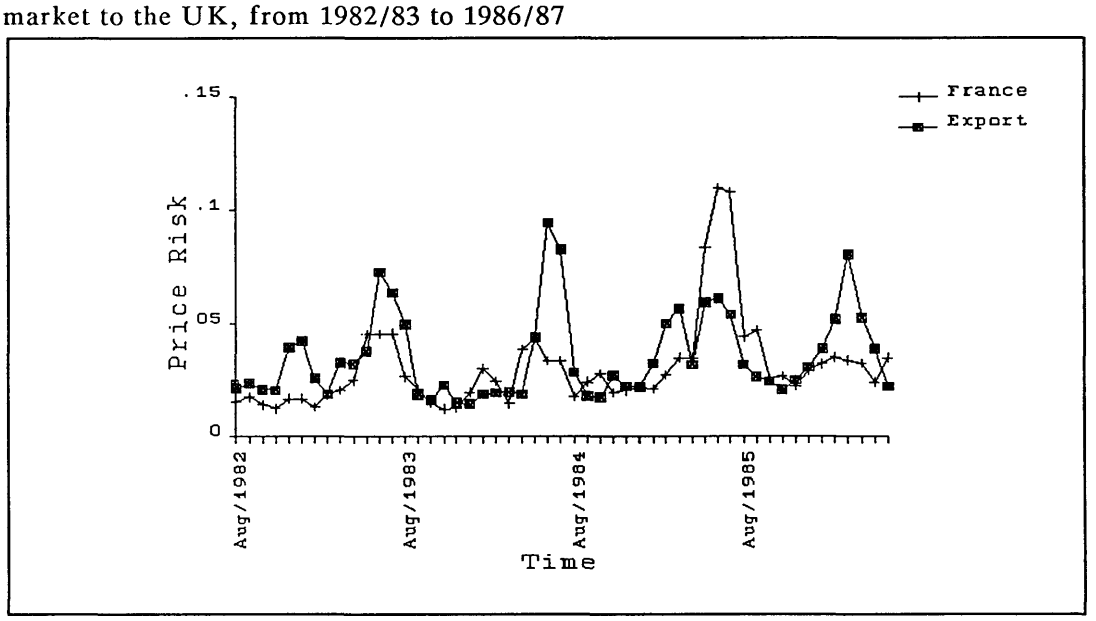


The leading role of the intervention price in spot market development is altered by institutional changes related to product quality requirement, the delay of payment, the co-

responsibility levy, the implementation of the buying-in price and some delivery month restrictions. By creating and modifying these EC arrangements, the European Commission has contributed to an institutional price risk. Such actions may destabilise market prices and increase uncertainty which may offset any reduction gained from the intervention system. Wheat operators have now to control and manage several determinants in the price formation, which makes the spot price less dependent on the intervention price. Such phenomena are particularly sensitive after the beginning of the marketing year. Empirical examination shows volatile results in February.

The increase in price risk over the period studied may be due to several factors. Apart from variables related to market fundamentals and to the EC wheat regime, the increase in price risk may be due to the methodology, and more precisely, to the difficulty of fitting the appropriate SARIMA models to the data. Yet, such an argument is contradicted by experience with different models which have generally proved to give low price risk estimates. The increase may also be due to a continuously increasing sampling period.

Figure 2.3 Short-term price risk of wheat in the domestic French market and the export market to the UK, from 1982/83 to 1986/87



The deterministic structure of the price time series, constituted by the gap between the market price and the intervention price, may be changing over the 1978/1987 period. Thus a specific structure extracted over the whole sample may not reflect the current spot market

price-intervention price relationship[17].

Table 2.3 shows that French market price risk was higher than in the UK. The average over the 1982/87 period of the ratio [UK price risk/French price risk] is .72. The difference between the two countries might suggest that the London wheat futures market has contributed to a reduced risk. Yet causal relationships of this type are difficult to assess and any early statement may prove to be premature. Price risk is also very dependent on the wheat marketing structure in France and in the UK. Marketing of wheat in France is dominated by the cooperative movement.

The high levels of price risk involved in intra-EC trade between France and the UK are rather surprising. Under free-market conditions this price risk would be expected to equal the UK price risk increased by the exchange rate risk between the £ Sterling and the French Franc. These results, at around twice the level in the UK, may reflect the influence of the MCA system and the uncertainty which surrounds its determination.

2.4.5.2 Portfolio price risk results

The contribution of wheat to portfolio variance follows a rather different pattern in France as compared to the UK (Table 2.3). While it is rather significant in France when compared with other commodities, particularly barley, it is relatively low in the UK. Egg prices are the main contributor to the portfolio variance despite wide annual fluctuations in both countries. The contribution of beefmeat prices to the portfolio variance is low in both countries, while that of pigmeat prices is relatively high in France and very variable in the UK. There are some negative contributions to the total portfolio variance from pigmeat and beefmeat in the UK during the 1985/86 season and from beefmeat in France during the 1984/85 season. Surprisingly, wheat price risk results obtained from monthly data in the portfolio risk analysis are systematically higher for France and the UK as compared with results obtained with weekly prices. In our assessment of risk, the covariance-effect between commodities is very strong since individual commodity price risk is higher than the portfolio price risk for most of the time and most of the commodities.

The risk diversification effect, when expressed as the ratio of the sum of individual

[17] It is worth noting that our results are conditional on the forecast model. Each operator has in fact its own price expectation model and hence its own measure of price risk.

commodity variances by the portfolio variance, reduces the sum of individual commodity variances by nearly 75% in both countries (Table 2-A.4). These results suggest that wheat price risk can be significantly reduced when wheat is part of a portfolio of agricultural commodities. Such a reduction appears to be more significant in France than in the UK.

Table 2.4 Contribution of each product to the commodity portfolio variance, from 1984/85 to 1986/87.

	UK			France 1*		
	1984/85	1985/86	1986/87	1984/85	1985/86	1986/87
Wheat	.17	.09	.10	.28	.17	.24
Barley	.24	.00	.12	.06	.03	.12
Eggs	.16	.92	.62	.52	.64	.07
Pigmeat	.28	-.01	.14	.19	.15	.53
Beefmeat	.15	-.01	.03	-.05	.01	.04

* France1 refers to the French domestic market

2.5 Conclusion

Risk is defined as the unpredictable component of any change of outcome derived from uncertain events. The operator's behaviour is assumed to follow the Expected Utility Hypothesis and his decision-making process can be represented in a mean-variance framework. The empirical assessment of risk is based on the price forecast error of operators whose price expectations are based on Box-Jenkins methods. Results of empirical investigation show that price risk is low in the EC wheat markets considered. This situation may reflect the impact of the intervention system which operates like a price floor. These findings appear to support the first sub-hypothesis of the thesis. While the combination of intervention prices set above long-run market-clearing prices and continuous conditions of oversupply in the EC wheat markets might have induced a price risk of almost zero, a low but significant price risk has been found. This finding may illustrate the policy uncertainty which has been a common feature of the CAP. The difficulty in predicting policy changes has turned price volatility into price risk.

The increase in price risk during the 1982/87 period considered in our study may be due to institutional factors relative to changes in the EC wheat regime and to changes in the market situation which is strongly influenced by the CAP. The relatively high price risk found in

the case of intra-EC trade may reflect the uncertainty derived from the agri-monetary system. Thus operators on EC wheat markets have to face a lower but less predictable price variability.

The CAP may then have reduced the need for futures trading by strongly affecting the level of price uncertainty, since the latter appears to be now lower that what it would have been under free-market conditions. It may also have changed the nature of this risk, which is now institutionally-derived and hence more difficult to cover on a futures market. Since futures markets were not originally designed to deal with institutional risk, we may question the ability of these markets to manage EC domestic price risk and MCA risk. However, the current development of the London wheat futures market, although still low in terms of turnover relative to that of the Chicago Board of Trade, suggests that this may not be completely unfeasible.

In the following Chapters 3 and 4, the performance of the London wheat futures market in providing an efficient hedging tool to EC wheat traders is examined. The basis for UK and French traders is first analyzed in Chapter 3 while the hedging effectiveness and the optimal hedging ratio is assessed in Chapter 4.

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CHAPTER 3

Analysis of the Basis

Chapter 2 has shown that wheat price risk in the UK and French markets, as well as in intra-EC trade between the two countries, is low. This result certainly reflects the influence of the EC wheat regime on EC wheat spot markets. This might be expected to affect the need for futures trading. However, it has also created an institutional price risk which may be difficult to cover on a futures market. The present chapter aims to test the second sub-hypothesis of the thesis which is concerned with the futures market performance in fulfilling its risk management role. It is hypothesised that the effectiveness of the wheat futures market in reducing price risk has been modified by the EC wheat regime. Investigation and testing of this sub-hypothesis are undertaken in Chapters 3 and 4. Chapter 3 focuses on the basis in order to examine the futures market performance in managing the institutional price risk and to evaluate the impact of the CAP on the market performance. In the first part of the chapter, the definition, use and performance of the basis, defined as futures price minus cash price, are discussed. The basis risk is then compared to the price risk. We later identify economic variables, with particular emphasis on CAP-related variables, in an attempt to explain variations in the basis. Finally similar investigation takes place but with particular reference to the theory of storage and with the basis redefined as the nearby futures spread.

3.1 The basis and hypotheses concerning basis formation

The performance of futures markets and hence their economic usefulness depends on the degree to which they respond to markets fundamentals. A way of examining the economic performance of a futures market is to consider the behaviour of the basis. Indeed, the study of the basis allows the investigation of the risk-reduction and commodity allocation functions of the futures market.

Agricultural operators within the marketing chain face the risk of price changes. By hedging on futures markets they can substitute risk of changes in the basis for the risk of changes in

the price[18]. If we consider an operator selling on the futures market and buying on the cash market at t_o and buying on the futures market and selling on the cash market at t_1, , his expected revenue E(R) can be expressed as

(3.1) $E(R) = E(R_c) + E(R^f)$

with R_c his cash market revenue equal to $[p_1 - p_o]$ and R^f, his futures market revenue, equal to $[p^f_o - p^f_1]$. If we now introduce the basis B_t, with B_o equal to $[p^f_o - p_o]$ and B_1 equal to $[p^f_1 - p_1]$, then (3.1) becomes

(3.2) $E(R) = E(B_o - B_1)$.

Therefore operators can transform their initial price risk by a basis risk which may be expected to be smaller since operators only need to examine and forecast variations of a price difference, approximately equal to the price of storage, as opposed to variations in the full price. A knowledge of basis movement can help in determining the optimal time, amount and location of trade. Successful hedging requires a full understanding and anticipation of factors that cause variability in the basis. The performance of the basis is evaluated by its ability to allocate commodities over time and space. For instance, an increase in the basis, i.e. a strengthening of the futures price relatively to the spot price, is an incentive to store.

The concept of the basis has long been studied. Working (1949) asserted that the difference between the futures price and the cash price for a storable commodity of the same quality and at the same location represents the market's estimate of the price of storage. It then offers incentives for, or deterrents to, storage. This price, determined by anticipations about the supply and demand for storage can be disaggregated into various elements such as the physical cost (that of maintaining storage facilities, of the transformation services such as drying and of losses from deterioration), the cost of insurance, the opportunity cost, the risk premium and the convenience yield[19]. In addition, the basis may represent other costs such as transport costs, when the cash and futures prices refer to different locations, and quality premium, when the quality of the underlying commodity traded on futures market does not correspond to that available on the spot market. Working (1948, 1949), Brennan (1958),

[18] The subtsitution of risk takes place in proportion of the cash position hedged on the futures market.

[19] The convenience yield refers to the benefits received by an operator who keeps a certain level of stockholding to ensure an orderly flow of commodities (Kaldor, 1939).

Telser (1958) and Cootner (1967) have also discussed the relationship between the basis and the temporal allocation of commodity.

3.2 Analysis of Basis Risk

Examination and test of the second sub-hypothesis of the thesis (section 1.6) is carried out in this section by the investigation of the five following auxillary hypotheses.

1. We first hypothesise that the basis risk in the UK may sometimes be higher than the price risk. Under normal market conditions, a lower basis risk would be expected. However, because of the EC wheat regime, the scope for risk reduction through the basis may be lower. Furthermore, the institutional component of the price risk may be amplified in the basis risk. If so, this would affect the ability of futures markets to manage price risk.
A situation where basis risk is higher than price risk might arise when the deviation of the spot price from the intervention price is more predictable than the deviation of the spot price from the futures price.
2. A similar auxillary hypothesis to 1. above for the French basis risk is formulated. Moreover, the agri-monetary system and the relative isolation of domestic EC markets may strengthen this result when compared to the UK situation.
3. The third auxillary hypothesis is that the basis risk is higher in France than in the UK. This hypothesis follows from the basis definition for French traders which takes into account risks associated with the agri-monetary system of the CAP and the exchange rate fluctuations.

4. We then hypothesise that the ratio of basis risk to price risk, which expresses the ability of the futures market to reduce price risk, is lower in the UK than in France.

5. The fifth auxillary hypothesis is that, the basis risk and the ratio of basis risk to price risk, for French operators exporting to the UK is lower than the basis risk prevailing for French domestic operators.

Three different bases are assessed now. The first relates to UK domestic operators, the second refers to French domestic operators and the third to French exporters to the UK. Though straightforward for the UK basis, the calculation of the basis risk for French operators needs to be introduced since it must incorporate the agri-monetary system of the EC.

3.2.1 Calculation of basis risk for French operators

3.2.1.1 Foreign-based futures trading

Concentration of European futures exchanges for grain within the UK suggests that we might expect a substantial proportion of hedging activity to come from traders who are located abroad (both buyers and sellers). Demand for hedging price risk does exist in the EC , especially in France, which is a major producer and exporter within and outside the EC. Such demand, when involving exports on the world market and on the EC market, may only be partially fulfilled on the US futures market and the London futures market (Terwitte, 1988). A very limited, if not negligible, part of the trading volume on the London futures market is placed by continental traders[20]. Surprisingly little investigation has been made concerning foreign-based futures trading and the factors influencing the hedging decisions of a foreign-based trader, whatever the traded commodity[21].

Continental operators trading in London predominantly face two types of risk:
. a basis risk which can be defined as the risk of basis changes over two different time periods. Under the influence of domestic conditions, the futures price in London and the cash price in France may vary in different ways, regardless of the exchange rate.
. an exchange rate risk which can affect both the level and variability of returns from commodity trading (Thompson and Bond, 1985). This exchange rate risk comes from the fluctuating nature of exchange rate. Developments in the financial and economic sectors can affect the exchange rate and then, by transmission, the price of the commodity expressed in £ sterling. In the case of the UK and France, the exchange rate risk is more difficult to estimate than for other European countries since the UK only joined the Exchange Rate Mechanism of the European Monetary System in October 1990.

Furthermore, in the case of French operators exporting to the UK, i.e. with physical transfer of the commodity, the MCA system must be taken into account. The existence of the MCA

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[20] It may be argued that this situation arises from a lack of price risk in EC wheat markets and in intra-EC trade. However evidence in Chapter 2 shows that price risk exists in France. There was an attempt to set up an "organized forward market" for wheat in Paris in the late seventies (Debatisse, 1982) and, more recently, a wheat futures contract.

[21] Bond, Thompson and Geldard (1985) revealed that the incentive of the Australian Wheat Board to hedge Australian wheat exports may be highly reduced in periods of basis volatility. Carter and Loyns (1985) confirm these results by highlighting the poor-cross hedging performance of the US cattle futures market for hedging Canadian feedlot cattle.

and its panoply of special rules render any forecasting exercise very complex. Considerations relative to market theory have been partly phased out to let monetary changes play a greater role in intra-EC wheat trade flows than they would have otherwise had [Von Cramon-Taubadel, 1989]. Operators involved in the wheat market are somewhat dependent on decisions taken by policy-makers. One implication of the MCA system for cross currency hedging is that to perfectly hedge a French trader would have to separately hedge the exchange rate risk effectively introduced by the MCAs. Strategies of French traders may differ substantially from those of domestic hedgers. We focus here on basis risk induced firstly by the exchange-rate and secondly by the agri-monetary system of the CAP[22].

3.2.1.2 The basis for foreign-based trading

The description of the basis is derived from the commercial position of the operator. If we adopt the following notation,

P^f_t : futures price at time t in £/tonne
$ER(£/FF)_t$: exchange rate of the £ against the FF at time t
B^{Fr}_t : basis at time t in FF/tonne
B^{UK}_t : basis at time t in UK in £/tonne
P^{UK}_t : spot price at time t in UK in £/tonne
P^{Fr}_t : spot price at time t in France in FF/tonne
RPD_t : raw spot price differential, in FF/tonne, MCA-unadjusted, i.e.$[P^{UK}_t * ER(£/FF_t)] - P^{Fr}_t$
PD_t : cash price differential, MCA adjusted in FF/tonne
MCA^{Fr}_t : total MCA at time t from France to UK, in %
MCA^{UK}_t : total MCA at time t from UK to France, in %
P_{int} : intervention price in £/tonne or FF/tonne

with

$$(3.3)\quad PD_t - [MCA^{Fr}_t * P_{int,t}{}^{Fr}] + [MCA^{UK}_t * P^{UK}_{int,t} * ER(£/FF_t)] = RPD_t$$

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[22] We may note that other approaches to foreign-based trading could have been undertaken. They are relative:
. to the financial and institutional constraints, such as incentive by private financial institutions and banks (Marquet, 1987), to the use of international operators and to government regulations on foreign participation (Kuhn, Shaviro and Burke, 1985 and Gemmill, 1983).
. to the contract design approach. The actual design of the wheat contract does not allow French traders to deliver on the Continent.
. to the existence of cross-hedging risk coming from a different quality between the commodity traded on the futures market and the French spot market. French wheat is generally of higher quality than the wheat produced in the UK.

The basis for French domestic operators can be defined as

(3.4) $B_t^{Fr} = [P^f_t * ER(£/FF_t)] - P_t^{Fr}$

and as

(3.5) $B_t^{Fr} = [B_t^{UK} * ER(£/FF)_t] + RPD_t$

Derived from the definition of PD_t, the equivalence between French and UK cash prices available for French exporters can be expressed as follows[23]:

(3.6) $PD_t + P_t^{Fr} - [MCA^{FF}_t * P_{int,t}^{Fr}] = [P^{UK}_t * ER(£/FF)_t] - [MCA^{UK}_t * P^{UK}_{int,t} * ER(£/FF)_t]$

The negative sign of the MCA term indicates that export to a country with a negative MCA results in receiving a refund while export to a country with a positive MCA results in a levy being paid. The price available for French exporters to the UK is as follows

(3.7) $P^{exp}_t = [P^{UK}_t * ER(£/FF)_t] - [MCA^{UK}_t * P^{UK}_{int,t} * ER(£/FF)_t] + [MCA^{Fr}_t * P_{int,t}^{Fr}]$

The basis for French exporters can then be derived and expressed as

(3.8) $B_t^{Fr} = [(P^f_t * ER(£/FF)_t) - (P^{UK}_t * ER(£/FF)_t)] + [MCA^{UK}_t * P^{UK}_{int,t} * ER(£/FF)_t] - [MCA^{Fr}_t * P_{int,t}^{Fr}]$

and

(3.9) $B_t^{Fr} = [B^{UK}_t * ER(£/FF)_t] + RPD_t - PD_t$

From equations (3.8) and (3.9), we can see that the basis risk for a French operator exporting to the UK can be disaggregated into the following elements : the basis risk in the UK, the MCA differential risk and the exchange rate risk, and the subsequent interactions of these elements.

As clearly shown in equations (3.5) and (3.9), additional components of variability are

[23] This definition of the price equivalence does not take into account the numerous specific rules relative to the MCA calculation and constitutes a somewhat rough formulation.

included in the basis definition for French operators relative to British operators. These additional components include the exchange rate risk and the risk of raw spot price differential. The latter in turn is composed by elements related to the MCA differential and to domestic market conditions prevailing in the UK and in France. Hence, one would expect to find a greater basis risk in France than in the UK.

The basis for French operators exporting to the UK is expected to be lower than that for French traders operating on the French domestic market. While both types of operator bear an MCA differential risk and an exchange rate risk, domestic operators face additional risks arising from domestic market conditions in both countries, expressed by PD_t.

3.2.2 Methodology for comparison of basis risk

The methodology used to assess basis risk is exactly the same as the one used in the calculation of price risk. Risk is defined as the standard deviation of the relative forecast errors over a three months time period. Forecast models are SARIMA models obtained through a Box-Jenkins approach.

We do not adjust the basis for the different time period up to maturity since that this is taken into account by a "seasonal" component. The number of weeks up to maturity, using our approach for the nearby contract, ranges from 11 or 12 or 13 weeks ,according to the month considered, to 3 weeks when we are at the very end of the month preceding the maturity month. So, every 8 or 9 weeks the time to maturity will be similar. This may appear to be a static approach but operators very often hedge according to strict hedging strategies relative to the contract traded, either with the nearby contract, for most of the time, or more rarely, with the next to nearby contract. For the next to nearby contract, we have approximately 20 weeks up to maturity at the very most, and up to 11 or 12 weeks at the least. The seasonal pattern is also expected to be of 8 weeks since as for the nearby futures contract, time to maturity will be identical every eight weeks.

The empirical analysis is undertaken from 1980/81 to 1986/87. A three year initial period is used to build up the models which are then regularly updated, as for the calculation of the price risk. Cash prices in the UK, in France and for French exporters are the same as those used in the price risk assessment. Data are the same as those used in the price risk analysis of chapter 2. Values of MCA for France and the UK are extracted from the weekly bulletin of Agra-Europe which is also used as source for the exchange rate between the £ and the FF. Futures prices have been obtained from the HGCA and refer to the EEC-wheat contract.

The basis risk is estimated monthly using the nearby basis[24] while annual assessment of the basis risk is undertaken for the nearby, next to nearby and November basis. We then explore the effects of hedging strategies on the basis development and examine the behaviour of the November contract.

3.2.3 Results of comparison of basis risk

Assessment of the basis risk enables us to test the five auxillary hypotheses[25] specified at the start of the section 3.2. The first auxillary hypothesis was that there exist periods of time where the basis risk in the UK is higher than the price risk. Table 3.1 shows that the nearby basis risk in the UK has widely fluctuated relative to the price risk. While in 1983/84 and 1986/87 the basis risk represents only about a third of the price risk, the level of basis risk during the two intermediate seasons 1984/85 and 1985/86 exceeds the price risk by about 20%. In absolute value, the basis risk seems to be fairly constant, at around .013, despite an upsurge in 1984/85. That season was characterised by very specific market conditions of oversupply after a record harvest, and heavy delivery to intervention stores which then became a commonplace outlet for producers and merchants. The evidence therefore supports the first auxiliary hypothesis.

Testing the second auxiliary hypothesis also gives positive results since the basis risk for domestic French operators is shown, (in Table 3.1), to be slightly higher than the French domestic price risk, while displaying a regularly increasing trend. However, this situation, not favourable for hedgers on the London futures market, is slowly improving as shown by the declining trend of the ratio [basis risk/price risk] in Table 3.1. Performance of the basis is slightly better for French exporters to UK. Although higher than the price risk in the first three seasons considered, the basis risk shows a sharp improvement in performance in 1986/87, where it is 50% lower than the price risk faced by exporters (Figure 3.1). The high basis risk for French operators may explain their low level of use of the London futures market. All the above results refer to intra-marketing year risk. The performance of the basis between two marketing years is better for French operators, since the basis risk is slightly lower than the price risk. Yet, it worsens in the UK, where the price risk between two seasons is 25% lower than the basis risk over the same period.

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[24] The nearby and the next to nearby basis denote respectively the basis obtained from the futures contract closest to maturity, i.e. the nearby futures contract, and from the next to nearby futures contract. In the model, hedgers do not use the expiring futures.

[25] Results in Tables 3.1 and 3.2 are extract from Table 3-A.1 in Appendix 3.

The test of the third auxillary hypothesis is also positive since, in terms of absolute values, the basis risk is lower in the UK than in France whatever the type of operators (Table 3.1 and Figures 3.1 and 3.2). This is expected, since operators in France face additional risks: exchange rate risk, raw spot price differential risk (equation 3.5) and MCA risk (equation 3.9). When we carry out a comparative examination of the ability of the futures market to substitute a lower basis risk for the market price risk in the UK and in France, we find that the basis performance in the UK is higher, on average, than in France but is more irregular (Table 3.1 and Figure 3.2). This appears to support the fourth auxillary hypothesis.

The fifth auxillary hypothesis is tested and again supported since monthly results show that basis risk is lower for French exporters than for French domestic operators, and that the basis performance, in reducing price risk, is significantly better for the former. This is expected since French domestic operators do not benefit from the price readjustment provided by the MCA system and they suffer from the market isolation created by the agri-monetary arrangements.

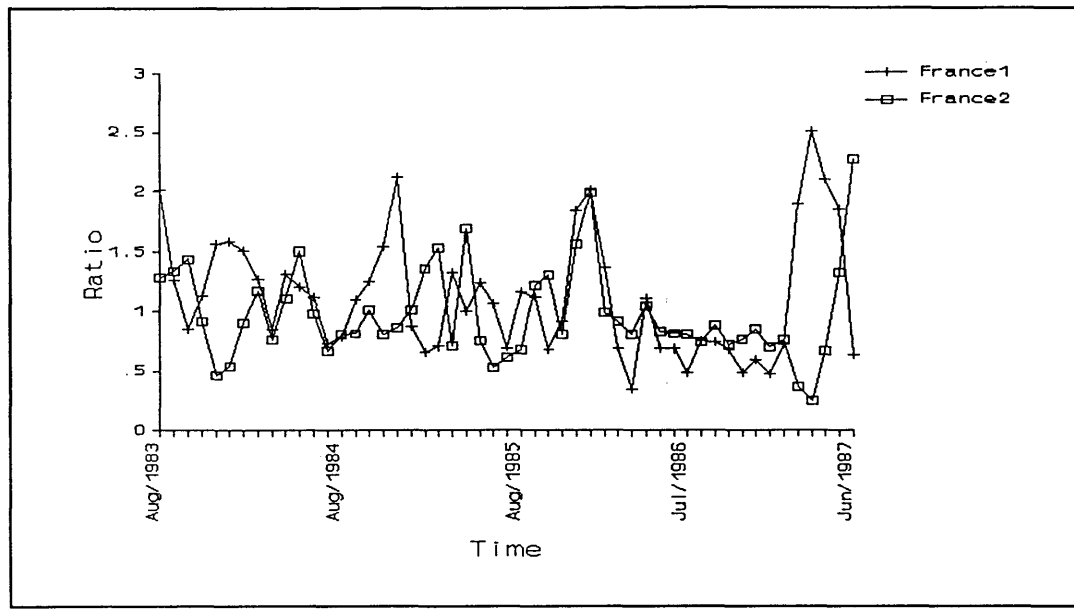
The results[26] obtained through assessment of annual basis risk in the very beginning of each season[27], (Table 3.2), confirm results from the tests of the five auxillary hypotheses displayed above. For the 1984/85 and 1985/86 seasons, they show the poor performance of the nearby basis in the UK, since the basis risk is higher than the price risk. A similar situation occurs for the next to nearby and November basis from 1984/85 to 1986/87. These results also cast doubts about the performance of the basis for French domestic operators since the basis risk, whatever the futures contract used, is systematically higher than the price risk for every season, except for the 1985/86 season. On the other hand, French exporters generally enjoy a better basis performance for all seasons and for all futures contracts. Apart from the 1984/85 season, the basis risk in the UK is lower than that borne by French exporters. The latter in turn benefit from a more favourable basis performance than their domestic counterparts.

The nearby basis performs better than the two other contract basis, and for all the three types of market operator. The next to nearby basis seems to perform slightly better than the November basis, except for French exporters.

[26] Results from price risk assessment can be found in Appendix 2.

[27] The basis risk is then assessed as the standard deviation of fifty-two weekly relative basis forecast errors.

Figure 3.1. Ratio [basis risk/price risk] for French* operators (08/1983 to 07/1987)



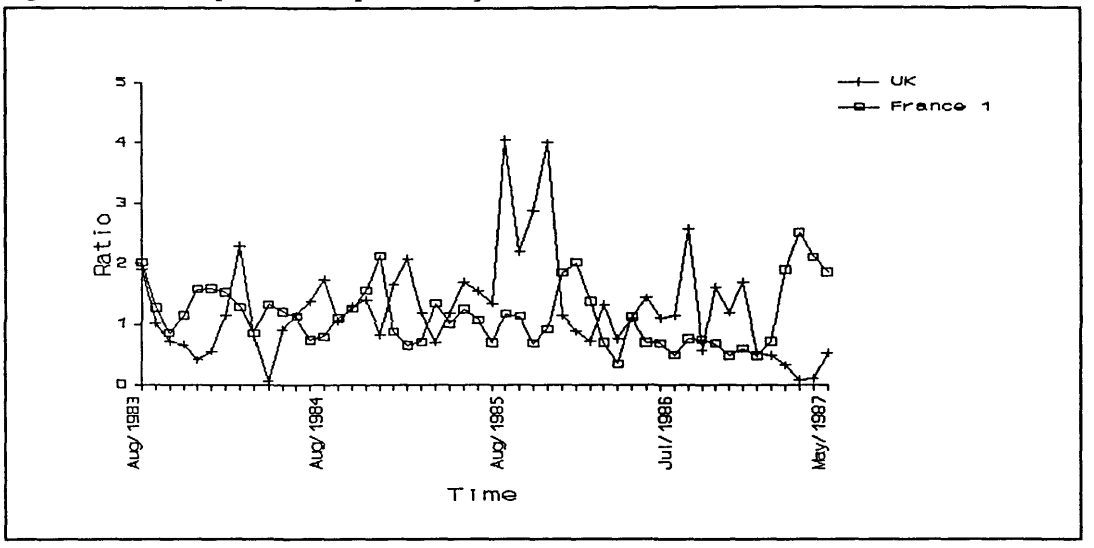
* France1 and France2 refer to domestic operators and exporters to the UK respectively

The poorer performance of the next to nearby and November basis, when compared to that of the nearby basis, may reflect, as expected, the greater risk associated with a longer term forecast and with a lower level of liquidity. Both bases seem to operate more poorly than the nearby basis, especially for UK operators.

The difference between the basis performance for French operators exporting to the UK and for British operators is expected to be smaller. We may deduce from these results that the role of the MCA system in reducing the impact of exchange rate fluctuations between institutional prices, and hence in reducing price risk, in intra-EC trade, is partially offset by the additional risk derived from the numerous arrangements surrounding its calculation[28].

[28] Operators involved in intra-EC trade traditionally hedge this MCA risk by forward contracting currency on the remaining part of the contract, i.e. the difference between the agreed price and the intervention price in ECU times the green rate of the appropriate currency (CEAS, 1989).

Figure 3.2 Ratio [basis risk/price risk] in the UK and in France1* (08/1983 to 05/1987)



* France1 refers to domestic operators and exporters to the UK respectively

Table 3.1 Nearby basis risk results, annual average of monthly basis risk and ratio [basis risk/price risk] from 1983/84 to 1986/1987*

	Basis risk			Ratio [basis risk/price risk]		
Intra-year	UK	France 1	France 2	UK	France 1	France 2
1983/84	.0148	.0248	.0285	.3699	1.2553	1.0175
1984/85	.0219	.0253	.0211	1.1771	1.1835	1.0564
1985/86	.0136	.0271	.0334	1.2019	1.1226	1.1829
1986/87	.0137	.0369	.0226	.3102	1.0980	.6715
1987/88	.0161	.0286	.0263	.5191	1.1659	.9769
Inter-year	.0407	.0390	.0454	1.2413	.9956	.9675
Overall (1983/87)	.0215	.0311	.0308	.5953	1.1258	.9747

* France 1 and France 2 refer to domestic operators and exporters to the UK respectively.

Figure 3.3. Ratio of Basis Risk between the UK and France (domestic operators, from 08/1983 to 10/1987)

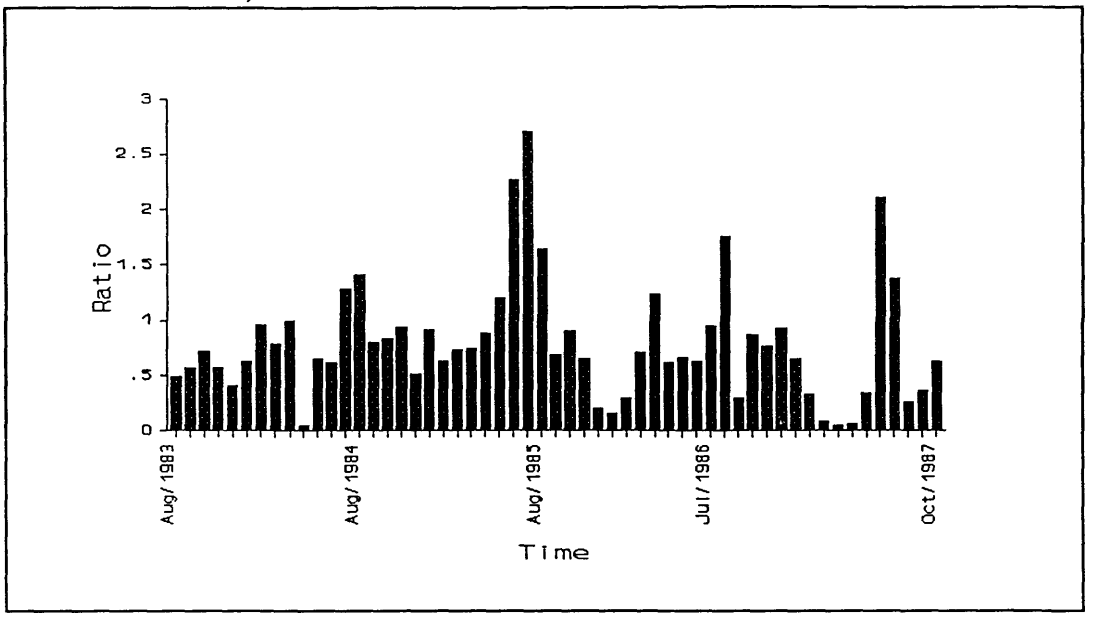


Table 3.2 Basis risk and ratio [basis risk/price risk], annual results based on weekly data from 1983/84 to 1986/87 for three different contracts*

	Basis risk				Ratio [basis risk/price risk]			
Nearby basis	83/84	84/85	85/86	86/87	83/84	84/85	85/86	86/87
UK	.0216	.0354	.0264	.0347	.4811	1.0382	1.3609	.9507
France 1	.0641	.0377	.0623	.0578	1.8911	1.3810	.9936	1.3319
France 2	.0481	.0380	.0457	.0450	.8181	.8837	.4989	.8687
Next to Nearby basis								
UK	.0195	.0371	.0409	.0383	.4343	1.0880	2.1083	1.0493
France 1	.0694	.0367	.0561	.0777	2.0475	1.3444	.8947	1.7905
France 2	.0459	.0351	.0571	.0514	.7806	.8162	.6233	.9923
November basis								
UK	.0263	.0423	.0389	.0373	.5857	1.2405	2.0052	1.0219
France 1	.0698	.0487	.0586	.0581	2.0593	1.7841	.9346	1.3388
France 2	.0854	.0304	.0556	.0457	1.4518	.7070	.6070	.8823

* France 1 and France 2 refer to domestic operators and exporters to the UK respectively.

The 1984/85 and the 1985/86 seasons show rather different results and generally a poor basis performance, whatever the contract basis or the type of operator involved. This may be due to the record harvest which occurred during those seasons and the massive delivery to intervention (22% and 10% of the UK production in 1984/85 and in 1985/86 respectively) which consequently took place.The market price then stabilised below the intervention price for most of the season before increasing later. Under these new low price risk conditions, the ability of the basis to reduce risk may have been made much less effective.

3.2.4 Conclusion

While it is generally found in futures markets that the basis risk is much lower than the cash price risk, the particular conditions of the UK and French wheat markets, investigated here, have cast doubt on the generality of this assertion. Low price risk, combined with institutional uncertainty, seems to have altered and affected the level, and the variability, of the basis performance, as shown by the results above. The five auxillary hypotheses have been successfully tested. None of the empirical results reject the initial sub-hypothesis that the CAP has affected the basis performance. The basis risk is frequently higher than the price risk in the UK and in France. While UK operators appear to benefit from a better basis performance than both French domestic operators and French exporters, the latter in turn enjoy a lower basis risk and ratio [basis risk/price risk] than French domestic operators. A study of the variables which influence the variations in the basis is now appropriate in order to fully understand the impact of the CAP on the basis, and to complete the analysis of the basis performance.

3.3 Econometric models of the UK Bases

3.3.1 Introduction

The following analysis aims to test the auxillary hypothesis that CAP-related variables play a major role in explaining variations in the basis and that the influence of market fundamental variables has been strongly reduced. The understanding of the basis behaviour is a good index of the performance of the futures market. The identification of factors that explain the wheat basis variations in the UK, with particular focus on CAP-related variables, is carried out using an econometric model which quantifies the impacts of changes in these economic factors on the basis variations. Ward and Dasse (1977) have outlined the failure of most studies of the basis to incorporate the uniqueness, or the specificity, of each market. In this analysis, we include variables derived from economic theory, and also variables related to the CAP which are specific to the London wheat futures market.

3.3.2 Methodology and identification of variables

The performance of the UK basis is evaluated by determining its response to changes in storage conditions, wheat market developments and wheat regime instruments and futures trading conditions. A second analysis considers the basis as the price spread between two distinct futures maturities. We first introduce the nine variables which are hypothesised to be related to the basis:

Table 3.3 Explained and explanatory variables* of the basis models

Explained and explanatory variables	Name of variables in the models
Contract basis (explained variable)	$LNDBAS_t$, $LNDBASN_t$ and $LNDBASV_t$ for the nearby, the next to nearby and the November basis respectively
1. level of wheat stock	$LNSTO_t$
2. level of barley stocks	$LNBAR_t$
3. cost at t of storage between month t and maturity month	$LNDCOST_t$, $LNDCOSTN_t$ and $LNDCOSTV_t$ for the nearby basis, next to nearby basis and the November basis respectively
4. wheat export volume	$LNEXPORT_t$
5. market liquidity (volume of trade / volume of open contracts)	$LNLIQ_t$
6. contract month indicators, 1 when the respective months are used, zero otherwise	$SEPT_t$, NOV_t, JAN_t, $MARCH_t$, MAY_t and $JULY_t$
7. intervention stock level	$LNSOLDE_t$
8. market price expressed as a % of the intervention price	$LNFLUCT_t$
9. a set of dummy variables referring to the evolution of the British market after 1981	$AVAI_t$, $AVAIFL_t$, $AVAISTO_t$, $AVAIBAR_t$, $AVAICOST_t$,are dummy variables referring to an intercept, $LNFLUCT_t$, $LNSTO_t$, $LNBAR_t$ and $LNDCOST_t$ respectively

* with t referring to the current month

1. The wheat basis is expected to be positively related to **the level of wheat stocks on farm** in the UK, which are to be differentiated from intervention stocks. If the level of stocks goes down, the convenience yield should increase, leading to a rise in cash price relative to the futures price, and to a decline in the basis. Alternatively, an increase in the level of stocks should cause a weakened spot market, and therefore a strengthened basis, given a decrease in spot price relative to the futures price. In the same way, an increase in

wheat stocks should cause an increase in the cost of storage, and consequently in the basis. By this analysis, we examine whether the wheat futures market follows the theory of storage. We thus investigate its credibility as a useful hedging tool.

2. **The stock level of barley**, a substitute product for wheat, is also considered since, under free market conditions, barley and wheat are likely to compete for storage capacity in the UK.

3. **Storage costs** are expected to be positively related to the basis. An increase in storage costs should cause a decrease in the storage incentive of operators. Wheat reallocation should then lead to a decrease in the cash market price which would, in turn, strengthen the basis. In our empirical analysis, we differentiate the storage cost into two different costs : a financial cost and a physical cost. We assume that storage is financed by overdraft, because this is commonly the case among farmers. Then the cost of storage for the month$_t$ is defined as

[[physical cost]+[average cash price$_t$*((base interest rate$_t$ + 2 %)/12)]]*[number of month to maturity]

with physical costs include depreciation, fuel and repairs, extra-drying and contract storage.

4. **Export commitments** are likely to be negatively related to the basis. Indeed, they are likely to cause upward pressure on the cash market, leading to a weakening of the basis. The export policy of the EC is expected to show a significant and pronounced impact on the basis development.

5. **Market liquidity** is measured by the ratio of total volume of trade to total open interest for all contracts traded (Teweles, Harlow and Stone, 1974)[29]. Minimum market liquidity is required to trade on the market without added entry and exit costs. If a liquidity problem exists, we assume that a relationship between this ratio and the basis will be found. However, no *a priori* sign of this relationship is specified.

6. **Dummy variables** were included in the basis model to account for the potential influence exerted on the basis by the **contract month** used in the calculation of the basis.

7. **The level of intervention stock of wheat** is considered when differentiating stocks of wheat directly available to the market (referred to as stock on farm in monthly statistics), variable 1, from stocks of intervention sale, the marketing of which depends on institutional

[29] Ward and Dasse (1977) define market liquidity as the ratio between the volume of trade and the open interest variation.

decisions. Furthermore, being a major instrument of the EC wheat regime, this variable is used to evaluate the real impact of that regime on the basis. As wheat intervention stocks are used by the EC Commission to release pressure on spot markets, we expect a negative relationship between the basis and the intervention stock level.

8. **The market price, expressed as a percentage of the intervention price (inclusive of the monthly increment)**, a major element of the EC wheat regime, constitutes a floor for market prices. Its determination, its level above market-clearing prices and availability, and the monthly increment system, is of fundamental importance in the spot market development (Warren and Brookes, 1986). This major instrument of the CAP is expected to have a strong influence on the basis.

9. **A set of dummy variables** is used to differentiate two **different states of the British wheat market**. Until 1980/81 the UK was not self-sufficient in wheat. Thanks to a conjunction of factors, of which the CAP by imposing high market prices, was a major one, British production has increased dramatically and has led the UK into surplus. This new market situation is in line with the introduction of the export and intervention stock level variables in the basis model since they now fully represent key elements of the UK wheat market. The CAP impact on the basis is expected to be more important after 1980/81, than during the transitional period of accession 1973/78.

Omitted variables[30] may include market anticipation on the institutional price-fixing and export refund tenders. Other possible variables such as wheat consumption (Telser, 1958) and lagged variables (especially the lagged price level on which farmers base their expectations and the lagged basis (Kahl, 1982)) could have influenced basis variations whatever the futures contract. Lagged variables have not been used because, with monthly prices, changes occurring during the month are transmitted within the same month's data. Some of them were tested, in particular the lagged cost of storage and the lagged stock level. However, they failed to provide models with any extra information[31]. It is worth noting that the transport cost rate is not included as a variable in any of the models since no specific location is

[30] Their influence may be reflected in the presence of autocorrelation.

[31] Kahl (1982) has analyzed the seasonal pattern of the corn basis over the 1960-75 time period by examining the annual variation of the monthly basis. Our methodology deals with monthly variation of the nearby basis over a thirteen-year period of time but with a pooling of all data, regardless of the monthly and then seasonal difference. It can be argued that this put at risk the significance of some explanatory variables which may explain some basis variations during only certain times of the year. Yet the small number of available data, thirteen observations, has prevented us to proceed Kahl's alternative approach of building a model for each month. The use of dummy variables partially offsets these distortions.

specified in the definition of cash prices. Provided that we work with price averages, we assume that any transport cost influence is accounted for in the disturbance term of the equation.

3.3.3 Empirical assessment

3.3.3.1 Data

The spot price at month t is the HGCA monthly average price for feed wheat in the UK. The empirical model uses monthly data from 1975/76 to 1987/88. In order to avoid potentially erratic fluctuations due to the maturity month, we do not use the month of maturity but adopt the next futures contract which is closest to maturity. In this analysis, time to maturity is never less than one month and can be as great as two months. Due to the introduction of the July futures contract only comparatively recently (1980), time to maturity can be of four months in May, from 1975/76 to 1980/81. The basis is deflated by the agricultural producer price index in order to reduce the effects of inflation on basis magnitudes and on the interactions of variables.

3.3.3.2 Definition of the models

The analysis examines the basis calculated from three different futures contracts, the nearby and next to nearby contracts and the November contract. A Seemingly Unrelated Regression (SUR) system (Zellner, 1962) is used so as to take account of the potential correlation which could exist between the error terms of the regressions of the three bases during each period[32]. Coefficient estimators obtained from a SUR system are roughly the same as the OLS estimators for each equation if the error terms are uncorrelated between two different equations or if the explanatory variables are all identical for each equation. If, however, the error term are correlated and the explanatory variables are not all identical, then the SUR method yields estimators that are asymptotically more efficient than those given by applying OLS to each equation individually. The gain in efficiency is greater the higher is the correlation of the disturbance terms and the less correlated are explanatory variables in the equations of the system (Intriligator, 1978). Furthermore, we adopt a multiplicative approach for the model because we assume that the multiplicative approach is more appropriate than an additive one since the impact of each variable on the basis is more likely to be multiplicative instead of strictly additive. We then proceed to a logarithmic transformation

[32] Yet note that if correlations between error terms are due to common omitted variables, it is not clear whether Zellner's SUR system is superior to the OLS estimations (Rao, 1974).

of the nonlinear relation, by assuming constant elasticities. The dependent variable, i.e. the basis, is restated since the presence of some negative values would have prevented us from applying this logarithmic transformation. Hence, we define the basis as the ratio between the futures price and the spot price. Moreover, this definition enables us to insert any potential trend in the price development which would have otherwise been accounted for by the lagged spot price variable. A ratio equal, greater than or less than one indicates a null, positive and negative basis, when defined as a price difference.

Three models per basis are developed. This reflects a) the availability of data (market liquidity data are available only from 08/1980) and b) the stronger impact of the EC wheat regime arrangements on the marketing of wheat in the UK after the transitional period of 1973-1978. One model is developed for the period 1975/76-1980/81 (or period I), a second for the period 1980/81-1987/88 (or period II) and a third for the whole time span 1975/76-1987/88. The first models to be estimated for the three bases consider what we will refer to as "basic" variables. They are the dummy variables relative to contract months, the level of stocks of wheat and barley, the cost of storage and the degree of fluctuation of market price around the intervention price. Whilst these models are estimated for the three time periods referred to above, a second type of model, estimated over the 09/1981-06/1988 period, takes account of three further variables: the level of export, the market liquidity and the level of intervention stocks.

The change in the British market in 1981 and referred to above should be reflected in the model. To that end, we undertake a Chow test to examine if the functions are the same on the time period 75/76-80/81 and 81/82-87/88. The F^* calculated from the basic equations, presented in Tables 3.4., 3.5 and 3.6 are 9.54, 6.39 and 6.68 for the nearby, next to nearby and November basis respectively. We compare these results with the F values from the table which are 1.83 at 5% and 2.32 at 1%. We then reject the null hypothesis and accept that the two functions differ significantly. Thus the economic relationship between the explanatory variables changes between the two periods of time. We then examine which slope coefficients are also affected by the change in the British market. For that purpose, an equation (one for each contract) with dummy variables for each slope coefficient of the models is constructed in order to measure the intercept and the coefficients changes.

3.3.4 Results

We examine the individual performance of independent variables. Results of the various models are given in Tables No.3.4, 3.5 and 3.6 for the nearby, next to nearby and November basis models.

. Contract month indicator

For the whole period, i.e. 1975/76 to 1987/88, the contract month indicators serve as intercept shifters for use of a contract other than the May contract in the calculation of the basis. September is significantly negative in all models except for the November contract[33]. This finding confirms expectations since trading a new crop futures typically induces a negative spread, relatively to that of May, between the current spot price referring to the previous crop marketing season and the current September futures price dealing with the new crop. This may reflect the market's signal to release stocks in anticipation of new crop supplies. For perhaps the same reason, the November contract month coefficient is also significant for the next to nearby basis. Regardless of their statistical significance, we can distinguish a clear pattern of positive coefficients in November which tends to decline throughout the marketing year and finishes negative in July. This expresses the weaker importance of the contract month indicator on the basis along the marketing year relatively to the May basis. These results may arise from the settling down of the basis after the post-harvest time period.

A higher number of significant contract month indicators are found during the 1981/88 period than during the 1975/81 period. This seems to indicate a stronger seasonal influence of the contract month used on the basis variations. This may be derived from the marketing of the British wheat crop which, owing to a regular surplus, has become more sensitive to EC mechanisms such as the intervention delivery option and export refund tenders. The wheat regime seems to have significantly influenced the basis development by concentrating some major operations of these market mechanisms in some particular periods.

. Stocks of wheat and barley (LNSTO and LNBAR)

In most of basis models (Tables 3.4, 3.5 and 3.6), the stock of barley is significant while the stock of wheat is not. We only obtain an expected positive coefficient during the period I. This coefficient is always negative in period II. November futures contract and the next to nearby contract present a negative relationship, significant for the former. The stock variables had a significant and stronger impact on the basis variations during the first time period. The statistical insignificance of these variables later may reflect the emergence of the EC intervention stores as a new market outlet for wheat operators. Whereas we might have expected a positive coefficient, all coefficients of barley stocks, except over the whole period and for the November contract which is not even significant, are negative and always

[33] As far as the November contract basis is concerned, dummy variables relate the time period of futures trading. For instance, the September variable stands for the September and October time period.

significant for the nearby contract basis. This variable seems to give extra-explanatory information to the model when compared with models with only the wheat stock variable. This may come from the fact that the basis is calculated for feed wheat prices[34].

. Cost of Storage (LNDCOST)

As expected, the cost of storage variable is positively related to the basis, except for the November futures contract. The November basis model offers two contrasting results between periods I and II, being significant and positive in period I and significant but negative in period II. The coefficients of the equations represent the elasticity of the basis with respect to the storage cost. Thus, the next to nearby basis is more responsive to changes in the storage cost than the nearby basis and considerably more so than the November basis. Barley stocks appear to be more responsive to feedwheat basis variations than wheat stocks which may include milling and breadmaking wheat.

. Fluctuation of the market price around the intervention price (LNFLUCT)

The influence of this variable and consequently of the intervention price level on the basis variations is very important as the level of the coefficient value and of the statistical significance attests. Statistically significant in all models, this variable always shows a negative sign. This means that the further the cash market price moves above the intervention price, the weaker is the basis. Alternatively, if it moves below the intervention price level, the basis strengthens. This basis behaviour comes also from fairly constant expected future prices.

. Variables relative to a shift in the models

We examine whether some slope coefficients are also affected by the change in the British market, following 1981 (Table 3.7). The impact of the intervention price variable is reinforced but at various levels, according to the contract basis considered. The influence of the cost of storage on the November basis has been completely reversed during the second period. It seems that this basis is highly dependent on the post-harvest institutional intervention. The influence of the cost of storage has been reduced for the nearby contract basis and for the next to nearby contract basis. This is interesting since it is not directly shown in the previous results.

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[34] This negative sign can be explained if we associate the fall in barley stocks with an increase of wheat stocks since these two commodities compete for storage space. This would strengthen the basis by bidding up storage cost. Similar results were found by Kahl and Curtis (1986). A ratio "stock of wheat/stock of wheat and barley" has been tested in order to examine the potential substitution between both commodities but no conclusive results were found.

. Variables only included after 1981

The two first variables, the intervention store level and the export volume, appear to be insignificant, except in the nearby basis model where the intervention store variable is significant at 11% with an expected negative sign. Indeed, when intervention store level increases, it releases the spot market from a surplus of wheat and therefore strengthens the physical market price. It also reduces the pressure on storage capacities which in turn lowers the storage cost, hence leading to a weaker futures price. Export variable coefficients are not significant. This result does not confirm early expectations, since it is well recognized that wheat exports strongly influence volume of trade on the futures market. This result may be explained by the fact that exporting mainly occurs early in the season and the impact on the basis could have been diluted amongst other variables such as stocks, at their highest during that time period, and the September contract month indicator[35]. The slope coefficient of the market liquidity variable was positive for the three bases but was only significant for the next to nearby basis and at 11% for the nearby basis[36]. This result suggests that when the volume of trade rises relatively to open interest, futures prices increase relative to cash prices. Speculative activity is translated into an increase of futures prices relative to cash prices. Nevertheless, this result is however difficult to interpret. The next to nearby basis appears to be more sensitive than the nearby basis to this speculative activity than the nearby basis. The latter generally benefits from a higher level of activity, hence reducing its sensitivity to the market liquidity.

3.3.5 Conclusion

The empirical results seem to support the auxillary hypothesis (section 3.3.1) that CAP-related variables play a major role in explaining variations in the basis and that the influence of market fundamental variables has been strongly reduced. The EC wheat regime appears to have influenced the basis development in the UK, particularly during the period 1981-88. The Chow test has highlighted changes in the determination of the basis models between the two time periods considered. This may be indicative of the CAP's impact on the basis behaviour since the 1981-88 period is very much influenced by the EC wheat regime after the 1973/78 transitional period.

[35] The export variable is highly correlated with other variables, such as the variable relative to fluctuation around the intervention price.

[36] Tilley and Campbell (1988) found an opposite result but argued that their result was very sensitive to whether data from the delivery month were included.

Table No.3.4 Models of the Nearby Basis

Variables	1975.09/ 1981.07	1981.09/ 1988.06	1975.09/ 1988.06	1981.09/ 1988.06
C	0.1462* (4.92)	0.3159* (9.67)	0.1700* (6.31)	0.3558* (8.89)
Sept	-0.1148* (-6.86)	-0.3131* (-11.33)	-0.1504* (-9.29)	-0.2921* (-10.33)
Nov	0.0019 (0.09)	0.0637* (4.55)	0.0184 (1.04)	0.0609* (4.46)
Jan	0.0052 (0.30)	0.0506* (4.21)	0.0164 (1.17)	0.0551* (4.53)
March	0.0043 (0.36)	0.0169 (1.58)	0.0045 (0.45)	0.0157 (1.52)
July	-0.0291 (-1.34)	-0.0681* (-5.11)	-0.0050 (-0.43)	-0.0638* (-4.85)
Lnfluct	-0.2464* (-4.28)	-0.2169* (-4.01)	-0.3497* (-6.53)	-0.2344* (-4.21)
Lnsto	0.0130 (1.77)	-0.0225* (-2.35)	0.0053 (0.83)	-0.0123 (-1.19)
Lnbar	-0.0256* (-3.62)	-0.0200 (-1.79)	-0.0249* (-3.61)	-0.0280* (-2.46)
Lndcost	0.0258* (3.35)	0.0341* (3.40)	0.0228* (3.56)	0.0356* (3.51)
Lnliq	---	---	---	0.0167 (1.62)
Lnexport	---	---	---	-0.0034 (-0.87)
Lnsolde	---	---	---	-0.0037 (-1.66)
AR(1)	0.8508 (11.82)	---	0.8595 (19.07)	---
Adj R^2	0.755	0.778	0.630	0.791
S.E. of Regression	0.0260	0.0251	0.0321	0.0244
Durbin-Watson	1.91	1.74	2.34	1.72
F-stat	22.65	32.54	27.09	26.59

* denotes the variables that are significant at the 5 % level

Table No.3.5 Models of the Next to Nearby Basis

Variables	1975.09/ 1981.07	1981.09/ 1988.06	1975.09/ 1988.06	1981.09/ 1988.06
C	0.0958* (2.42)	0.2159* (7.10)	0.1436* (4.64)	0.2398* (2.87)
Sept	-0.1023* (-5.68)	-0.2061* (-9.25)	-0.1357* (-9.04)	-0.1942* (-8.79)
Nov	-0.1045* (-4.09)	-0.2465* (-7.28)	-0.1491* (-6.76)	-0.2304* (-6.85)
Jan	0.0066 (0.38)	0.0305 (1.67)	0.0179 (1.26)	0.0352 (1.96)
March	0.0036 (0.29)	0.0218 (1.70)	0.0123 (1.24)	0.0332* (2.51)
July	0.0516* (2.25)	-0.0130 (-0.99)	0.0232* (2.09)	-0.0063 (-0.49)
Lnfluct	-0.3339* (-5.47)	-0.4276* (-5.62)	-0.4237* (-8.03)	-0.4044* (-5.33)
Lnsto	0.0015 (0.19)	-0.0149 (-1.35)	-0.0090 (-1.41)	-0.0158 (-1.43)
Lnbar	-0.0136 (-1.84)	-0.0167 (-1.29)	-0.0100 (-1.45)	-0.0160 (-1.25)
Lndcost	0.0641* (3.18)	0.0507* (2.36)	0.0523* (3.28)	0.0662* (2.97)
Lnliq	---	---	---	0.0298* (2.58)
Lnexport	---	---	---	0.0028 (0.51)
Lnsolde	---	---	---	-0.0049 (-0.88)
AR(1)	0.8931 (15.06)	0.6572 (6.25)	0.8949 (23.72)	0.6265 (5.44)
Adj R^2	0.788	0.891	0.815	0.898
S.E. of Regression	0.0286	0.0283	0.0331	0.0273
Durbin-Watson	1.87	1.75	2.02	1.71
F-stat	27.11	67.54	68.43	56.33

* denotes the variables that are significant at the 5 % level

Table No.3.6 Models of the November Basis

Variables	1975.09/ 1981.07	1981.09/ 1988.06	1975.09/ 1988.06	1981.09/ 1988.06
C	0.0613 (1.17)	0.0535 (1.84)	0.0822 (1.95)	0.2152 (1.75)
Sept	0.0205 (0.87)	0.1263* (5.45)	0.0762* (4.12)	0.1191* (4.71)
Nov	0.0673* (3.24)	0.0697* (3.51)	0.0676* (4.19)	0.0678* (3.17)
Jan	0.0462* (2.59)	0.0416* (2.47)	0.0427* (3.11)	0.0364 (1.86)
March	0.0253* (1.96)	0.0196 (1.61)	0.0229* (2.31)	0.0174 (1.29)
July	-0.0034 (-0.13)	-0.0390* (-2.19)	-0.0402* (-2.64)	-0.0399* (-2.12)
Lnfluct	-0.3594* (-5.17)	-0.5077* (-7.64)	-0.4679* (-9.05)	-0.5162* (-7.54)
Lnsto	0.0057 (0.37)	-0.0135 (-1.36)	-0.0177* (-2.08)	-0.0127 (-1.19)
Lnbar	-0.0101 (-0.83)	-0.0070 (-0.69)	0.0025 (0.33)	-0.0065 (-0.60)
Lndcost	0.0039* (5.35)	-0.0029* (-4.23)	0.0003 (0.54)	-0.0029* (-4.09)
Lnliq	---	---	---	0.0110 (1.02)
Lnexport	---	---	---	-0.0045 (-0.79)
Lnsolde	---	---	---	-0.0108 (-1.18)
AR(1)	0.9113 (16.80)	0.8461 (12.50)	0.9281 (30.25)	0.7838 (8.62)
Adj R^2	0.751	0.849	0.800	0.849
S.E. of Regression	0.0296	0.0286	0.0341	0.0285
Durbin-Watson	1.87	1.97	1.89	1.88
F-stat	22.14	46.74	62.33	36.29

* denotes the variables that are significant at the 5 % level

Table No.3.7 Models with Dummy Slope Coefficients, 09/1975-06/1988

Variables	Nearby Basis	Next to Nearby Basis	November Basis
C	0.1955* (8.26)	0.0970* (3.09)	0.0704 (1.53)
Sept	-0.1660* (-10.64)	-0.1497* (-10.26)	0.0766* (4.35)
Nov	0.0344* (2.17)	-0.1677* (-8.03)	0.0678* (4.44)
Jan	0.0279* (2.20)	0.0184 (1.37)	0.0431* (3.32)
March	0.0113 (1.21)	0.0122 (1.32)	0.0224* (2.39)
July	-0.0156 (-1.34)	0.0148 (1.42)	-0.0318* (-2.06)
Lnfluct	-0.1715* (-2.91)	-0.2691* (-4.27)	-0.3665* (-5.42)
Lnsto	0.0042 (0.52)	-0.0018 (-0.22)	-0.0123 (-1.08)
Lnbar	-0.0271* (-3.52)	-0.0192* (-2.47)	-0.0012 (-0.13)
Lndcost	0.0421* (5.41)	0.1021* (5.53)	0.0023* (3.28)
AvaiFL	-0.2579* (-3.09)	-0.2645* (-3.02)	-0.2036* (-2.20)
AvaiSTO	0.0062 (0.51)	-0.0145 (-1.21)	-0.0004 (-0.04)
AvaiBAR	-0.0080 (-0.64)	0.0145 (1.18)	-0.0008 (-0.06)
AvaiCOST	-0.0255*	-0.0816*	-0.0038*
Avai	-0.0248	0.0877*	-0.0023
AR(1)	0.7144	0.8479	0.9244
Adj R^2	0.706	0.848	0.828
S.E. of Regression	0.0286	0.0301	0.0316
D-W	2.05	1.87	1.80
F-stat	25.52	58.01	50.14

* denotes the variables that are significant at the 5 % level

The basis still responds to variables which relate to market fundamentals. The storage cost variable is very significant but its influence declines during the 1981-88 period. The influence of stock level variables changed throughout the period. But, variables such as the degree of fluctuation of the market price around the intervention price and, to a lesser degree, the intervention level, are also important in explaining basis variations. By regulating the marketing of wheat, the CAP has allowed the basis to become strongly influenced by the intervention price which represents a floor in the price determination, especially in the 1981/88 period where surplus of wheat became a structural feature of the British market. The seasonal pattern of the basis, expressed by the dummy variables, is significantly different for the three bases over the two periods. Not only is it apparent that the CAP has reduced the influence of market fundamentals and introduced new variables in the determination and the understanding of the basis, but it has also modified the way and the degree in which the basis reacts to these variables over time.

3.4 Econometric model of the futures spread

The influence of the CAP on the basis is now explored with specific reference to the theory of storage. This analysis seeks to test the auxillary hypothesis stated in section 3.3.1 that CAP-related variables play a major role in explaining variations in the basis and that the influence of market fundamentals variables has been strongly reduced. We propose to undertake the study by examining the influence of storage market variables on the futures basis or futures spread defined as

$SC_t = [P^f_{t,\text{next to nearby}} - P^f_{t,\text{nearby}}]$, with $P^f_{t,\text{next to nearby}}$ and $P^f_{t,\text{nearby}}$ the price of the next to nearby and nearby futures contracts respectively and t the month of quotation. The theory of storage offers a theoretical explanation of basis movements. Futures spread is assumed to reflect the cost of storage between the two maturity months plus a risk premium minus a convenience yield. This approach to the basis is more likely to respond to the storage market conditions than the previous definition of the basis. The previous definition of the basis accounted for variables related not only to the theory of storage but also to the conditions of supply and demand prevailing on the cash market and to factors such as transportation cost and quality variations derived from the contract design. With this new measure of the basis we focus on storage market determinants. We seek to determine whether the wheat futures market is suitable and efficient in its role of allocating storage and more generally wheat production throughout seasons.

3.4.1 Methodology of analysis

The methodology followed is similar to the one previously utilized. We build an econometric

model of the futures price spread. We stress, among other storage market fundamental variables, the importance and the impact of the monthly increment on the futures spread.

The explanatory variables are as follows :

1. the stock level of wheat on farm : $LNSTO_t$
2. the stock level of barley on farm : $LNBAR_t$
3. the cost of storage : $LNCOST_t$
4. the intervention store level : $LNSOLDE_t$
5. the monthly increment : $LNMINC_t$
6. a set of dummy variables relating the contract month used
7. two dummy variables $D11_t$ and $D12_t$ relative to the level of monthly increment and the change of the marketing season.

Variables 1 to 4 have already been used in section 3.3 and are not described here.

5. **The monthly increment** has been a common feature of the EC institutional price system. Yet, after the 1986/87 season, its use has been modified and availability reduced. As far as the intervention price is concerned, the monthly increment availability has been reduced to the August/April time period in 1986/87 and to the November/May time period in 1987/88. We expect to find a positive slope coefficient for the monthly increment. Indeed, an increase in the monthly increment tends to lift the expected future spot price and consequently the futures spread. Any increase in the monthly increment is an incentive to store for producers. Nevertheless, the various modifications in the intervention system regulations may have somewhat altered the impact of the monthly increment on the spot price and consequently on the futures spread.

6. **A set of dummy variables** is introduced in the model to investigate whether the use of a specific **contract month** in the futures spread is of any importance in explaining the behaviour of the spread. The definition of this dummy variable refers to the nearby contract used in the prevailing spread and thus concerns the two preceding months. For example, the January dummy variable is concerned with the January-March spread which is considered during the months of November and December.

7. The **D11 and the D12 dummy variables** are incorporated into the model to take account of two **specific features of the monthly increment system.** D11, defined as the May dummy variable times the value of the monthly increment variable prevailing in May, relates the particular condition of the monthly May/September spread (from August 1975 to August 1980) and the monthly May/July spread (from August 1980 onwards) which benefits from

only one half monthly increment each. The D12 dummy variable is defined as the July dummy variable time the value of the monthly increment variable prevailing in July. This dummy variable aims to highlight the change of marketing year within the spread and the contribution of only half a monthly increment to that particular spread. Both dummy variables are expected to show a negative sign.

3.4.2 Empirical Assessment

The data used are from the same source as the first analysis and relate the same time period. All prices and cost variables are deflated. For reasons similar to that of the first analysis, the time span 1975/76 - 1987/88 is split into two distinct time periods. One model is developed for the period 1975/76-1980/81, then for the period 1980/81-1987/88 and finally for the whole time period 1975/76-1987/88. The econometric model is also tested from August 1975 to June 1986 and from August 1975 to June 1988. The distinction between the two samples arises from changes which have occurred in the intervention system after 1985/86 season and particularly in the monthly increment availability.

A multiplicative approach is adopted for the estimation of the econometric model. The dependent variable had to be modified since negative values prevented us from using a logarithmic transformation. The spread is therefore defined as

$\log [[(P^{f}_{o,\text{next to nearby}} - P^{f}_{o,\text{nearby}})/(P^{f}_{o,\text{nearby}})]+1]$

A value equal, superior or inferior to zero indicates a null, positive or negative futures spread. As with previous models, a Chow test is calculated to examine whether the two equations before 1981 and after 1981 are identical. The F^{*} calculated from the basic equations are 5.52 and 5.63 for the whole time period from 08/1975 to 06/1988 and for the time period 08/1975 to 06/1986 respectively. We may assert that the two functions differ significantly since the tabulated F values are 1.83 at 5% and 2.32 at 1%.

3.4.3 Results

The results are presented in Table 3.8. Only three variables are significant over the complete period. The dummy variables D11, MAY and JULY are the only significant variables of the model, while the cost of storage variable is also significant during the first period. The strong grip of the CAP on the marketing of wheat, as well as its frequent modifications, appears to have resulted in the storage market variables being insignificant during the second period. The significance of the D11 dummy variable may emphasize the importance of the level of the monthly increment for the May futures spread and its changes over two different marketing seasons. The sign of this dummy variable coefficient tends to show that, while in

the first period the drop in value of the contribution of the monthly increment was reflected by a corresponding fall in the futures spread, the second period and the whole period give an opposite and perhaps unexpected result. The May and July dummy variables refer to the May-July and July-September futures spreads respectively. Their negative signs indicate the lower value of these spreads relative to the March-May spread, used as the intercept benchmark. They denote the shift in trade from the old to the new crop.

If we remove the 1986/87 and 1987/88 seasons from the sample, the cost of storage slope coefficient becomes significant with a positive sign as expected. Furthermore, the monthly increment variable which was not significant during the first period of time is significant and positive after 1980, although with a very low elasticity level. The MAY, JULY and D11 dummy variables also remain significant over the whole period. The shift in the nature of the significant variables between the first and the second period confirms the Chow test estimation. Whatever the sample used, i.e. from 08/1975 to 06/1986 or to 06/1988, most of variables which were significant over one particular period are no longer significant. For both samples, the seasonal pattern of the futures spread, expressed by the contract month dummy variables, changes significantly. Some variables such as the cost of storage and the monthly increment have limited influence over time.

It seems that, while the cost of storage variable is generally a major determinant of the basis variations from 1975, at least up to June 1986, the monthly increment has only had a real influence on the basis in the 1980's. This may have resulted from market conditions of oversupply which have heavily affected the storage market after 1981 and made the cash price more dependent on this CAP instrument. Thus, the EC wheat regime through the level and the availability of the monthly increment appears to have played an important role in the allocation of the wheat crop and in the determination of the basis, when expressed as futures spread. This seems to support the sub-hypothesis that the CAP has affected the basis performance and, hence, the futures market performance.

Table No. 3.8 : Econometric models of the futures spread

Variable	1975.08/ 1980.07	1980.08/ 1988.06	1975.08/ 1988.06	1980.08/ 1986.06	1975.08/ 1986.06
C	0.0102* (2.25)	-0.0005 (-0.02)	0.0088 (1.58)	0.0032 (0.35)	0.0084 (1.75)
D11	-0.0955* (-2.17)	0.1123* (2.57)	0.1314* (5.20)	-0.0462 (-1.04)	0.0993* (4.41)
D12	---	-0.0054 (-0.46)	-0.0049 (-0.88)	-0.1293* (-2.56)	-0.0072 (-1.24)
Sept	0.0016 (0.58)	0.0079 (0.71)	0.0075 (1.84)	0.0945* (2.55)	0.0046 (1.28)
Nov	0.0022 (0.92)	0.0031 (0.67)	0.0031 (1.03)	0.0023 (0.77)	0.0022 (0.92)
Jan	0.0001 (0.07)	0.0004 (0.11)	0.0006 (0.30)	0.0001 (0.06)	0.0002 (0.12)
May	0.03123 (1.21)	-0.0776* (-2.57)	-0.0946* (-5.76)	0.0298 (0.95)	-0.0765* (-5.20)
July	---	-0.0743* (-8.11)	-0.0777* (-17.92)	0.0055 (0.15)	-0.0818* (-19.25)
Lnsto	0.0002 (0.17)	-0.0024 (-0.76)	-0.0004 (-0.30)	0.0030 (1.16)	0.0005 (0.41)
Lnbar	6.53E-05 (0.05)	0.0029 (0.96)	0.0010 (0.75)	-0.0026 (-1.06)	-0.0001 (-0.12)
Lncost	0.0129* (2.39)	0.0119 (0.52)	0.0055 (0.47)	0.0270* (3.84)	0.0152* (2.62)
Lnminc	-7.8E-05 (-0.44)	0.0001 (0.28)	2.25E-05 (0.11)	0.0056* (2.43)	0.0001 (0.19)
Lnsolde	---	0.0009 (0.45)	---	0.0003 (0.78)	---
AR(1)	0.3459 (2.48)	0.8284 (8.24)	0.7698 (10.04)	---	0.4235 (4.97)
Adj R^2	0.838	0.917	0.912	0.957	0.939
S.E.R.	0.0044	0.009	0.0078	0.0068	0.0064
D-W	1.94	1.91	1.85	1.62	1.90
F-Stat	31.10	79.9	133.4	133.71	170.11

* Test of Student significant at 5%

3.5 Conclusion

This chapter is concerned with the basis performance of the wheat futures market and aimed to test the second sub-hypothesis of the thesis that the CAP, through the EC wheat regime and the agri-monetary system, has altered the performance of the futures market by increasing the basis risk thus reducing its economic usefulness. Two analyses are carried out. The first one is concerned with the assessment of basis risk. It shows that the nearby basis risk fluctuates and is sometimes higher than the price risk in the UK, particularly in the 1984/85 and 1985/86 seasons, where the institutional price risk and specific market conditions are reflected in the level of basis risk development. The agri-monetary system also influences the behaviour of the basis for foreign operators by introducing a degree of uncertainty associated with the MCA system, hence reducing the value of access to the futures market. The basis risk in France is only slightly lower on average than the price risk for operators exporting to the UK and is higher than the price risk for domestic operators. The poor performance of the basis for the latter may reflect the isolation of national physical markets derived from the agri-monetary system. It may also explain the very low level of Continental futures trading in London. Results from this analysis seem to support the five auxiliary hypotheses presented in 3.1. Indeed basis risk in the UK and in France is higher than price risk at certain periods of time. Basis risk and the ratio of basis risk to price risk are both higher in France than in the UK but higher for French domestic operators than for French exporters to the UK.

The second analysis examines the main factors which influence and explain variations in the basis and seeks to determine which economic factors relative to market fundamentals and which factors related to the CAP are specific to the London wheat futures market. The results show that, while these factors have changed along with the new conditions prevailing on the British market, the CAP appears to have significantly influenced the basis behaviour. Indeed, it has modified the seasonal pattern of the basis and reduced the influence of some market fundamental variables, such as the stock levels of wheat and barley, on the basis determination. Furthermore the EC wheat regime tends to promote the emergence of some institutional variables such as the intervention system variables and, to a minor degree, the intervention store level of wheat.

Empirical results in this chapter appear to support the second sub-hypothesis of the thesis that the CAP has altered the performance of the London wheat futures market by increasing the basis risk and it has in many ways been a major determinant of basis development and of basis performance in the London wheat futures market. By reducing the scope of risk reduction on the futures market and access to the futures market and by making the basis

dependent on institutional and political decisions, hence creating basis uncertainty, the EC wheat regime proves to be highly influential in the wheat basis formation.

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CHAPTER 4

Examination of the performance

of the hedging function

Chapter 4 explores the effect of the CAP on the London wheat futures market with regard to its hedging function. It aims at complementing the first results obtained in chapter 3. As stated in Chapter 1, the major hypothesis of this chapter is that the CAP has affected the hedging function of the London wheat futures market. Examination of this hypothesis is undertaken by the analysis of two separate, although very closely linked, issues. On the one hand, the Optimal Hedging Ratio (OHR hereafter) is presented, described and empirically investigated. In a situation of low but institutional price risk, specific levels of trade on the futures market are hypothesised to be found since risk reduction may not be the primary goal of operators on the market. On the other hand, the hedging effectiveness (HE hereafter) of the market is examined. Although no *a priori* results are hypothesised, the unique environment in which the market operates may induce low HE values by American standards (Brown, 1985 and Miller and Kahl, 1987 and 1989). To that end, a new approach to the definition and measurement of HE, more suited to the London wheat futures market, is taken so as to study the ability of the wheat futures market in managing low and institutional price risk.

4.1 Introduction to hedging

There is no exact definition of hedging. Hieronymus (1971) describes the hedging process as the trading of a position in futures market equal and opposite to an already existing or likely to exist cash market position. Hedging can also be integrated in the economic activity of the farm enterprise where it is considered as a way of insulating one's economic activity from price level speculation while retaining the opportunity to speculate in basis variation (Heifner, 1978). These two definitions of hedging refer to two types of position on the futures market, so-called "routine hedging" and "discretionary hedging" respectively.

The study of hedging has a long history. The traditional approach to hedging in futures markets was simple and clear-cut. Hedging was considered as a way of shifting risk to speculators (Hoffman, 1932 and Kaldor, 1939). Operators were divided into producers, merchants, manufacturers on the one hand and speculators on the other hand. The former were supposed to hedge in order only to shift their risk onto speculators. Working (1949) was to change all that by claiming that hedging was only a sort of arbitrage, engaged only if a possibility of profit existed. Hedging was then considered as a form of speculation on the basis. Hedging is now associated in a new theory which makes a synthesis of both risk and return opportunities. Johnson (1960) and Stein (1961) have considered hedging as a simple application of portfolio theory[37]. Following empirical studies they argue that both cash and futures commercial positions need not be equal. These authors have rationalized the observation that participants in futures markets are not fully hedged. They have been able to integrate the risk avoidance theory with Working's point of view. Under the portfolio model, it may be rational to be less than fully hedged[38].

4.2 The optimal forward contracting ratio determination

4.2.1 Application of portfolio theory

Portfolio theory is here considered as it applies to the study of hedging. The latter defines the analysis of the marketing opportunities of agricultural agents as the analysis of a portfolio of assets. Portfolio theory provides a theoretical framework for the study of the optimization conditions of agricultural agents revenue between uncertain assets. It is assumed that farmers' major objective is to combine different marketing contracts in an "efficient" portfolio. Their assets are represented by the revenue from the marketing of their agricultural products on the cash market, of their contracts on the futures market and of their contracts on the forward market.

Following Heifner (1972, 1973), we consider that market operators define their commercial positions so as to maximize profit adjusted from risk in the next time period. That

[37] The recognition of the variable nature of the hedged quantity is important for agricultural commodities since producers have to face both price risk and quantity risk. So deviations from a fully hedged position depend on the kind of relationship between output and price variability.

[38] This approach has been challenged by Brown (1985) who found that hedge ratios for some particular products are not significantly different from one and who then asserted that the portfolio model may not be adequate to support the risk reduction motivation of hedging.

proposition refers to the efficiency-frontier concept which is composed of all commercial positions which individually represents a portfolio (or a combination of assets) in which return is maximized for a given variance (risk). For purposes of analytic convenience, agents' preferences are assumed to be represented in a mean-variance framework, as introduced in Chapter 2. Indeed, a mean-variance framework assumes that the agent's expected utility is a function of only expected income and variance of income. A derivative from this assumption is that agents have either a constant risk aversion (exponential utility function) or a risk aversion increasing with wealth (quadratic utility function)[39].

The agent's objective function R, within the mean-variance framework, is given by

$$(4.1) \qquad R = E(H) + [A \,.\, Var(H)]$$

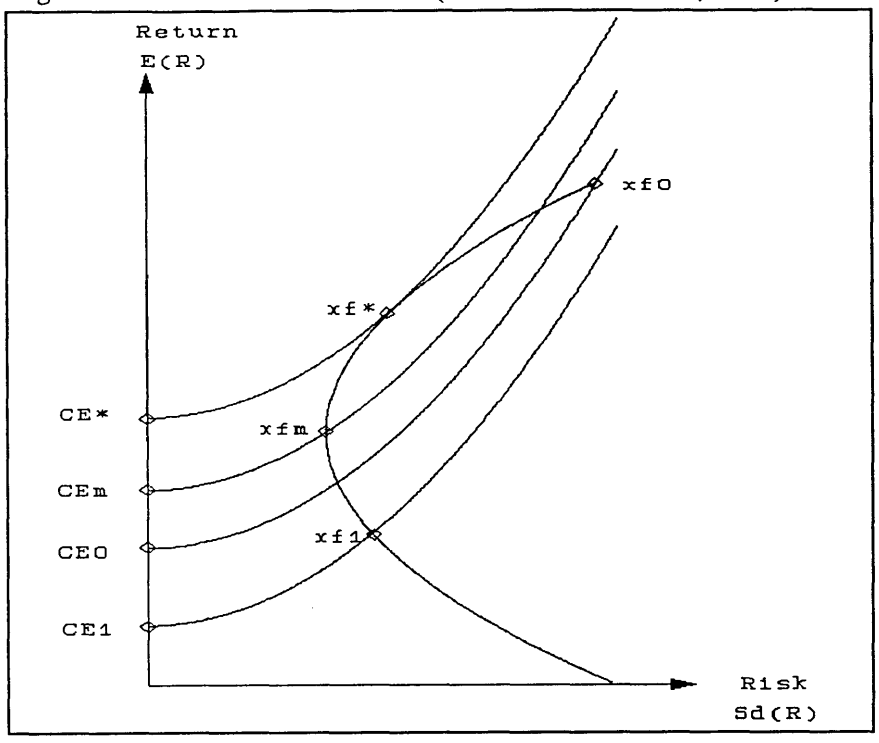
where H is the revenue (return) on the total portfolio of assets and A the risk aversion parameter, negative if the individual is risk-averse. As for all empirical studies on futures markets, we here assume that operators are risk-averse and cases where A is null or positive are not included in the study. Indifference curves are generated in accordance with the agent's utility function. Then, the optimal risk-return position is established by setting the agent's subjective marginal rate of substitution between risk and return equal to the slope of the risk-return possibility curve. Different positions can be compared by examining their certainty equivalent returns. The certainty equivalent return is defined as the intersection point of the indifference curve passing through the position in question and the expected return axis.

Agents seek to choose the unique optimal portfolio as the efficient portfolio which maximizes their utility. Figure 4.1 plots the certainty equivalent return (CER) of various hedge strategies. These strategies can be classified by agents in accordance with their CER which, in turn, are a function of their indifference curve shape. CE^*, CE_m, CE_o and CE_1 in Figure 4.1 denote the certainty-equivalent return from the optimal hedge, the minimum-risk hedge, the unhedged and the full hedge positions, respectively. The hedging levels for a optimal, risk-minimizing, unhedged and full-hedge position are also denoted by x^{f*}, x^f_m, x^f_o and x^f_1 respectively. In the example, since x^f_m is inferior to 1, agents will prefer the risk-

[39] This assumption has raised many criticisms. Both of these preferences structures have been described as unrealistic (Rolfo, 1980). Levy and Markowitz (1979) assert that, regardless of the utility function and the distribution of profits, the maximization of the mean-variance objective function may provide a reasonable approximation to the maximization of the real objective function. Kroll, Levy and Markowitz (1984) also argue that the mean-variance model stands up well when compared to direct utility maximization.

minimizing hedging strategy than a fully-hedged strategy.

Figure 4.1 Risk and return curve (from Cecchetti et al, 1988)



The curved line in Figure 4.1 represents the risk-return curve of assets constituted by the expected returns and standard deviations of various proportion of assets in a portfolio. As is clear from our analysis, the determination of the optimal hedge ratio depends on both the risk-return possibility curve of assets and the agent's utility function. When compared to the usual portfolio-problem, this approach for agricultural agents is different. First, the position on the cash market is very often given, despite the stochastic nature of the production function[40]. Cash and futures market assets are rarely substituted. Then, forward and futures contracts can have negative values, implying purchase or a sale of these contracts, while this is not possible for common shares. Agents can also buy futures contracts for more than their wealth. Finally, we consider that there is no risk-free asset which could enable agents to increase their utility level.

4.2.2 Definition of trading models

There is some important literature which has focused on the theoretical solvability of the optimal hedging ratio, i.e. the ratio of the optimal futures or forward position to the cash

[40] Production decisions are not taken into account.

position. The formulae found generally differ from one study to another because of the underlying assumptions. For example, Johnson (1960), Ward and Fletcher (1971) and Heifner (1972,1973) determine the optimal commercial position simultaneously while Peck's optimal hedging ratio (1975) is computed assuming that the cash market position is given. These differences in the underlying assumptions regarding the cash position are of major importance since they determine whether or not the optimal hedging ratio is dependent on the individual's risk aversion.

The analysis of the optimal hedging ratio focuses on three types of agents: producers, merchants and traders. Whereas there is a long tradition of futures trading for merchants and traders, farmers' trade on the futures market has been quite limited (CFTC, 1978 and Heifner et al., 1977). This may come from the more complex situation that producers face. While merchants can regulate their supply and their inventories, farmers do not know and cannot accurately forecast their final production, even after all production decisions have been made. The restrictive choice of these operators is derived from the consideration that the producer's, merchant's and trader's situation may represent an objective view of the performance of the market[41] since these operators can trade every cash, forward and futures position available to other market agents. Traders are assumed not to be related to the physical like merchants.

While we seek to study the influence of the CAP on the level and the variability of the optimal hedging ratio, an attempt is made to improve the methodologies applied in previous studies. The latter have generally assumed that the cash position is constant, i.e. yields are certain. Prior to harvest, we consider yield uncertainty in the optimal hedging ratio calculation. At harvest, producers are assumed to have a given cash position and to choose their portfolio from the two following marketing opportunities: the forward and futures contracts. On the other hand, merchants and traders are assumed to choose their optimal commercial positions either simultaneously or with a given cash position.

[41] The limitation of the study of hedging to these three operators may appear restrictive. Theoretical models of futures market equilibrium commonly represent a greater number of potential market operators (Stein, 1979; Anderson and Danthine, 1983). The latter introduce four basic types of agents that they distinguish by the nature of their trading opportunities: speculators, producers, processors and, when the traded product is storable, storage companies. The cereal processor's position is not analysed here since this would involve various elements such as the input flexibility or inflexibility, the transformation function and the output price uncertainty, which go beyond the scope of the study. Yet, the hedging principles are the same and it is only their application to a particular type of operators which differs.

Previous studies have generally failed to address the issue of forward marketing as a substitute or a complement to futures trading. In the evolution of market organization, forward trading is considered as a precursor of futures trading (Bakken, 1960). However, forward cash contracting remains important for some agricultural commodities which are traded on futures exchanges and in particular for wheat in the UK. In order to understand the state of development of both markets and to what extent they interact with each other, investigation of the optimal hedging ratio for both types of contract is implemented. The optimal hedging ratio assessment may enable us to draw some conclusions about the marketing practices of the grain producers in the UK.

4.2.3 The producer's case

4.2.3.1 Prior to harvest

We assume that the producers' revenue can be represented by a portfolio of activities which is composed of three assets, the cash marketing revenue at harvest, the forward contract revenue and the futures contract revenue. At t_1, producers are assumed to sell their production on the cash market while buying the futures contracts that they sold at t_0 and delivering the quantity sold forward at t_0.

As assumed earlier, producers seek to maximize their objective function within a mean-variance framework by choosing the optimal level of holding of forward or/and futures contracts. We assume that the maximization choice is determined after planting decisions. Producers want to know how many futures or/and forward contracts to trade, in relation with their expected output. If the following notations are adopted,

y : output (tonne)
p_1 : cash price at t_1 (£/tonne)
P_o : cash price at t_o (£/tonne)
P^f_o : futures price at t_o for delivery at t_1, (£/tonne)
p^f_1 : futures price at t_1 for delivery at t_1, (£/tonne)
P^F_o : forward price at t_o for delivery at t_1, (£/tonne)
x^f : number of futures contracts (tonne)
x^F : number of forward contracts (tonne)
x^s : number of cash contracts (tonne)
E(.) : expected value
Var(.) : variance
Cov(.,.): covariance
Sd(.) : standard deviation
Cor(.,.) : coefficient of correlation
CV(.,.) : coefficient of variation

R^f, R^F and R^c are defined as $(P^f_o - p^f_1)$, $(P^F_o - p_1)$ and $(p_1.y)$ respectively.

Producer's revenue H can then be described as follows

(4.2) $H = R^c + x^f.(R^f) + x^F.(R^F)$

The first-order condition for maximization of R in equation (4.1) with x^f and x^F as the choice variables leads to the following system of partial derivatives

(4.3) $d(R) / d(x^f) = 0$
$d(R) / d(x^F) = 0$

with

(4.4) $E(H) = E(R^c) + x^f.E(R^f) + x^F.E(R^F)$

(4.5) $Var(H) = Var(R^c) + Var[x^f.(R^f) + x^F.(R^F)] + 2.Cov[(R^c); x^f.(R^f) + x^F.(R^F)]$

and eventually to

(4.6) $$x^{f*} = \frac{-E(R^f)}{2.A.Var(R^f)} - \frac{Cov[R^c;R^f]}{Var(R^f)} - \frac{x^F.Cov[R^f;R^F]}{Var(R^f)}$$

(4.7) $$x^{F*} = \frac{-E(R^F)}{2.A.Var(R^F)} - \frac{Cov[R^c;R^F]}{Var(R^F)} - \frac{x^f.Cov[R^f;R^F]}{Var(R^F)}$$

Note that x^{f*} and x^{F*}, the optimal levels of futures and forward contracts, play a symmetrical role in both equations (4.6) and (4.7). The second-order condition gives

(4.8) $d^2(E(R))/d(x^f) = 2.A.Var(R^f)$ and $d^2(R)/d(x^F) = 2.A.Var(R^F)$

and, since A<0, is negative. Then x^{f*} and x^{F*} are both maxima.
From equations (4.6) and (4.7), we obtain a definite value of x^{f*} and x^{F*}

(4.9)
$$x^{f*} = \left[\frac{1}{(1-Cor^2(R^f;R^F))}\right].\left[\frac{E(R^F).Cor^2(R^f;R^F)}{2.A.Cov[R^f;R^F]} - \frac{E(R^f)}{2.A.Var[R^f]} + \frac{Cov[R^c;R^F].Cor^2(R^f;R^F)}{Cov[R^f;R^F]} - \frac{Cov[R^c;R^f]}{Var[R^f]}\right]$$

(4.10)
$$x^{F*} = \left[\frac{1}{(1-Cor^2(R^f;R^F))}\right].\left[\frac{E(R^f).Cor^2(R^f;R^F)}{2.A.Cov[R^f;R^F]} - \frac{E(R^F)}{2.A.Var[R^F]} + \frac{Cov[R^c;R^f].Cor^2(R^f;R^F)}{Cov[R^f;R^F]} - \frac{Cov[R^c;R^F]}{Var[R^F]}\right]$$

To obtain the optimal hedging ratio, the futures and forward hedging levels x^{f*} and x^{F*} are divided by E(y)[42]. The ratio of these two optimal positions can also be derived as follows

(4.11)

$$\frac{x^{f*}}{x^{F*}} = \frac{[E(R^F).Cov(R^f;R^F)-E(R^f).Var(R^F)]+[2.A.(Cov(R^c;R^F).Cov(R^f;R^F)-Var(R^F).Cov(R^f;R^c))]}{[E(R^f).Cov(R^f;R^F)-E(R^F).Var(R^f)]+[2.A.(Cov(R^c;R^f).Cov(R^f;R^F)-Var(R^f).Cov(R^c;R^F))]}$$

When considering (4.6), we can distinguish three components in the optimal hedging ratio x^{f*}:

The first one represents the speculative component and is inversely proportional to the producer's risk parameter. It approaches zero if the producer is infinitely risk averse. In this case, the producer would only minimise the variance of his income. The numerator of the speculative component represents the bias in the futures price since it is the difference between the futures price at t_0 and the producer's expectation of the futures price at t_1. This component disappears if the futures market is unbiased, otherwise it is negative or positive according to the expected level of the bias. Note that this component relative to the expected return from holding futures is not affected by either yield or cash price variability.

The second and the third components constitute the two hedging components. As far as the second is concerned, the hedging ratio is related to the covariance between the marketing revenues realized on the cash market and on the futures market, which in turn depends on the elasticity of market demand and the correlation between the individual production and the total market supply, i.e. roughly the aggregated production. The third component indicates that the hedging ratio is negatively related to the level of forward contracting and to the covariance between the futures market revenue and the forward market revenue.

These conclusions are the same as those drawn by more general models[43], such as those from

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[42] The OHR is obtained by dividing (4.9) and (4.10) by E(y) in the case of production uncertainty or by y in the case of storage (or of a certain cash quantity).

[43] McKinnon (1967) was apparently the first to examine the effects of both price and quantity uncertainty on the optimal hedging ratio. Nevertheless, his analysis was based on some assumptions which may be viewed as inaccurate and may lead to biased results: the two main assumptions referred to the unbiasedness of the futures price (which is supposed to be equal to the eventual spot price) and to the hypothesis that the producer seeks to minimise risk and not maximise utility. If the latter is true, we could put producer's activity into question since agriculture constitutes a fairly risky business. Heifner (1978) modified

Anderson and Danthine (1983) and Grant (1985), who consider the case where production and marketing decisions are taken simultaneously. The former decomposed the optimal futures position into three components (p.377) : the expected output, a hedging adjustment term and a speculative component.

Equation (4.7) gives the optimal amount of forward contracting relatively to the cash and the futures positions. This equation is analogous to equation (4.6). Like for the optimal "futures" hedging ratio, the optimal "forward" hedging ratio is composed of three components. The first one concerns the speculative component of the "forward" hedging ratio. As described above, it disappears when the producer is infinitively risk-averse or if the forward market is not biased, i.e. the expected future spot price at t_1 is equal to the forward price at t_0 for t_1. The second and the third components indicate that the size of the "forward" hedging ratio is directly negatively related to the covariance of the cash marketing revenue and the forward market revenue and to the size of the futures position and the covariance between the futures revenue and the forward revenue[44].

4.2.3.2 Storage

We consider that the storage cost is known with certainty by producers at the time of the storage decision and does not represent a risk for them. Their profit H can be described as follows

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McKinnon's model by introducing basis risk. Gemmill (1980) derived the optimal hedge for a producer but assumed that the futures price was constant from year to year and that the bias was constant.

[44] If we assume that prices and yields are multivariate normal, further decomposition can be achieved by transforming (4.6) and (4.7) into (4.12) and (4.13)

$$(4.12)\quad x^{f*} = \frac{-E(R^f)}{2.A.Var(R^f)} - \frac{Cov[p_1;R^f].E(y)}{Var(R^f)} - \frac{E(p_1).Cov[y;R^f]}{Var(R^f)} - \frac{x^F.Cov[R^f;R^F]}{Var(R^f)}$$

The multivariate normality may be considered as a questionable assumption. However, some authors have already used it such as McKinnon (1967), Heifner (1972), Gemmill (1980) and Miller and Kahl (1987).

$$(4.13)\quad x^{F*} = \frac{-E(R^F)}{2.A.Var(R^F)} - \frac{Cov[p_1;R^F].E(y)}{Var(R^F)} - \frac{E(p_1).Cov[y;R^F]}{Var(R^F)} - \frac{x^f.Cov[R^f;R^F]}{Var(R^F)}$$

To obtain the final composition of x^{f*} and x^{F*} and the corresponding ratio, we just need to develop equations (4.9) and (4.10) and their ratio (4.11).

(4.14) $H = y.(p_1 - C) + x^f.(P^f_o - p^f_1) + x^F.(P^F_o - p_1)$

with C the storage cost, y the total stored production and t_1 representing now the time at which farmers sell their stocks on the cash market.

Using $R^c = y.(p_1 - C)$, and proceeding with the same method as before, we obtain

$$(4.15)\quad x^{f*} = \frac{-E(R^f)}{2.A.Var(R^f)} - \frac{x^F.Cov[R^f;R^F]}{Var(R^f)} - \frac{Cov(R^c;R^f)}{Var(R^f)}$$

$$(4.16)\quad x^{F*} = \frac{-E(R^F)}{2.A.Var(R^F)} - \frac{x^f.Cov[R^f;R^F]}{Var(R^F)} - \frac{Cov(R^c;R^F)}{Var(R^F)}$$

and then (4.17) and (4.18)

(4.17)

$$x^{f*} = \left[\frac{1}{(1-Cor^2(R^f;R^F))}\right].\left[\frac{E(R^F).Cor^2(R^f;R^F)}{2.A.Cov[R^f;R^F]} - \frac{E(R^f)}{2.A.Var[R^f]} + \frac{Cov[R^c;R^F].Cor^2(R^f;R^F)}{Cov[R^f;R^F]} - \frac{Cov[R^c;R^f]}{Var[R^f]}\right]$$

(4.18)

$$x^{F*} = \left[\frac{1}{(1-Cor^2(R^f;R^F))}\right].\left[\frac{E(R^f).Cor^2(R^f;R^F)}{2.A.Cov[R^f;R^F]} - \frac{E(R^F)}{2.A.Var[R^F]} + \frac{Cov[R^c;R^f].Cor^2(R^f;R^F)}{Cov[R^f;R^F]} - \frac{Cov[R^c;R^F]}{Var[R^F]}\right]$$

To obtain the optimal forward contracting ratio (i.e. forward or futures), we divide x^{F*} and x^{f*} by y.

4.2.4 Merchants and traders

Despite the distinction between merchants, who are involved in all three markets, i.e. the cash, forward[45] and futures markets, and traders and brokers, who are mainly involved in the "paper" and futures markets, similar trading principles apply to all of them, especially when no storage is involved. As far as these operators are concerned, we choose to examine two particular cases. In the first one, operators define their optimal commercial position by trading on the futures and/or forward markets with a given cash position. Measurement of OHR is similar to the producer's case in section 4.2.3.2., with a stored production set at 1 and with R^c equivalent to $(p_1 - P_o - C)$. In the second case trading takes place on the forward (or

[45] Sometimes referred to as the 'paper' market in the U.K..

cash) and futures markets either simultaneously or with a given forward (or cash) position. Given that the case in which the cash position is similar to the producer's case when storage is involved, we focus on the situation where forward and futures positions are simultaneously determined.

These operators, who do not face quantity[46] risk, are assumed in the following to buy at t_o on the forward (or cash) market for delivery at t_1 while selling on the cash market at t_1, and to sell at t_o and to buy at t_1 on the futures market. Following the same assumptions as in the producer's case :

$$(4.19)\quad E(H) = x^f.(P^f_o - E(p^f_1)) + x^F.(E(p_1) - P^F_o)$$

and with $R^f = (P^f_o - p^f_1)$ and $R^F = (p_1 - P^F_o)$ (the contrary of the producer's case),

$$(4.20)\quad Var(H) = x^{2f}.Var(R^f) + x^{2F}.Var(R^F) + 2.x^f.x^F.Cov(R^F;R^f)$$

Following the differentiation of the objective function with respect to x^f and x^F, we obtain

$$(4.21)\quad x^{f*} = \frac{-E(R^f)}{2.A.Var(R^f)} - \frac{x^F.Cov.[R^f;R^F]}{Var(R^f)}$$

$$(4.22)\quad x^{F*} = \frac{-E(R^F)}{2.A.Var(R^F)} - \frac{x^f.Cov.[R^f;R^F]}{Var(R^F)}$$

---

[46] No differentiation for storage takes place here since we assume that storage cost is known with certainty. If merchants want to choose the quantity x^{c*} to store in order to optimize their risk/return position (as opposed to the fixed stored quantity y in the preceding case), then we obtain the following system

(4.26a)

$$x^{f*} = \frac{-E(R^f)}{2.A.Var(R^f)} - \frac{x^c.Cov[R^c;R^f]}{Var(R^f)} - \frac{x^F.Cov(R^F;R^f)}{Var(R^f)}$$

$$x^{F*} = \frac{-E(R^F)}{2.A.Var(R^F)} - \frac{x^c.Cov[R^c;R^F]}{Var(R^F)} - \frac{x^f.Cov(R^F;R^f)}{Var(R^F)}$$

$$x^{c*} = \frac{-E(R^c)}{2.A.Var(R^c)} - \frac{x^f.Cov[R^c;R^f]}{Var(R^c)} - \frac{x^F.Cov(R^F;R^c)}{Var(R^c)}$$

From (4.21) and (4.22), we set

$$(4.23)\quad x^{f*} = \frac{[Cov[R^f;R^F].E[R^F]] - [E(R^f).Var(R^F)]}{2.A.[Var(R^f).Var(R^F) - Cov^2(R^F;R^f)]}$$

$$(4.24)\quad x^{F*} = \frac{[Cov[R^f;R^F].E[R^f]] - [E(R^F).Var(R^f)]}{2.A.[Var(R^f).Var(R^F) - Cov^2(R^F;R^f)]}$$

and then, the optimal hedging ratio represented by the optimal futures position divided by the optimal forward (or cash) position is

$$(4.25)\quad \frac{x^{f*}}{x^{F*}} = \frac{[Cov[R^f;R^F].E[R^F]] - [E(R^f).Var(R^F)]}{[Cov[R^f;R^F].E[R^f]] - [E(R^F).Var(R^f)]}$$

As concluded by Kahl (1983), it is interesting to note that if the risk aversion affects the size of x^{f*} and x^{F*}, it does not affect their ratio[47].

4.3 Hedging effectiveness

4.3.1 Introduction

Examination of the hedging effectiveness (HE hereafter) of the wheat futures market takes place using two distinct approaches. We first investigate the traditional concept of hedging effectiveness which is described in the literature. Then, analysis of the hedging effectiveness is carried out under a new approach which considers both risk and return. HE results are compared to the HE of a naive strategy, under both approaches. We compare the hedging effectiveness to the naive strategy. The naive strategy refers to a strategy where the futures market position exactly offsets the agent's spot market position. With regard to wheat, a naive strategy consists of selling a futures contract of wheat for each equivalent volume of spot wheat held (to be purchased).

[47] The influence of risk aversion on the optimal hedging ratio is analysed by Kahl (1983) who compares the ratio proposed by Heifner (1972,73), Johnson (1960), Ward and Fletcher (1971) and Telser (1955/56) where cash and futures market position are simultaneous, and the ratio given by Peck (1975) and Ederington (1979) when the cash market position is given.

4.3.1.1 Traditional definition

Following Johnson (1960) and Heifner (1972), the traditional definition of hedging effectiveness is 'the proportional reduction in income variance obtained through hedging', generally when the variance through hedging is minimized. It can be shown that the effectiveness of minimum-risk hedging can be measured by the square of the correlation coefficient between cash and futures income. This measure has been used, among others, by Ederington (1979), Lasser (1987) as well as Braga and Martin (1987)[48]. Hedging effectiveness is viewed as the percentage of reduction due to futures trading.

(4.27) $HE = 1 - [Var(R^f+R^c)^* / Var(R^c)]$

where $Var(R^f+R^c)^*$ denotes the minimum variance of a portfolio containing futures contracts and cash contracts, and $Var(R^c)$ the variance of the unhedged income . This traditional definition does not take into account the possibility of maximizing expected utility, which in turn depends on expected return and variance of return. It focuses rather on risk minimization. Yet limitations inherent in the HE assessment do exist. Such limits have been outlined by Lindahl (1989) who argues that comparative analysis of the hedging effectiveness measured by the R^2, i.e. higher R^2 associated with lower basis risk, can only be valid when referring to the same particular spot position. Indeed, with the traditional definition of HE, expected income changes cannot be differentiated from unexpected income changes. The traditional measure of HE gives only a relative judgement about the ability of a futures market (or a forward market) to reduce income variance.

If HE values from the London wheat futures market are compared with values obtained on other futures markets such as the Chicago Board of Trade (CBT), the London values may be expected to be much lower. This arises from the much bigger income variance to be handled by the CBT. Moreover, the higher HE does not provide any information on the remaining basis risk, which is the real concern of operators on the wheat futures market. While we may

[48] Braga and Martin (1987) study the opportunity of hedging the corn and wheat variable levy of the EC on the Chicago Board of Trade. They use the coefficient of determination of the regression of the variable levy over the commodities futures prices as a measure of the ex-post hedging effectiveness. Terwitte (1987) includes the notion of forecast error of cash and futures income in the calculation. He asserts that the hedging effectiveness with the risk-minimizing hedge ratio can be measured by the coefficient of determination of the least-square regression of the futures price forecast errors on the cash price forecast errors. Terwitte approach differs from the traditional approach which uses price differences or percentages changes in the regression (Hayenga, Schroeder and Witt, 1986).

assume that risk reduction is not the primary concern of operators on the London futures market, we must doubt the validity of the traditional approach for measuring HE on the London wheat futures market. We now introduce a new approach to HE which takes account of both risk and return opportunities.

4.3.1.2 A new methodology for assessing hedging effectiveness

Howard and D'Antonio (1984) have described a measure of hedging effectiveness which incorporates both risk and return concepts. We here proceed with a modification of the Howard and D'Antonio approach[49]. Under our hypothesis, the agent is assumed to maximize his expected utility. We define HE as

$$(4.28) \qquad HE = [[E(U(R^f+R^c)) - E(U(R^c))] / E(U(R^c))]$$

where $E(U(R^c))$ is the expected utility of the agent's income in an unhedged strategy and $E(U(R^f+R^c))$ denotes the expected utility of the agent's income in an hedged strategy. This approach constitutes an individual measure of the hedging effectiveness, as opposed to the traditional measure or the Howard and D'Antonio measure. Our assessment of HE is aimed at taking into account not only the risk-reducing aspect of hedging but also its return aspect. We measure the HE as the relative increase in expected utility for a portfolio containing futures contracts as compared to one without futures contract. On Figure 4.1, this can be expressed by the relative measurement of a shift from an indifference curve to another by using the certainty-equivalent return of each indifference curve. Our approach differs from that of Howard and D'Antonio since they did not use the agent's risk aversion and his indifference curves in their HE assessment. Their approach to HE is based on two measures : the spot-futures correlation coefficient and a ratio, the so-called risk-return relative obtained from the risk-free rate, the expected returns and the standard deviations of return for the spot and futures positions. They measured the HE as "the increase in expected portfolio returns for a portfolio containing futures as compared to one without futures at the same level of risk" (pp 104, Howard and D'Antonio, 1984)[50]. In order to achieve consistency

[49] In their initial assumptions these authors consider an agent who has the choice of investing between three assets: the spot contract, the futures contract and a risk-free asset. They avoid using the agent's risk aversion parameter. Although computationally and analytically practical, such an hypothesis would be unrealistic when applied to the producer's and merchant's cases for which the spot position is often given and the risk-free asset use is of no great interest.

[50] Howard and D'Antonio (1987) later proposed two revised definitions of HE, derived from the one quoted above.

with the OHR study, our approach is based on utility maximization. A major drawback of this analysis comes from the necessity of utility function specification. For purposes of simplification, we introduce the HE in situations where only futures contracts and cash positions are considered.

4.3.1.2.1 Hedging effectiveness for a fixed cash position

This case considers operators buying on the spot market at t_o for sale at t_1 and selling on the futures market at t_o for purchase at t_1.

(4.29) $HE = [[x^f.E(R^f) - A'.x^{2f}.Var(R^f) - 2.A'.x^f.Cov(R^f;R^c)] / E(U(R^c))]$

or

(4.30) $HE = [[x^f.(A'.Var(R^f)).(2.x^{*f} - x^f)] / E(U(R^c))]$ $\qquad A' = - A$

For analytical convenience, we assume in the following that $E(U(R^c))$ is positive, not equal to 0 and constant since the cash position is given. The study of the characteristics of HE, with regard to the futures trading level, is carried out by first examining the derivative of HE with x^f as choice variable:

(4.31) $d(HE)/d(x^f) = [1/E(U(R^c))].[E(R^f) - 2.A'.x^f.Var(R^f) - 2.A'.Cov(R^f;R^c)]$

HE is optimal when x^f corresponds to the optimal hedging level (see equation 4.21). This point represents the maximum of HE since $d^2(HE)/d(x^f)^2$ is negative. As shown in Figure 4.2, HE is positive only between two values of x^f, namely x^f_1 and x^f_2. x^f_1 is equal to 0, i.e. the unhedged position, while x^f_2 is equal to $2x^{*f}$, i.e.

(4.32) $$x^f_2 = \frac{E(R^f)}{A'.Var(R^f)} - \frac{2.Cov(R^f;R^c)}{Var(R^f)} = 2.x^{*f}$$

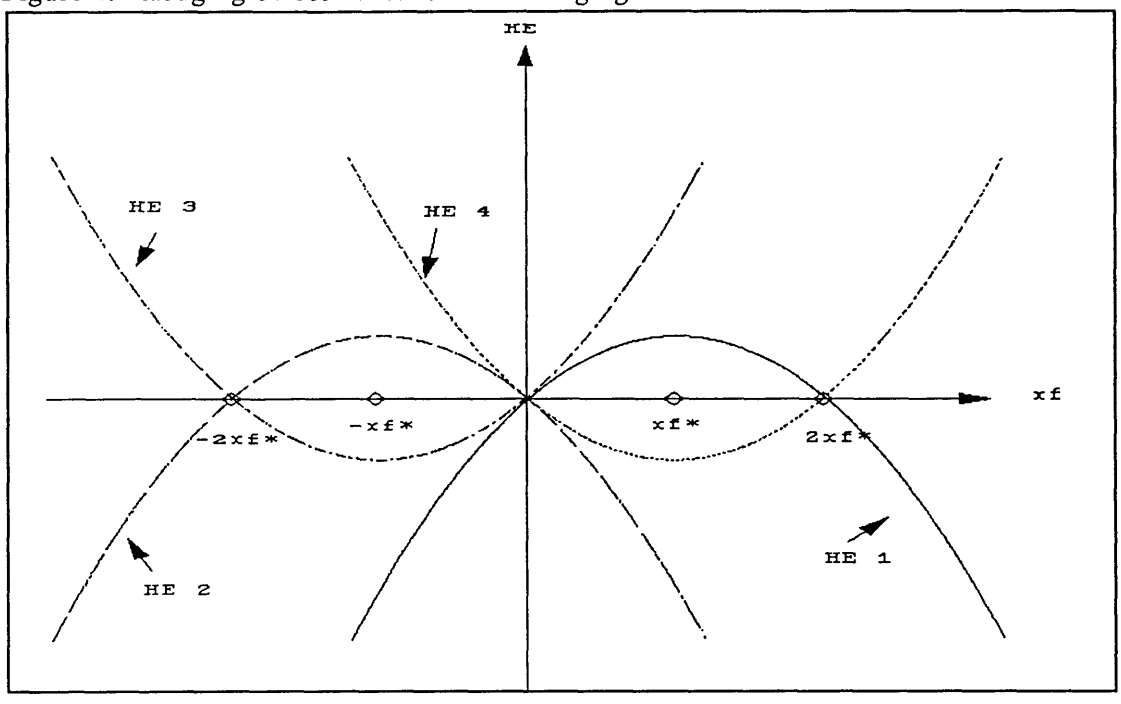
In the case where $E(U(R^c))$ is negative, i.e. generally when the agent is very risk averse, HE is as follows

(4.33) $HE = [E(R^f+R^c) - A'.Var(R^f+R^c) - E(R^c) + A'.Var(R^c)] / [E(R^c) - A'.Var(R^c)]$

HE should now be assessed in a reverse fashion. The more negative HE is, the more effective is the hedge. On the other hand, the more positive HE is, the less effective is the hedge. This

may be one limit of the mean-variance framework in its ability to represent the agent's

Figure 4.2 Hedging effectiveness and the hedging level



HE 1, HE 2, HE 3 and HE 4 denote the cases where, respectively, $E(U(R^c))$ and x^f are positive, $E(U(R^c))$ is positive and x^f negative, $E(U(R^c))$ and x^f are negative and $E(U(R^c))$ is negative and x^f positive.

objective function[51]. If the agent is extremely risk averse, then HE becomes equal to $[[Var(R^c) - Var(R^f+R^c)]/-Var(R^c)]$. HE varies between -1, when $Var(R^f+R^c)$ is equal to 0, and $+\infty$ following an increase in $Var(R^f+R^c)$. Whereas the traditional formula of HE leads to a HE included in the interval $[-\infty,1]$, this new measure of HE gives a similar result, but opposite in sign, as compared to the situation in which the return concept is not taken into account. This follows from the fact that we measure HE using a rate of increase in expected

[51] The problem of the sign of $E(U(R^c))$ and its implications for results analysis can be overcome by using, in the denominator of the ratio in (4.28), the absolute value of $E(U(R^c))$. A similar approach has been followed by Chang and Shanker (1987) and Howard and D'Antonio (1987). Nevertheless, the first formula has been kept to stick to the original methodology used in this chapter, regardless of its analytical convenience.

utility whilst the traditional formula measures a rate of decrease in the income variance[52].

We can now examine HE at the optimal hedging level. After replacing x^{f*} in (4.29) we obtain

$$(4.33)\quad HE^{*} = \frac{1}{E(U(R^{c}))} \cdot \left[\frac{E^{2}(R^{f})}{4.A'.Var(R^{f})} + \frac{A'.Cov^{2}(R^{f};R^{c})}{Var(R^{f})} - \frac{Cov(R^{c};R^{f}).E(R^{f})}{Var(R^{f})} \right]$$

and

$$(4.34)\quad HE^{*} = [1/E(U(R^{c}))].\ [(1/(2.Sqr(A').CV(R^{f}))) - (Sqr(A').Cor(R^{f};R^{c}).Sd(R^{c}))]^{2}$$

Therefore, we may confirm that using our measure of HE^{*}, the use of futures contract always enhances the agent's expected utility when trade takes place at the optimal hedging level. If, for instance, HE^{*} is equal to 0.10, then we can argue that the agent's certainty equivalent return has been increased by 10 % thanks to the use of the optimal level of futures contracts. We now determine what influences the HE^{*} when the hedging level is optimal. The second term of the product in the right side of the equation (4.33) can be written as follows

$$(4.35)\quad Cor^{2}(R^{f};R^{c}).(A'.Sd^{2}(R^{c})) - Cor(R^{f};R^{c}).(E(R^{f}).Sd(R^{c})/Sd(R^{f})) + (E^{2}(R^{f})/4.A'.Sd^{2}(R^{f}))$$

which is a second-order polynomial form in $Cor(R^{f};R^{c})$. The determinant of this polynomial form is null implying a single solution, $[E(R^{f})/2.A'.Sd(R^{f}).Sd(R^{c})]$, when set to zero. Therefore, when $Cor(R^{f};R^{c})$ is equal to $Cor_{i} = [E(R^{f})/2.A'.Sd(R^{f}).Sd(R^{c})]$, with Cor_{1} if $E(R^{f})$ is positive, otherwise Cor_{2}, the HE, when the optimal hedging level is optimal, is minimum and equal to zero. This point represents the minimum of the HE^{*} curve and the maximum of the HE curve in the case where x^{f*} is null. We are then at the double-point solution when $x^{f}_{1} = x^{f}_{2}$ (in equation 4.32). The figure 4.3 below, provided that $E(U(R^{c}))$ is positive, expresses the variations of HE^{*} according to $Cor(R^{c};R^{f})$ values. The two curves refer to the two cases where $E(R^{f})$ is positive and negative.

The two limits are HE^{*}_{a} and HE^{*}_{b}, when $Cor(R^{f};R^{c})$ is set at -1 and 1. When $Cor(R^{f};R^{c})$ is set

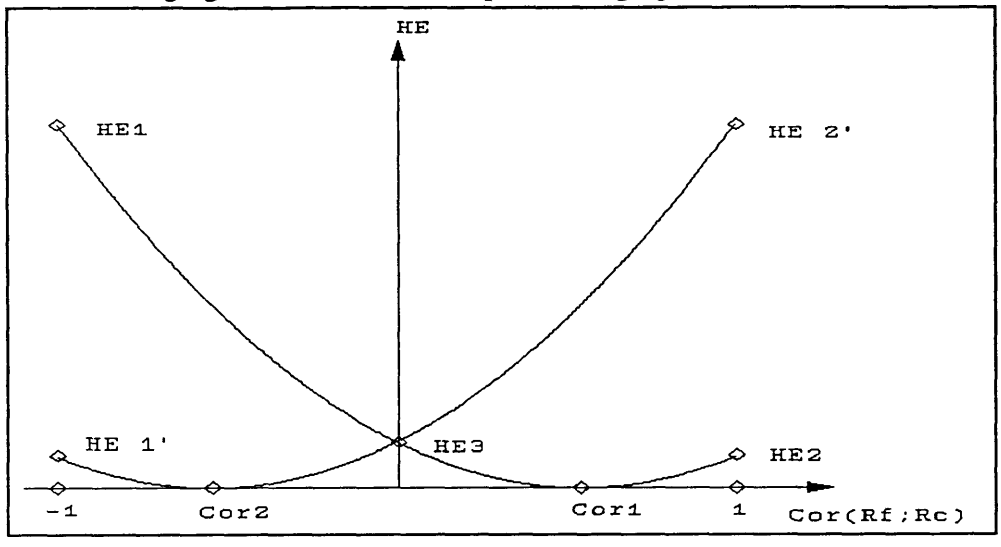
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[52] If we consider only the variance, which is the case for a very risk-averse agent, then $E(U(R^{f}+R^{c})) = - A'.Var(R^{f}+R^{c})$ and $E(U(R^{c})) = - A'.Var(R^{c})$, then our measure of HE is equal to $[-1 + Var(R^{f}+R^{c})/Var(R^{c})]$, while the traditional measure is equal to $[1 - Var(R^{f}+R^{c})/Var(R^{c})]$. The opposite sign between these two approaches comes from the antagonism of the two measures. One assesses a rate of reduction while the other one is concerned with a growth rate.

at 1[53], HE* is equal to

$$(4.36)\quad HE^*_b = \frac{4.A'^2.Sd^2(R^f).Sd^2(R^c) - E(R^f).4.A'.Sd(R^f).Sd(R^c) + E^2(R^f)}{4.A'.Sd^2(R^f).(E(R^c) - A'.Sd^2(R^c))}$$

Figure 4.3 The hedging effectiveness at the optimal hedging level as a function of $Cor(R^c;R^f)$



and, when $Cor(R^f;R^c)$ is set at -1, HE* becomes

$$(4.37)\quad HE^*_a = \frac{4.A'^2.Sd^2(R^f).Sd^2(R^c) + E(R^f).4.A'.Sd(R^f).Sd(R^c) + E^2(R^f)}{4.A'.Sd^2(R^f).(E(R^c) - A'.Sd^2(R^c))}$$

If $E(R^f)$ is negative, then the upper limit of HE* is given by HE^*_b. On the other hand, when $E(R^f)$ is positive, the upper limit is equal to HE^*_a. Since we may reasonably assume that $Cor(R^f;R^c)$ is positive as well as $E(U(R^c))$, then the upper limit of HE* will depend on the existence and the sign of the bias $E(R^f)$. If there is no bias, then from equation (4.33) we can deduct that HE* is equal to

$$(4.38)\quad HE^*_h = \frac{Cov^2(R^c;R^f).A'}{Sd^2(R^f)} \cdot \frac{1}{E(U(R^c))}$$

[53] HE^*_b is equal to HE'_2 or HE_2 in Figure 4.3, when $E(R^f)$ is negative or positive respectively. HE^*_a is also equal to HE_1 or HE'_1, when $E(R^f)$ is positive or negative respectively.

By analogy with the optimal hedging ratio vocabulary, we can refer to HE^*_h as the hedging component of the HE^*. The third component of HE^* in (4.33) is in turn related to both speculative and hedging considerations.

If $Cor(R^c;R^f)$ is equal to 0, then HE^* is equal to HE^*_p , defined as

$$(4.39)\quad HE^*_p = [E^2(R^f)/(E(U(R^{c*})).4.A'.Var(R^f))] = [1/E(U(R^{c*})).(2.A'^{1/2}.CV(R^f))$$

and is mainly related to the risk aversion of the agent and the coefficient of variation of the futures income. HE^* is then only composed of the first element of (4.33). The latter can be described as the speculative component of HE^*, since it does not depend upon the cash/futures market prices relationship.

4.3.1.2.2 Hedging effectiveness for simultaneously determined cash and futures positions

The application of the above HE definition to this case is not possible since no initial cash position can be fixed by definition. It is assumed, since it is the only sensible assumption, that the spot position considered, x^s, is optimal.

$$(4.40)\quad HE = [[E(U(R^{f*}+R^{c*})) - E(U(R^{c*}))] / E(U(R^{c*}))]$$

$$(4.41)\quad HE = \frac{x^{f*}.E(R^f) - A'.x^{2f*}.Var(R^f) - 2.A'.x^{f*}.x^{s*}.Cov(R^f;R^c)}{x^{s*}.E(R^c) - A'.x^{2s*}.Var(R^c)}$$

Replacing x^{f*} and x^{s*} by the results in equations 4.23 and 4.24, we finally obtain

$$(4.42)\quad HE = \frac{[Cov(R^f;R^c).E(R^c).Sd(R^f) - E(R^f).Var(R^c).Sd(R^f)]^2}{E(U(R^{c*})).4.A'.[(Var(R^f).Var(R^c)) - Cov^2(R^f;R^c)]^2}$$

The sign of (4.42) depends on the sign of $E(U(R^{c*}))$. Therefore, under this definition the use of futures contracts always increases the agent's expected utility. (4.42) is equivalent to

$$(4.43)\quad HE = \frac{[Cor(R^c;R^f).E(R^c)/Sd(R^c) - E(R^f)/Sd(R^f)]^2}{4.A'.[1-Cor^2(R^f;R^c)]^2.E(U(R^{c*}))}$$

and to

$$(4.44) \quad HE = \frac{1}{4.A'.E(U(R^{c*}))} \cdot \frac{[Cor(R^f;R^c).E(R^c)/Sd(R^c) - E(R^f)/Sd(R^f)]^2}{[1-Cor^2(R^c;R^f)]^2}$$

Investigation of HE leads to the examination of the first derivative of the function $T(Cor(R^c;R^f))$ defined as

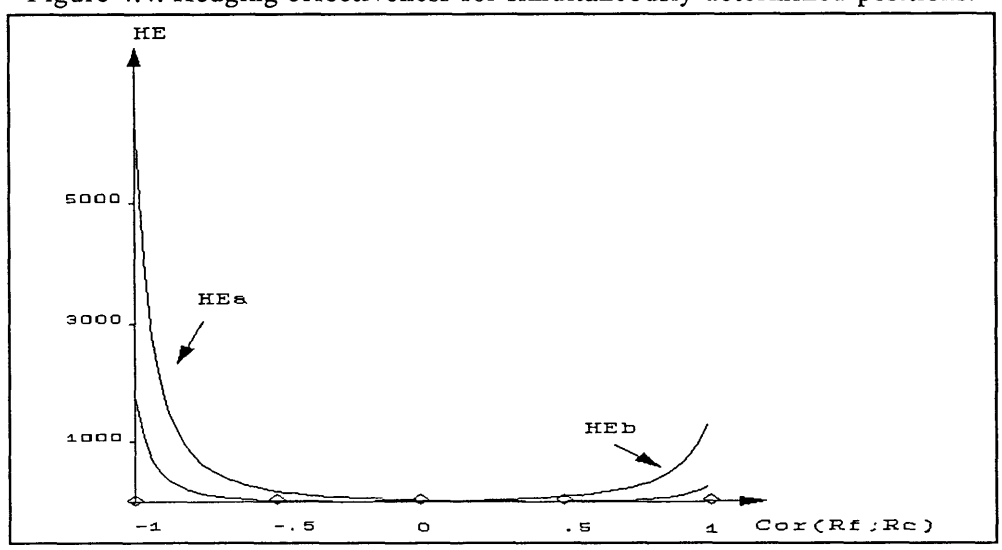
$$(4.45) \quad T(Cor(R^c;R^f)) = [[Cor(R^f;R^c).E(R^c)/Sd(R^c) - E(R^f)/Sd(R^f)]^2/[1-Cor^2(R^c;R^f)]]^2$$

then if 'a' denotes $(E(R^c)/Sd(R^c))$ and 'b' $(E(R^f)/Sd(R^f))$

$$(4.46) \quad T'(Cor(R^c;R^f)) = \frac{2.[Cor(R^f;R^c).a - b].[a.Cor(R^f;R^c)^2 - 2.b.Cor(R^c;R^f) + a]}{[1-Cor^2(R^c;R^f)]^3}$$

While we can expect a shape similar to the one in Figure 4.4., the exact shape of HE* in the [-1;1] interval is function of the values of $(E(R^c)/Sd(R^c))$ and $(E(R^f)/Sd(R^f))$, their ratio and their respective and relative sign.

Figure 4.4. Hedging effectiveness for simultaneously determined positions.



HEa and HEb denote the cases where (a,b) in equation (4.44) equals (10,3.33) and (10,-2.5) respectively. A' and $E(U(R^{c*}))$ are set to 0.01 and 25 respectively.

4.3.1.3 Hedging effectiveness elasticity

Measurement of the elasticity of HE with x^f takes place so as to define the sensitivity of the HE to any deviation from the optimal hedging level. The elasticity of hedging effectiveness, as far as the new definition of hedging effectiveness is concerned, is defined as the ratio of the proportional change in the hedging effectiveness d(HE)/HE to the proportional change in the hedging level $d(x^f)/x^f$. Hence

$$(4.47) \qquad e_h = [(d(HE)/HE) \,/\, (d(x^f)/x^f)]$$

We first consider the case when the cash position is given. As far as agricultural operators are concerned, with similar marketing strategies as those quoted above, e_h can be described as

$$(4.48) \quad e_h = 1 + \frac{-A'.\, x^f.Var(R^f)}{E(R^f) - A'.x^f.Var(R^f) - 2.A'.Cov(R^f;R^c)}$$

If e_h is denoted as a function $E_h(x^f)$ of x^f, we have

$$(4.49) \quad E_h(x^f) = 1 + [-A'.\, x^f.\, Var(R^f)]/[E(R^f) - A'.x^f.Var(R^f) - 2.A'.Cov(R^f;R^c)]$$

then

$$(4.50) \quad E_h'(x^f) = [A'.Var(R^f)].[2A'.Cov(R^f;R^c) - E(R^f)] \,/\, [E(R^f) - A'.x^f.Var(R^f) - 2.A'.Cov(R^f;R^c)]^2$$

We can also write (4.50) as

$$(4.51) \quad E_h'(x^f) = [-x^{*f}.2.A^{2'}.Var^2(R^f)]/[E(R^f) - A'.x^f.Var(R^f) - 2.A'.Cov(R^f;R^c)]^2$$

Note that we do not consider the case where $x^f = [E(R^f) - 2.A'.Cov(R^f;R^c)]/A'.Var(R^f)]$ for which $E_h(x^f)$ is not defined, i.e. when x^f is equal to the double of the optimal hedging level. In the particular case where $E(R^f) = 2.A'.Cov(R^f;R^c)$, i.e. x^{f*} is null, $E_h'(x^f)$ is not defined since the numerator is null but the denominator is also null. The asymptote of equation $x^f = [[E(R^f) - 2.A'.Cov(R^f;R^c)]/A'.Var(R^f)]$ and the Y axis becomes identical. We can therefore assert that E'_h is never null.

Analysis of the function $E_h(x^f)$ gives the following:

1. If $2.A'.Cov(R^f;R^c) > E(R^f)$, i.e. x^{f*} is negative (Figure 4.5), $E_h'(x^f)$ is positive and E_h is a constantly increasing function. The curve is limited by two asymptotes whose equations are $x^f = [[E(R^f)-2.A'.Cov(R^f;R^c)]/A'.Var(R^f)]$ and $E_h(x^f) = 2$.
$E_h(x^f) = 1$ for $x^f = 0$ and $E_h(x^f)$ equals 0 for x^f equals to $[E(R^f)/2.A'.Var(R^f)] - [Cov(R^f;R^c)/Var(R^f)]$, which is the optimal hedging ratio[54].

2. If $2.A'.Cov(R^f;R^c) < E(R^f)$, case where x^{f*} is positive, (Figure 4.6), $E_h'(x^f)$ is negative and $E_h(x^f)$ always decreases. As in the previous case, the curve has two asymptotes whose equations are $x^f = [E(R^f)-2.A'.Cov(R^f;R^c)]/[A'.Var(R^f)]$ and $E_h = 2$.
$E_h(x^f) = 1$ for $x^f = 0$ and $E_h(x^f) = 0$ for $x^f = [E(R^f)/2.A'.Var(R^f)] - [Cov(R^c;R^f)/Var(R^f)]$, which is the optimal hedging ratio.

If x^{f*} is positive, situations which can be expected under agents strategies introduced in sections 4.2.3.1, 4.2.3.2 and 4.2.4, then any trade over the optimal level on the futures market may produce a negative elasticity. In such case, if one increases the level of trade x^f over the optimal level x^{f*}, this would rapidly lead to a decrease in the hedging effectiveness. However, if one trades below the optimal hedging level, increase in trade, up to the optimal hedging level, raises the HE more than proportionally, up to an unhedged position, i.e. $x^f=0$, and less than proportionally from an unhedged position to x^{f*}. Similar but opposite results follow from the analysis of the case where x^{f*} is negative.

With two simultaneously determined positions, we have

$$(4.52)\quad e_h = 1 - \frac{A'.x^f.Var(R^f)}{E(R^f) - A'.x^f.Var(R^f) - 2.A'.x^{s*}.Cov(R^f;R^c)}$$

We then focus on the function $E_h(x^f)$ denoted

$$(4.53)\quad E_h(x^f) = 1 + [-A'.x^f.Var(R^f)] / [E(R^f) - A'.x^f.Var(R^f) - 2.A'.x^{s*}.Cov(R^f;R^c)]$$

then $E_h'(x^f)$, with respect to x^f, is equal to

$$(4.54)\quad E_h'(x^f) = [-2.A'^2.x^{f*}.Var^2(R^f)]/[E(R^f)-A'.x^f.Var(R^f)-2.A'.x^{s*}.Cov(R^f;R^c)]^2$$

[54] This last result can be checked by assessing the elasticity of HE at the optimal hedging level x^{*f} by replacing in the formula above x^f by the optimal hedging level in equation (4.21).

The study of $E_h(x^f)$ is not described here since it follows the same principles as in the case of a fixed cash position and since $E_h(x^f)$ has similar characteristics[55].

Figure 4.5 Elasticity of hedging effectiveness and the optimal hedging ratio when x^f is negative[56]

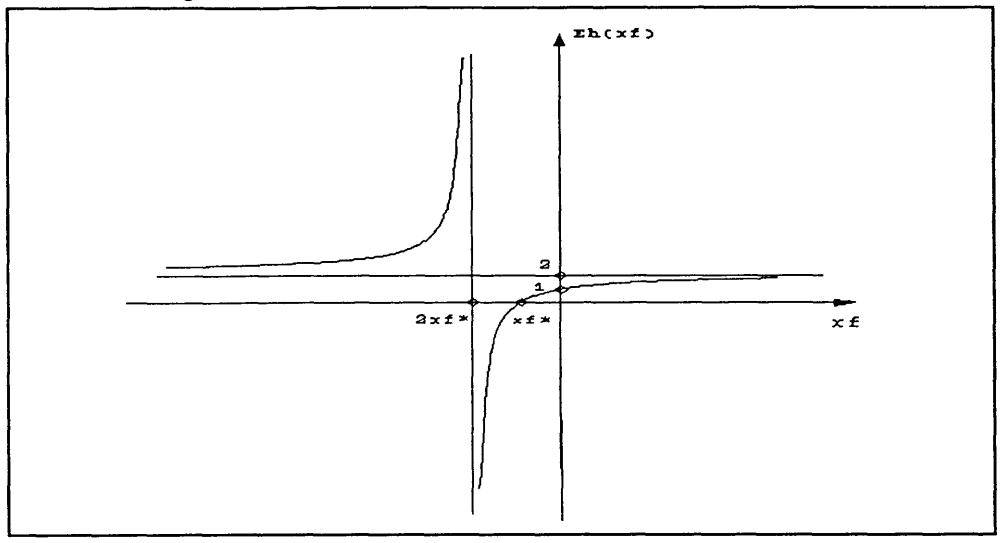
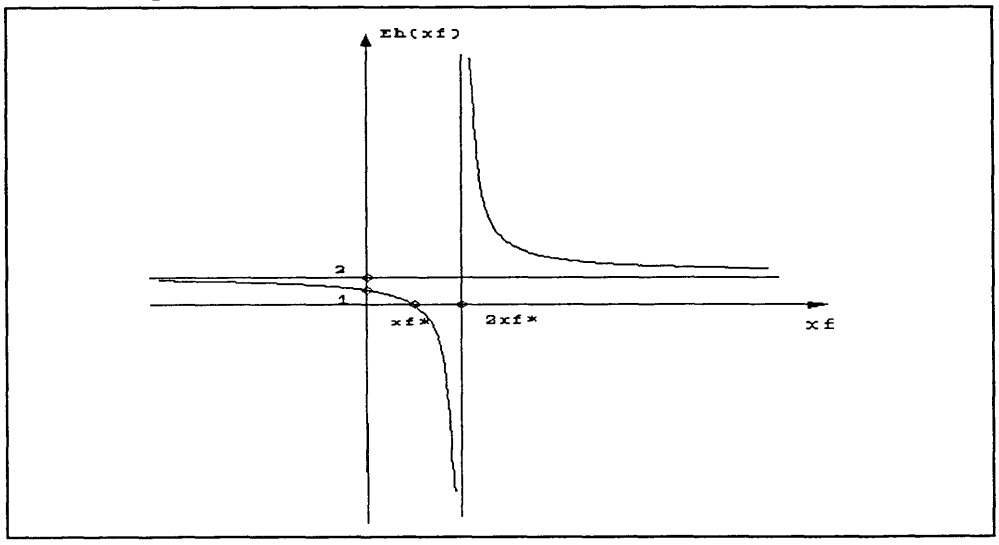


Figure 4.6 Elasticity of hedging effectiveness and the optimal hedging ratio when x^f is positive



[55] The only difference lies in the expression $[2.A'.Cov(R^f;R^c) - E(R^f)]$ for a given cash position which becomes $[2.A'.x^{s*}.Cov(R^f;R^c) - E(R^f)]$ in the case of simultaneously determined positions.

[56] The exact shape of HE depends on various parameters and in particular the risk aversion and $E(U(R^c))$ which can flatten or stretch out the shape of the curve. Yet the general form of the latter follows the curves displayed in Figures 4.5 and 4.6.

4.4 Empirical analysis

4.4.1 Hedging models

As suggested earlier, simplifying assumptions used in the previous studies have introduced a lack of realism into the modelling of the marketing and investment process. Our approach involves several investigations. Examination of the OHR and HE development over a five-year period for producers and merchants[57] and a seven-year period for traders is carried out. The influence of the CAP on these ratios is then assessed over a long time span. Simulations on the degree of risk aversion are also carried out investigating the sensitivity of the results to this parameter. The empirical assessment is undertaken using ex-post data.

4.4.2 Producer's and merchant's hedges

The OHR decomposition in equations (4.9), (4.10), (4.17) and (4.18) is used here to study each component and their development over time. Comparative inquiry of the two marketing contracts, namely forward and futures contracts, also takes place. Two distinct portfolios are then defined. Portfolio I denotes a portfolio with both futures and forward contracts along with the cash position, while portfolio II refers to a portfolio with either futures or forward contract. As mentioned earlier, only hedging models with identical cash data sets can have their HE validly compared. Hence in the case of producers and merchants, the comparative study of the HE obtained from a futures contract, a forward contract or a mixed portfolio, can only be undertaken for each type of operator and hedging situation.

Shortage of data at the beginning of the 1973/74-1988/89 sample and consistency requirements for the rest of the sample have constrained us to the use of monthly averages of the Friday closing prices. Forward prices were only available for a forward date of two months. Hence, their use was restricted to the corresponding hedging situations. Production data are Great Britain annual averages[58]. When storage is involved, storage costs are assumed

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[57] From now on, merchant's hedges refer to hedges involving futures, forward and cash markets. Trader's hedges denote simultaneously determined positions on forward and futures markets (see 4.2.4).

[58] Most previous studies involving production uncertainty have been based on yield aggregation beyond the producer level. Bias in the hedging results inherent to the variable nature of individual producer performance when investigated at an aggregated level has been outlined in some evidence, Eisgruber and Schuman (1963), Capstick and Cochran (1983) and Miller and Kahl (1987). However I do not believe that large systematic differences in the major producing areas of the United Kingdom exist. Therefore, as stressed by some

to be equal to the nearby futures spread (as defined in section 3.4.5) weighted by the number of months of storage.[x] The stored quantity, y, is set at 1. We examine the hedging level and the hedging effectiveness of various hedging situations. Indeed, the rigidity of the common two-period analysis of hedging does not allow for marketing plan revision[59]. Hedges examined here for producers and merchants are listed below in Table 4.1..

Table 4.1 Hedging situations for producers and merchants

Hedging Situations No.	Date of futures and forward hedging	
	Sale	Purchase
1	October	January
2	October	March
3	December	March*
4	February	September*
5	February	November*
6	June	September
7	June	November*

* no forward contract used in this strategy owing to a shortage of data.

4.4.3 Trader's hedges

The statistical parameters used in the OHR and HE definition are estimated over time periods of different lengths so as to define how much information the hedger should consider to be useful in the definition of his hedge. Indeed, if the cash-futures relationship is stable, then the longer the sample, the more accurate the estimates. On the other hand, if the cash-futures relationship is unstable, a longer period will increase the probability that the estimates reflect a situation that no longer exists[60]. Prices refer to futures, forward and

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researchers (Miller and Kahl, 1989), even if there are differences, they do not significantly affect the hedging ratios. Moreover, as far as the study of the influence of the CAP is concerned this issue is also less relevant.

[59] The more we go into the production season or into the hedging time period, the more accurate prices and yields forecast may be. Then, as outlined by Berck (1981), the optimal path for a hedge to follow between planting time and harvest time is difficult to determine.

[60] Cechetti, Cumby and Fliglewski (1988) estimate the optimal futures hedge by including the temporal evolution of the joint distribution of cash and futures prices. They use estimates from an Autoregressive Conditional Heteroscedasticity (ARCH) specification of the joint distributions to model these temporal variations.

[x] The use of the temporal spread between futures as a measure of storage costs is justified since it represents the market's estimate of the storage cost, inclusive of the convenience yield and the risk premium.

spot contracts over the 1980/1981-1987/88 period. The first closing Friday of the maturity month is used as the expiration futures price in order to avoid the usual price fluctuations which occasionally occur during the final trading days of a futures contract. The futures contract used is the closest to expiration (i.e. the nearby contract) at the time the hedge should be lifted and then the next to nearby futures contract. Whilst evidence has consistently shown that the nearby contract has been the most effective for financial contracts (Ederington, 1979, Hill and Schneeweiss, 1980), examination of the next to nearby contract is aimed at testing the influence of the nature of the futures contract used in the OHR and HE assessment. Traders and merchants are regarded as following a hedging model which involves a regularly renewed hedge of one, two, four and eight weeks. For each of this hedge, investigation of the case where the cash (or forward) position is given or simultaneously defined with the futures position, is undertaken.

Hedges over four and eight weeks follow the same principles as those described earlier in section 4.2.4.. As far as the one and two weeks hedges are concerned, traders are assumed to operate only on the cash and futures markets. No storage cost is taken into account here. Equation (4.19) now becomes:

$$(4.53)\quad E(H) = x^f.(P^f_o - E(p^f_1)) + x^s.(E(p_1) - P_o)$$

As suggested earlier, neither the traditional nor the new definition of HE is adapted to the simultaneous determination of the commercial positions on the two markets. Indeed the minimum-variance position involved in the traditional definition of HE should result in no-trade in both markets; on the other hand, the new approach of HE requires the consideration of the cash position in the denominator, that would occur in the case of an unhedged strategy. Inherent in the definition of the simultaneous positions, this cash position is impossible to determine[61]. The calculation of HE for simultaneously determined positions, whatever the definition of HE used, always involves the use of the optimal cash position and futures position. Direct comparative analysis of HE for each hedge model can only take place between the nearby and the next to nearby contract.

[61] In this particular case, the new approach of HE could involve the integration of the risk-free rate of return as the initial cash position. Yet, this definition would be more suited to investors or traders than to agricultural agents such as producers or merchants.

4.4.4 Summary of hedging models characteristics

To sum up, each hedging model is characterized by four features:
. a strategy which refers to an optimal hedge, a naive hedge or a risk-minimizing hedge.
. a type which is concerned with the type of operators involved, either producers and merchants, or traders.
. a portfolio. It includes either futures or forward contracts together (portfolio I) or separately (portfolio II) for producers and merchants. It also refers to the case where both cash and futures positions are simultaneously determined (portfolio III) or to the case where the cash position is fixed (portfolio IV), for traders.
. a hedging situation which denotes the time the time period over which the hedging model is investigated.
A fifth differentiation is operated for the examination of the hedging effectiveness which either uses the traditional or the new approach.

4.5 Results

Owing to the similarity of the results obtained from the different hedging models and for purpose of simplification and convenience, three hedging models are examined. First, an intra-season hedge, hedging situation No.1, is investigated for producers and merchants. Then we focus on an inter-season hedge with production uncertainty, hedging situation No.4. Conclusions from these two hedges are then completed by other hedging models. Finally, trader's hedges are reported with particular reference to the one-month hedge. Results not displayed here are shown in Appendices 4-A and 4-B.

4.5.1 October/January hedge

4.5.1.1 Producers

Results[62] in Tables 4.2, 4.3 and 4.4 show that the futures OHR, i.e. the ratio of futures trading level to the stored quantity, is almost always higher than the forward OHR, i.e. the ratio of forward trading level to the stored quantity[63]. This occurs, whatever strategy is

[62] Both futures and forward sales are referred as hedging in the following. This improper use of semantics is derived from descriptive convenience and do not alter the true nature of forward contracting as a sale at fixed price.
[63] In all cases but in 1983/84 for risk-lovers.

adopted by the agent, the agent's risk aversion and the portfolio constitution.

When the futures and forward contracts are used together, i.e. portfolio I, levels of OHR are very high especially when risk aversion decreases as shown in the top of Table 4.2. The futures OHR sign is opposite to expectations, apart from the 1983/84 season (bottom of Table 4.2). Instead of selling futures, producers have to buy futures contracts at the beginning of their hedge. This position is generally referred to as reverse-hedging[64]. With portfolio II, levels of OHR decrease substantially and OHR, at a risk aversion level of -1000, varies in the interval [1.5;-1.9] for the futures-based portfolio and in the interval [1.16;-1.25] for the forward-based portfolio. A situation of reverse-hedging still occurs for futures contracts over the 1984/85 to 1987/88 period, although slightly restricted to the 1984/85 to 1986/87 period in the case of forward contracts[65].

Whatever the portfolio adopted, the level of OHR widely fluctuates over the time period examined in Table 4.2. OHRs are almost invariant with respect to the level of risk aversion under -1. If agents are very risk-averse, i.e. A=-1000, the OHR is equivalent to the corresponding risk-minimizing hedging ratio (Table 4.2), regardless of the level of the speculative element of OHR. On the other hand, the OHR is very sensitive to variations in the risk aversion level between -1 and -.001. Especially between -.1 and -.001 where they result in dramatic changes in the OHR value. A low level of risk aversion boosts the speculative element which in turn outweigh the hedging element. Detailed examination of this phenomenon can be undertaken from Tables 4.3 and 4.4 where values of the various components of equations (4.9) and (4.10) are expressed. The situation of reverse-hedging of the futures position can be explained by the regular negative sign of both hedging and speculative components (C and G in Tables 4.2 and 4.3), apart from the 1983/84 season. The sign findings are more mixed for the forward OHR. Nevertheless, it should be noted that the futures hedging elements of the OHR are constantly higher than those of the forward contract. Rolfo (1980) and Miller (1986) explained the situation of reverse-hedging by suggesting that the speculative component "swamped" the hedging component for low level of risk aversion. Our results in Table 4.3, like Kahl and Miller's, show that even risk-minimizers may choose this marketing strategy.

[64] The term reverse-hedging indicates the purchase of futures contract. In this study it also denotes the purchase of forward contracts by a stockholder.

[65] Although negative OHR results are given in 1987/88 for risk-lovers.

Table 4.2 Optimal hedging ratio from 1983/84 to 1987/88, producer's hedge from October/January.

Hedging ratio		1983/84	1984/85	1985/86	1986/87	1987/88
Optimal hedging ratio Portfolio I[1]						
A = -1000	x^{f*}/y	3.003	-.954	-2.173	-2.872	-1.263
	x^{F*}/y	-2.323	.205	.992	1.302	1.031
	x^{f*}/x^{F*}	-1.292	-4.651	-2.191	-2.205	-1.223
A = - 1	x^{f*}/y	2.893	-1.144	-2.421	-3.124	-1.467
	x^{F*}/y	-2.158	.380	1.193	1.495	1.189
	x^{f*}/x^{F*}	-1.340	-3.009	-2.027	-2.089	-1.234
A = -.1	x^{f*}/y	1.894	-2.858	-4.651	-5.396	-3.312
	x^{F*}/y	-.671	1.958	3.011	3.235	2.604
	x^{f*}/x^{F*}	-2.821	-1.459	-1.544	-1.668	-1.271
A = -.001	x^{f*}/y	-107.997	-191.357	-249.968	-255.250	-206.238
	x^{F*}/y	162.953	175.575	202.902	194.572	158.293
	x^{f*}/x^{F*}	-.662	-1.089	-1.231	-1.311	-1.302
Optimal hedging ratio Portfolio II						
A = -1000	x^{f*}/y	1.552	-.806	-1.448	-1.921	-.514
	x^{F*}/y	1.168	-.643	-.971	-1.252	.020
A = -1	x^{f*}/y	1.544	-.871	-1.549	-2.031	-.605
	x^{F*}/y	1.204	-.637	-.992	-1.284	.013
A = -.1	x^{f*}/y	1.474	-1.446	-2.452	-3.031	-1.423
	x^{F*}/y	1.531	-.582	-1.189	-1.565	-.048
A = -.001	x^{f*}/y	-6.205	-64.789	-101.824	-113.050	-91.433
	x^{F*}/y	37.394	5.477	-22.869	-32.494	-6.882

[1] Portfolio I and II refer to the use of the futures and forward contracts together and separately respectively. The quantity stored y is set at 1.

Table 4.3 Hedging ratio from 1983/84 to 1987/88, producer's hedge from October/January, determinants independent of the risk aversion coefficient.

Hedging ratio	1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]					
T	3.652	2.783	2.936	2.858	2.385
B	-.729	.463	.708	.915	-.014
C	1.552	-.806	-1.448	-1.921	-.514
D	-1.804	.717	1.308	1.708	.412
W	1.168	-.643	-.971	-1.252	.021
Minimum-risk ratio[2] Portfolio I[3]					
x^f/y	3.004	-.954	-2.173	-2.872	-1.262
x^F/y	-2.324	.205	.991	1.302	1.031
Minimum-risk ratio Portfolio II					
x^f/y	1.552	-.806	-1.448	-1.921	-.514
x^F/y	1.168	-.643	-.971	-1.252	.021

[1] The quantity stored y is set to 1. The ratio determinants correspond to formula elements in (4.9) and (4.10) with
$T=(1/(1-Cor^2(R^f;R^F)))$; $B=(Cor^2(R^f;R^F).Cov(R^F;R^c)/Cov(R^f;R^F))$; $C=(-Cov(R^f;R^c)/Var(R^f))$; $D=(Cor^2(R^f;R^F).Cov(R^f;R^c)/Cov(R^f;R^F))$; $W=(-Cov(R^F;R^c)/Var(R^F))$.

[2] It refers to the minimization of the income variance and is equal to $[(T.(B+C))/y]$ and $[T.(D+E)/y]$ for futures and forward contracts respectively when these contracts are used together and to $[-Cov(R^f;R^c)/(Var(R^f).y)]$ and $[-Cov(R^c;R^F)/(Var(R^F).y)]$ when these contracts are used separately.

[3] Portfolio I and II refer to the use of the futures and forward contracts together and separately respectively.

Table 4.4 Hedging ratio from 1983/84 to 1987/88, producer's hedge from October/January, determinants dependent from the risk aversion coefficient, values for A = -.1[1].

Hedging ratio	1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[2]					
F	-.226	-.044	.159	.228	.050
G	-.077	-.639	-1.003	-1.111	-.909
H	.090	.568	.906	.988	.728
I	.362	.061	-.218	-.312	-.069

[1] Simulation for other values of A are not shown below since they are directly proportional to the present values.
[2] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $G = (-E(R^f)/(2.A.Var(R^f)))$, $F = (E(R^F).Cor^2(R^f;R^F)/2.A.Cov(R^f;R^F))$ for futures contracts. $I = (-E(R^F)/(2.A.Var(R^F)))$, $H = (E(R^f).Cor^2(R^f;R^F)/2.A.Cov(R^f;R^F))$ for forward contracts. Equations (4.9) and (4.10) can be rewritten as $x^{f*} = (1/T).(G+F+B+C)$ and $x^{F*} = (1/T).(H+I+D+W)$.

Hedging effectiveness assessed by the traditional measure gives very low results with HE varying between 0 and .19. The hedging effectiveness of the naive hedge is even negative for most seasons. This is certainly due to the large difference between the risk-minimizing ratio and 1. The new measure of HE introduced in section 4.3.1.2.1 also shows low level of HE in Table 4.5. Portfolio I only presents a marginal increase in HE when compared to portfolio II. The futures market proves to be more effective in hedging cash position than the forward market. As expected and demonstrated in section 4.3.1.2.1, Table 4.5 shows that the optimal hedging level has a greater HE than the risk-minimizing hedge and the naive hedge, when assessed with the new measure. The latter generally shows a dramatic increase as risk aversion drops. HE results obtained with the new measure are also similar to HE results calculated from the traditional approach in Table 4.6 when the risk aversion level is high, i.e. close to -1000. HE of an optimal hedge is very similar, or even equivalent, to the HE obtained from a risk-minimizing hedge. Only in the case of low risk aversion do these different hedges result in a different value for HE[66]. This seems to imply that expected return on cash, forward and futures markets as well as risk aversion play a minor role in the HE calculation, expressed in equation 4.3.3, when A is equal to -1000 in Table 4.5. The

[66] This makes sense since risk-lovers are not expected to follow a risk-minimizing hedge.

Table 4.5 Hedging effectiveness assessed with the new formula, from 1983/84 to 1987/88, producer's hedge from October/January.

Hedging Effectiveness		1983/84	1984/85	1985/86	1986/87	1987/88
Portfolio I[1]						
A = -1000	HE*[2]	-.135	-.019	-.110	-.216	-.056
	Naive H.[3]	-.066	.174	.359	.475	.365
	Min. H.[4]	-.135	-.019	-.110	-.216	-.056
A = - 1	HE*	-.163	-.033	-.248	-.571	.356
	Naive H.	-.085	.254	.708	1.132	-1.794
	Min. H.	-.163	-.033	-.246	-.568	.349
A = -.1	HE*	.081	.047	.104	.135	.034
	Naive H.	.071	-.104	-.124	-.132	-.047
	Min. H.	.071	.027	.078	.109	.021
A = -.001	HE*	.804	1.295	2.111	2.164	1.237
	Naive H.	.005	-.012	-.023	-.025	-.013
	Min. H.	-.027	.012	.039	.052	.015
Portfolio II[5] / x^f						
A = -1000	HE*	-.101	-.019	-.097	-.191	-.022
	Naive H.	-.088	.077	.181	.251	.170
	Min. H.	-.101	-.109	-.097	-.191	-.022
A = -1	HE*	-.127	-.032	-.213	-.494	.144
	Naive H.	-.113	.115	.364	.606	-.873
	Min. H.	-.127	-.031	-.212	-.492	.141
A = -.1	HE*	.085	.031	.073	.101	.015
	Naive H.	.076	-.057	-.072	-.078	-.029
	Min. H.	.084	.024	.061	.088	.009
A = -.001	HE*	.007	.412	1.009	1.168	.579
	Naive H.	-.002	-.013	-.019	-.021	-.012
	Min. H.	-.004	.010	.028	.039	.006

Table 4.5 (continued).

Portfolio II[6] / x^F		1983/84	1984/85	1985/86	1986/87	1987/88
A = -1000	HE*	-.031	-.009	-.035	-.066	.000
	Naive H.	-.030	.054	.110	.149	.072
	Min. H.	-.031	-.009	-.035	-.066	.000
A = -1	HE*	-.041	-.013	-.071	-.162	.000
	Naive H.	-.040	.077	.214	.351	-.348
	Min. H.	-.041	-.013	-.070	-.162	.000
A = -.1	HE*	.049	.004	.014	.022	.000
	Naive H.	.043	-.025	-.033	-.037	-.007
	Min. H.	.046	.004	.013	.021	.000
A = -.001	HE*	.153	.002	.041	.079	.003
	Naive H.	.008	.001	-.004	-.005	-.001
	Min. H.	.009	-.001	.003	.006	.000

[1] Portfolio I and II refer to the use of the futures and forward contracts together and separately respectively; $E(U(R^c))$ is negative but for cases where A=-.1, A=-.001 and A=-1 for 1987/88. [2] This HE* denotes the HE for a portfolio involving x^f* and x^F*.
[3] Naive H. relates the naive strategy with an hedge level of $(x^f;x^F) = (1,1)$.
[4] Min. H. refers to the HE of an hedging strategy where $(x^f;x^F)$ is from a minimum-risk strategy. [5] Portfolio where futures contracts are used separately from forward contracts.
[6] Portfolio where forward contracts are used separately from futures contracts.

Table 4.6 Hedging effectiveness, from 1983/84 to 1987/88, producer's hedge from October/January, with the traditional formula.

Hedging Effectiveness	1983/84	1984/85	1985/86	1986/87	1987/88
Portfolio I[a]					
x^f and x^F	.135	.019	.109	.216	.056
$(x^f;x^F) = (1;1)^b$	.066	-.174	-.358	-.475	-.364
Portfolio II					
x^f	.101	.019	.097	.191	.022
x^F	.031	.009	.035	.066	.000
$x^f = 1$	.088	-.077	-.180	-.251	-.170
$x^F = 1$	.030	-.054	-.110	-.149	-.072

[a] Portfolio I and II refer to the use of the futures and forward contracts together and separately respectively. x^f and x^F are set at the risk-minimizing hedging levels as defined earlier. [b] The case where $(x^f;x^F)$ is equal to (1,1) refers to a naive hedging strategy.

naive hedging strategy presents negative HE results. Hence, the traditional definition of hedging, which advocates a hedging ratio of 1, is shown to perform poorly.

The futures market appears to be a better tool for hedging purposes than the forward market at the optimal hedging level or at the minimum-risk level. If a naive hedging strategy is applied on both markets, the negative impact on the agent's expected utility will be lower in the case of forward contracting than in the case of hedging futures as shown in Table 4.5. This situation is the direct consequence of the high level of the futures OHR which is well above 1 for most of the time. Even if producers choose to operate on only one market, for instance the futures market, producers would have had to buy in October up to two or three times their stored production in 1986/87 to achieve an optimal hedge. The use of both forward and futures contracts slightly increases the HE when compared to portfolio I. However, it has the main drawback to drastically increase the level of trade on both markets and hence renders this type of strategy very questionable.

4.5.1.2 Merchants

Hedging ratios are very close to one and zero when both forward and futures contracts respectively are used in a risk-minimizing hedge. In portfolio II, futures and forward contracts are sensitive to risk aversion changes. This comes from the low level of the hedging component when compared to the speculative component particularly for the futures contract (in Table 4.4, the speculative elements are denoted by G and I and, in Table 4.8, by the hedging elements C and E).

Since the speculative element G is negative for the futures contract in Table 4.4, any decline in the risk aversion level reduces the optimal hedging level which becomes negative for A=-.001, as shown in Table 4.7. When futures and forward contracts are used together, Table 4.7 shows that the ratio of futures trading level to the forward trading level is very low and negative before increasing quite dramatically along with a decrease in risk aversion. If traded separately, the trade level of forward contract is fairly constant around unity, apart from the case where A=-.001. On the other hand, the futures trading level declines quite strongly and is negative as soon as A=-.1, for most of the time period studied (Table 4.7). It also widely fluctuates across seasons.

The HE of this merchant hedge is fairly high, around .80, when assessed by the traditional measure (Table 4.10). This is particularly true in the case of portfolio I or portfolio II with

Table 4.7 Optimal hedging ratio from 1983/84 to 1987/88, merchant's hedge from October/January.

Hedging ratio		1983/84	1984/85	1985/86	1986/87	1987/88
Optimal hedging ratio[1] Portfolio I						
A = -1000	x^{f*}/y	-.018	-.077	.022	-.008	-.034
	x^{F*}/y	.914	1.006	.989	.994	1.043
	x^{f*}/x^{F*}	-.027	-.076	.022	-.008	-.032
A = - 1	x^{f*}/y	-.129	-.267	-.225	-.260	-.239
	x^{F*}/y	1.080	1.181	1.191	1.187	1.200
	x^{f*}/x^{F*}	-.120	-.226	-.188	-.219	-.199
A = -.1	x^{f*}/y	-1.128	-1.981	-2.455	-2.531	-2.083
	x^{F*}/y	2.567	2.760	3.008	2.926	2.615
	x^{f*}/x^{F*}	-.439	-.717	-.816	-.865	-.796
A = -.001	x^{f*}/y	-111.021	-190.486	-247.773	-252.383	-205.027
	x^{F*}/y	166.194	176.373	202.903	194.266	158.301
	x^{f*}/x^{F*}	-.668	-1.079	-1.221	-1.295	-1.295
Optimal hedging ratio Portfolio II						
A = -1000	x^{f*}/y	.552	.648	.745	.718	.722
	x^{F*}/y	.892	.937	1.010	.986	1.015
A = -1	x^{f*}/y	.544	.584	.644	.607	.631
	x^{F*}/y	.929	.944	.988	.955	1.008
A = -.1	x^{f*}/y	.474	.008	-.258	-.392	-.186
	x^{F*}/y	1.255	.999	.791	.674	.946
A = -.001	x^{f*}/y	-7.205	-63.334	-99.629	-110.415	-90.196
	x^{F*}/y	37.119	7.059	-20.882	-30.254	-5.887

[1] Portfolios I and II refer to the use of the futures and forward contracts together and separately respectively. The quantity stored y is set at 1.

Table 4.8 Hedging ratio from 1983/84 to 1987/88, merchant's hedge from October/January, determinants independent from the risk aversion coefficient.

Hedging ratio	1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]					
T	3.652	2.783	2.936	2.858	2.385
B	-.557	-.676	-.737	-.721	-.736
C	.552	.648	.745	.718	.722
D	-.642	-.576	-.673	-.639	-.578
W	.892	.937	1.010	.986	1.015
Minimum-risk ratio[2] Portfolio I[3]					
x^f/y	-.018	-.071	.022	-.007	-.034
x^F/y	.914	1.006	.989	.993	1.043
Minimum-risk ratio Portfolio II					
x^f/y	.552	.648	.745	.718	.722
x^F/y	.892	.937	1.010	.986	1.015

[1] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $T=(1/(1-Cor^2(R^f;R^F)))$; $B=(Cor^2(R^f;R^F).Cov(R^F;R^c)/Cov(R^f;R^F))$; $C=(-Cov(R^f;R^c)/Var(R^f))$; $D=(Cor^2(R^f;R^F).Cov(R^f;R^c)/Cov(R^f;R^F))$; $W=(-Cov(R^F;R^c)/Var(R^F))$.
The stored quantity y is set at 1.

[2] It refers to the minimization of the income variance and is equal to $[(T.(B+C))/y]$ and $[T.(D+E)/y]$ for futures and forward contracts respectively when these contracts are used together and to $[-Cov(R^f;R^c)/(Var(R^f).y)]$ and $[-Cov(R^c;R^F)/(Var(R^F).y)]$ when these contracts are used separately.

[3] Portfolios I and II refer to the use of the futures and forward contracts together and separately respectively.

Determinants of the optimal hedging ratio which are dependent on the risk aversion coefficient are not shown below because of their similarity with those, displayed in Table 4.4, of the producer's hedge with the same time period. Equations (4.9) and (4.10) can be rewritten as $x^{f*} = (1/T).(G+F+B+C)$ and $x^{F*} = (1/T).(H+I+D+W)$.

Table 4.9 Hedging effectiveness assessed with the new formula, from 1983/84 to 1987/88, merchant's hedge from October/January.

Hedging Effectiveness		1983/84	1984/85	1985/86	1986/87	1987/88
Portfolio I[1]						
A = -1000	HE*[2]	-.885	-.835	-.793	-.801	-.772
	Naive H.[3]	1.492	.507	.140	.225	.058
	Min. H.[4]	-.885	-.835	-.793	-.801	-.772
A = - 1	HE*	-.915	-.897	-.864	-.898	-.897
	Naive H.	1.365	.662	.408	.578	.252
	Min. H.	-.907	-.881	-.841	-.871	-.881
A = -.1	HE*	-1.137	-3.519	114.641	6.935	7.332
	Naive H.	.641	2.560	-112.296	-7.849	-5.612
	Min. H.	-1.035	-1.449	19.227	.815	2.413
A = -.001	HE*	-146.271	600.871	202.196	168.631	113.296
	Naive H.	-.806	-5.445	-2.247	-2.004	-1.248
	Min. H.	-1.291	.945	-.368	-.354	-.037
Portfolio II[5] / x^f						
A = -1000	HE*	-.631	-.491	-.534	-.516	-.431
	Naive H.	-.217	-.346	-.471	-.437	-.367
	Min. H.	-.631	-.491	-.534	-.516	-.431
A = -1	HE*	-.581	-.409	-.445	-.428	-.378
	Naive H.	-.175	-.202	-.311	-.249	-.249
	Min. H.	-.581	-.404	-.434	-.413	-.371
A = -.1	HE*	-.291	.000	2.995	.409	.097
	Naive H.	.065	1.558	-67.965	-4.734	-3.826
	Min. H.	-.288	.649	-42.138	-2.864	-2.205
A = -.001	HE*	-1.845	184.351	94.402	89.232	52.229
	Naive H.	.547	-5.867	-1.904	-1.623	-.164
	Min. H.	.293	-3.794	-1.417	-1.165	-.840

Table 4.9 (continued).

Portfolio II[6] / x^F		1983/84	1984/85	1985/86	1986/87	1987/88
A = -1000	HE*	-.885	-.832	-.793	-.801	-.771
	Naive H.	-.873	-.829	-.793	-.800	-.771
	Min. H.	-.885	-.832	-.793	-.801	-.771
A = -1	HE*	-.906	-.866	-.845	-.871	-.874
	Naive H.	-.901	-.863	-.845	-.869	-.874
	Min. H.	-.905	-.866	-.845	-.869	-.874
A = -.1	HE*	-1.113	-1.283	2.664	.990	2.261
	Naive H.	-1.067	-1.283	.084	.759	2.254
	Min. H.	-1.020	-1.279	.928	.777	2.249
A = -.001	HE*	-26.138	1.857	3.352	5.504	3.201
	Naive H.	-1.398	.488	.328	1.369	3.074
	Min. H.	-1.251	.461	1.332	1.364	3.075

[1] Portfolios I and II refer to the use of the futures and forward contracts together and separately respectively; $E(U(R^c))$ is negative but for A=-.001, from 1984/85 onwards and A=-.1 from 1985/86 onwards. [2] This HE* denotes the HE for a portfolio involving x^f and x^F. [3] Naive H. relates the naive strategy with an hedge level of $(x^f;x^F) = (1,1)$. [4] Min. H. refers to the HE of a portfolio where $(x^f;x^F)$ is from a minimum-risk strategy. [5] Portfolio with only futures contracts. [6] Portfolio with only forward contracts.

Table 4.10 Hedging effectiveness from 1983/84 to 1987/88, merchant's hedge from October/January, with the traditional formula.

Hedging Effectiveness	1983/84	1984/85	1985/86	1986/87	1987/88
Portfolio I[a]					
x^f and x^F	.885	.835	.793	.801	.772
$(x^f;x^F) = (1;1)^b$	-1.492	-.507	-.139	-.225	-.058
Portfolio II					
x^f	.631	.491	.534	.516	.431
x^F	.885	.832	.793	.801	.771
$x^f = 1$	.217	.346	.471	.437	.367
$x^F = 1$	.872	.829	.793	.801	.771

[a] Portfolios I and II refer to the use of the futures and forward contracts together and separately respectively. x^f and x^F are set at the risk-minimizing hedging level. [b] The case where $(x^f;x^F)$ is equal to (1,1) refers to a naive hedging strategy.

forward contracts only. The use of only futures contracts somewhat lowers the HE. Whereas the HE of a naive hedge compares favourably when forward contracts are used (the risk-minimizing ratio is indeed very close to 1), it declines with the use of futures contracts and becomes negative with portfolio I (the risk-minimizing ratio of a futures-based strategy is close to zero). HE measured with the new formula in Table 4.9 gives similar results: the naive hedge performs poorly for portfolio I and for a futures-based portfolio II. As far as the forward-based portfolio II is concerned, the HE of a naive strategy is very similar to the HE of an optimal strategy given the proximity of OHR to unity. As expressed earlier the risk aversion has a great influence on the agent's expected utility and then on the HE measure. At a level of A=-.1 and below, the HE changes dramatically and the HE of an optimal hedge outperforms the risk-minimizing hedge. The HE is yet very irregular. In the case of this merchant hedge, we can note the importance of the new measure of HE. At a level of risk aversion close to -.1, which is not too low[67], important and drastic shifts in the HE results highlights the relevance of taking the expected return and the risk aversion into account in the HE definition. At the difference of the producer's hedge over the same time period, the hedging component of the merchant's hedge in Table 4.8 cannot fully offset the growing importance of the speculative element of the OHR (Table 4.4).

The main difference between the producer's and the merchant's situation is found in the hedging component whose value is mainly negative for the former while positive for the latter (elements C and W in Table 4.8). Furthermore in the merchant case, the speculative element of the forward OHR (element I in Table 4.4) is too small to significantly affect the forward OHR size, while this is not the case of the futures OHR (element G in Table 4.4). Although no direct comparison is possible, over the October/January period the forward market appears to have a greater HE for merchants than for producers. The forward OHR for the former is close to unity and is much more stable than the futures OHR (Tables 4.9 and 4.10). This in turn explains the relatively good results of the forward contract obtained from the naive strategy. More generally we can argue that the HE and the OHR for merchants seem to be more stable, more effective and closer to unity respectively than for producers. Although futures contracts seem to perform slightly better for producers, forward contracts give evidence of a much stronger performance for merchants.

[67] Peck (1975) studied the optimal hedge of an egg producer, assuming a risk aversion parameter in the range [-.1;-.001].

4.5.2 February/September hedge

No forward contract has been integrated in the producer's portfolio for this seven-month hedge due to a shortage of prices seven months forward. The risk-minimizing ratio in Table 4.11 appears to be very fluctuating with two reverse-hedging situations and a ratio above one in 1986/87. The variability of this ratio is also found in the OHR measurement which generally displays negative results when risk aversion declines. This situation is mainly due to the hedging component B whose values changes from -3.5 to 10 while the speculative component S is fairly constant and negative, apart from the 1987/88 season. Similar results of OHR and HE are obtained from the February/November hedging situation in Appendix Tables A-4.12 and B-4.10.

Table 4.11 Hedging ratio from 1983/84 to 1987/88, producer's hedge from February/September.

Hedging ratio		1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[2]						
S		-.249	-.188	-.186	-.161	-1.196
B		1.534	-3.558	.097	10.034	-.193
Minimum-risk ratio[3] $x^f/E(y)$		.290	-.640	.016	1.653	-.031
Optimal hedging ratio $x^{f^*}/E(y)$						
Risk Aversion	A=-1000	.290	-.640	.016	1.653	-.031
	A=-1	.285	-.643	.013	1.651	-.051
	A=-.1	.243	-.674	-.015	1.626	-.224
	A=-.001	-4.430	-4.040	-3.218	-1.011	-19.397

[1] Simulation for other values of A are not shown below since they are directly proportional to the present values.
[2] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $S = (-E(R^f)/(2.A.Var(R^f)))$; $B = (-Cov(R^f;R^c)/Var(R^f))$. S assessed for an A value of -.1.
[3] It refers to the minimization of the income variance and is equal to $[-Cov(R^f;R^F)/(Var(R^f).E(y))]$.

HE assessed with the traditional measure appears to be very low, in Table 4.12, as well as the HE of the naive hedge which is even negative during three years. The new measure of HE does not provide more information. Values of HE are also very low and no improvement,

from the expected income and the risk aversion component of HE, is shown even with low risk aversion.

4.5.3 Other hedging models for producers and merchants

The October/March and December/March hedges (in Appendix 4-A) bear evidence of the high level of futures OHR and low level of forward OHR found with the producer's hedge over the October/January period. On the other hand, the OHR level in the merchant's case for these two hedges is slightly higher than that obtained in the October/January hedge. Yet no reverse-hedging situation appears in these two hedges, except in low risk aversion

Table 4.12 Hedging effectiveness, from 1983/84 to 1987/88, producer's hedge from February/September.

Hedging Effectiveness		1983/84	1984/85	1985/86	1986/87	1987/88
New Formula						
A = -1000	HE*[1]	-.004	-.024	.000	-.234	.000
	Naive H.[2]	.022	.133	.077	-.197	.046
	Min. H.[3]	-.004	-.024	.000	-.234	.000
A = - 1	HE*	-.004	-.024	.000	-.241	.000
	Naive H.	.023	.136	.079	-.203	.051
	Min. H.	-.004	-.024	.000	-.241	.000
A = -.1	HE*	-.004	-.032	.000	-.331	-.004
	Naive H.	.033	.165	.107	-.281	.126
	Min. H.	-.003	-.032	.000	-.331	-.001
A = -.001	HE*	.066	.060	.037	.003	.335
	Naive H.	-.033	-.033	-.026	-.008	-.035
	Min. H.	-.008	.017	-.001	-.017	.001
Traditional Formula						
HE[4]		.004	.024	.000	.234	.000
Naive H.		.041	-.089	-.031	.164	-.052

[1] HE* refers to an optimal hedging level. $E(U(R^c))$ is always negative but in the case where A=-.001.
[2] Naive H. relates the naive strategy with an hedge level of $x^f = 1$.
[3] Min. H. refers to the hedge level of x^f of a minimum-risk strategy.
[4] HE is from a risk-minimizing strategy

situations. While the HE[68] is higher for both operators and both hedge situations than during the October/January hedge, merchants enjoy a much higher HE than producers, jointly with a lower hedging ratio. Futures-based portfolios display a higher HE than forward-based portfolios for producers, whereas results show reversed findings for merchants.
Examination of the June/November hedge, whose results are in Appendices 4-A and 4-B, confirms the poor results obtained by the February/September hedge. The HE is almost null whatever the HE definition applied, except when the risk aversion is very low. Reverse-hedging situations are found in 1983/84 and 1984/85 for the June/November and June/September hedges respectively (in Appendix 4-A). The low level of the speculative element relatively to the hedging element prevents the OHR or the HE to change significantly with the risk aversion. As for other producer's hedges, the OHR is very variable.

4.5.4 Trader's hedges[69]

In the case of simultaneously determined positions in Table 4.13, OHRs from the nearby contract for a one-month hedge are close to unity while OHRs from the next to nearby contract are more mixed. Fairly wide variations exist, whatever the contract considered. Reverse-hedging situations are also a common feature of this hedge. When the cash position is given in Table 4.14, the OHR results are more stable, at around .45. At a high level of risk aversion, the nearby contract gives OHR values slightly lower than those from the next to nearby contract. Differences in OHR measurement arising from distinct samples then strongly diminish. The OHR generally declines with risk aversion, before becoming negative at very low level of risk aversion.

A similar situation is found in the case of a two-month hedge, in Appendix 4-A, but, with a higher level of OHR in the case of a given cash position, and a lower level of OHR when both cash and futures positions are simultaneously determined. It appears that the shorter the hedge, i.e. in our case the one-week and two-week hedge, the higher and the more fluctuating the level of OHR, whatever the hedging portfolio used, either III or IV. The situation, where the cash position is given, appears to provide lower and relatively more stable OHR. This stability is found over time, over the distinct sampling periods and the nature of the contract considered.

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[68] While keeping in mind restrictions related to the traditional measure of HE.
[69] Results and comments concerning trader's hedges are also valid for merchants using a similar strategy.

In the case of a given cash position and for a one-month hedge, the HE of the nearby contract is rather low, at around .35, and declines in line with the risk aversion before increasing sharply at very low level of risk aversion, as reported in Table 4.16. At very high level of risk aversion, the minimum-risk hedge displays results similar to those of the optimal hedge. When the risk aversion decreases, results from a risk-minimizing hedge are extremely low but still higher than those from a naive hedge. The nearby futures contract generally shows lower HE results than the next to nearby contract in the first half of the total sampling period, while this order is reversed later in the second half. The traditional definition of HE gives HE results identical to those of the new approach when risk aversion is very high. HE from a one- and two-week hedge is extremely low, close to 0, and only improves at very low level of risk aversion. HE from a two-month hedge, in Appendix 4-B, is relatively high, at around .60. As in the case of the one-month hedge, HE decreases with the risk aversion before dramatically increasing at very low level of risk aversion.

Empirical evidence of HE for simultaneously determined positions for the one- and two-week hedges generally show negative HE whatever the definition of HE used, apart from the HE measured under the new approach for a very low risk aversion level (Appendix 4-B). The next to nearby contract has a higher HE when assessed by the traditional measure in the case of one-month hedge, while the nearby contract proves to be more effective when HE is obtained by the new formula (Tables 4.15 and 4.16). Results of HE for a two-month hedge are mixed but generally higher than those of a one-, two- and four-week hedge. In summary, HE for simultaneously determined positions of a one-, two-, four- and eight-week hedge shows rather mixed and widely fluctuating results.

Table 4.13 Optimal hedging ratio for a one-month hedge[1], from 1981/82 to 1987/88, with various sampling periods and for simultaneously determined cash and futures positions.

Simultaneously determined positions	Nearby futures contract			Next to nearby futures contract		
	All data	24 data	36 data	All data	24 data	36 data
1982/83	3.141^{+}			2.768^{+}		
1983/84	-4.273^{+}	8.260^{+}		-.632	1.239^{+}	
1984/85	-3.067	-19.371^{+}	-5.630	.328	.875^{+}	.058
1985/86	-6.962^{+}	-.040^{+}	-1.834^{+}	-1.253	3.096	.090
1986/87	-2.662	42.666^{+}	1.452^{+}	-.961	4.896	.152^{+}
1987/88	-1.103	-.374	-.603	-.321	-.305	-2.996

[1] Due to a shortage of one-month forward prices in 1980/81, no optimal hedging ratio has been computed for the 1981/82 period; $^{+}$ denotes the coefficients not significantly different from 1 at the 5% level.

Table 4.14 Optimal hedging ratio for a one-month hedge[1], from 1981/82 to 1987/88, with various sampling periods and for a given cash position.

Given Cash position[2]		Nearby futures contract			Next to nearby futures contract		
		All data[3]	24 data	36 data	All data	24 data	36 data
1982/83	A=-1000	.481			.608		
	A=-1	.440			.575		
	A=-.1	.077			.281		
	A=-.001	-39.83			-32.06		
1983/84	A=-1000	.441	.411		.601	.590	
	A=-1	.400	.365		.568	.545	
	A=-.1	.026	-.048		.283	.140	
	A=-.001	-41.09	-45.55		-31.05	-44.43	
1984/85	A=-1000	.439	.442	.451	.570	.594	.586
	A=-1	.408	.415	.418	.561	.602	.570
	A=-.1	.128	.175	.118	.481	.671	.423
	A=-.001	-30.64	-26.23	-32.81	-8.263	8.342[+]	-15.75
1985/86	A=-1000	.435	.465	.432	.586	.651	.594
	A=-1	.412	.458	.413	.565	.643	.582
	A=-.1	.201	.399	.241	.376	.574	.475
	A=-.001	-22.99	-6.126	-18.79	-20.47	-6.943[+]	-11.33
1986/87	A=-1000	.449	.438	.469	.613	.791	.653
	A=-1	.422	.418	.452	.584	.688	.626
	A=-.1	.177	.236	.297	.323	-.241	.382
	A=-.001	-26.76	-19.83	-16.78	-28.33	-102.4	-26.43
1987/88	A=-1000	.464	.480	.483	.599	.655	.701
	A=-1	.437	.442	.464	.574	.608	.648
	A=-.1	.197	.101	.297	.343	.184	.166
	A=-.001	-26.26	-37.40	-18.05	-25.04	-46.45	-52.84

[1] Due to a shortage of one-month forward prices in 1980/81, no optimal hedging ratio has been computed for the 1981/82 period. [2] The cash position is set at 1; [+] denotes the coefficients not significantly different from 1 at 5%. [3] This sample is made of all prices available, with a minimum sample of 12 data at the beginning in 1982/83.

Table 4.15 Hedging effectiveness for a one-month hedge, from 1981/82 to 1987/88, with various sampling periods and for simultaneously determined positions.

Simultaneously determined positions [1]		Nearby futures contract			Next to nearby futures contract		
		New HE*[2]	Trad. HE Naive H.[3]	Trad. Min H.	New HE*	Trad. HE Naive H.	Trad. Min. H.
1982/83	A=-1000	.000	-.155	302.645	.000	.137	-162.69
	A=-1	-.003			-.002		
	A=-.1	-73.17			-38.93		
	A=-.001	21.115			15.648		
1983/84	A=-1000	.000	-.388	-77.062	.000	.166	-1.976
	A=-1	-.003			-.001		
	A=-.1	-137			-.118		
	A=-.001	35.056			6.408		
1984/85	A=-1000	.000	-.187	-218.92	.000	.153	.259
	A=-1	-.001			.000		
	A=-.1	-.398			-.059		
	A=-.001	21.485			3.042		
1985/86	A=-1000	.000	-.226	-56.770	.000	.147	-2.949
	A=-1	-.001			.000		
	A=-.1	-.160			-.027		
	A=-.001	26.423			4.539		
1986/87	A=-1000	.000	-.196	-16.795	.000	.165	-1.687
	A=-1	-.001			.000		
	A=-.1	-.201			-.054		
	A=-.001	17.346			4.681		
1987/88	A=-1000	.000	-.129	-7231.3	.000	.183	-.429
	A=-1	-.001			.000		
	A=-.1	-.184			-.043		
	A=-.001	9.122			1.562		

[1] The sample is made of all prices available, with a minimum sample of 12 data at the beginning in 1982/83; $E(U(R^c))$ is always negative but for the cases where A=-.001.
[2] Results obtained with the formula (4.44). [3] The traditional definition of hedging effectiveness is here assessed with x^{f^*} and x^{F^*}. The HE is set at: $HE = 1 - [Var(x^{f^*}R^f + x^{F^*}R^F)/Var(x^{F^*}R^F)]$. In the case of naive hedge, $(x^{f^*};x^{F^*})$ is equal to (1;1).

Table 4.16 Hedging effectiveness of a one-month hedge, from 1981/82 to 1987/88, with a given cash position.

Hedging Effectiveness		82/83	83/84	84/85	85/86	86/87	87/88
New Approach [1]							
Nearby contract							
A = -1000	HE*[2]	-.327	-.402	-.343	-.346	-.348	-.338
	Naive H.[3]	.052	.240	.214	.235	.172	.112
	Min. H.[4]	-.327	-.402	-.343	-.346	-.348	-.338
A = - 1	HE*	-.291	-.362	-.316	-.322	-.325	-.321
	Naive H.	.189	.450	.345	.333	.281	.210
	Min. H.	-.287	-.358	-.314	-.321	-.323	-.319
A = -.1	HE*	-.073	-.003	-.086	-.121	-.119	-.161
	Naive H.	102.505	1.735	3.788	1.821	2.443	3.031
	Min. H.	81.945	.562	.446	.048	.163	.219
A = -.001	HE*	30.076	41.872	27.702	25.867	23.279	17.805
	Naive H.	-.576	-2.070	-1.831	-2.321	-1.771	-1.383
	Min. H.	-.354	-.908	-.796	-.998	-.788	-.636
Next to Nearby contract							
A = -1000	HE*	-.363	-.434	-.319	-.290	-.291	-.282
	Naive H.	-.214	-.231	-.136	-.145	-.174	-.157
	Min. H.	-.363	-.434	-.319	-.290	-.291	-.282
A = - 1	HE*	-.341	-.426	-.329	-.281	-.279	-.275
	Naive H.	-.141	-.171	-.126	-.115	-.137	-.124
	Min. H.	-.338	-.424	-.329	-.281	-.278	-.275
A = -.1	HE*	-.415	-.074	-.624	-.196	-.179	-.247
	Naive H.	159.117	.597	.137	.355	.605	.885
	Min. H.	57.703	.368	-.600	-.131	-.033	-0.48
A = -.001	HE*	22.779	15.137	1.222	9.504	11.802	8.094
	Naive H.	-1.083	-.892	-.296	-.944	-.842	-.628
	Min. H.	-.664	-.544	-.165	-.551	-.512	-.371

Table 4.16 (cont.)

Traditional Approach[5]	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
Nearby	.327	.402	.343	.346	.348	.338
Next to nearby	.363	.434	.319	.290	.291	.282

[1] The sample is made of all data available, with a minimum of 12 at the beginning in 1982/83. $E(U(R^c))$ is always negative except for the cases where A=-.001.
[2] This HE* denotes the HE for an hedge portfolio involving x^{f*} and x^{s*} and corresponds to equation (4.33).
[3] The naive strategy refers to the case where $(x^f;x^c)$ is set at (1,1); HE is then equivalent to $HE = [E(R^f)+(A.Var(R^f)) +(2.A.Cov(R^f;R^c))]/[E(U(R^c))]$.
[4] Min. H. refers to the hedge level of $(x^f;x^s)$ of a minimum-risk strategy. Then HE is set equal to $HE = [((-Cov(R^f;R^c).E(R^f))-(A.Cov^2(R^f;R^c)))/Var(R^f)]/[E(U(R^c))]$.
[5] Results from the naive strategy are not displayed here since equivalent to those shown in the case of simultaneously determined positions. The traditional approach of HE refers to the risk-minimizing strategy whose HE can be described as
$HE = Cov^2(R^f;R^c)/(Var(R^f).Var(R^c))$.

4.6 Discussion

The aim of this discussion is to interpret the various results obtained in our empirical study in the light of the initial sub-hypothesis. The discussion of results is divided into three distinct parts relating to producers, merchants and traders. Many comments which concern producers are also valid for merchants.

4.6.1 Producers

The results for producers suggest various issues which may limit the use of futures markets by these operators. The first issue concerns the fluctuating nature of the OHR. The low level of statistical parameters used in the OHR and HE determination such as the variance of futures and/or of cash price changes, have made the OHR very sensitive to any change in the value of one of them. It then becomes difficult for producers to follow a consistent and optimal marketing strategy based on historical data. The level of trade suggested by the OHR values is also fairly high, well above unity, and may deter operators from trading on the futures market. Reverse-hedging situations arise very often. Such trading conditions are due to frequent negative hedging and speculative OHR components. Negative hedging components which express a negative correlation between producer's cash and futures income (see equations 4.6, 4.7, 4.9 and 4.10) are surprising and may be due to production

variability. The low level of futures and cash income variance makes the OHR sensitive to variability in production[70]. The reverse-hedging conditions, combined with a high level of trade, is a further deterrent to producers trading on the futures market.

The various hedging periods experimented display rather similar conclusions. The inter-season hedge takes account of production uncertainty and shows sign of greater variability in the hedging component of OHR and hence in the OHR level. This variability in the hedging element shown in hedging situations 4, 5, 6 and 7 may be due to production uncertainty and, especially for hedging starting in February, to the uncertainty surrounding the annual wheat price-fixing.

Examination of the forward market as an alternative to futures trading has given interesting results. The level of the forward OHR is always lower than that of the futures OHR although their variability and their sign show similar characteristics. Whereas the HE of a forward-based portfolio is lower than that of a futures-based portfolio, the low level of the OHR and its proximity to unity may be a major advantage of forward contracting as opposed to futures contracting. Trade involving the use of both forward and futures contracts have proved to be inadequate for producers. The marginal gain obtained in the hedging effectiveness is certainly more than offset by the very high level of trade on both forward and futures markets.

Sensitivity to the risk aversion parameter is a common feature of the results. This high degree of sensitivity comes from the relatively high level of the speculative element relative to the hedging element in the OHR and HE measures. The low market price risk may have favoured the development of such a situation. The influence of institutional and political events may also have favoured the emergence of a risk premium paid by producers to speculators. The institutional nature of the price risk may have deterred speculators from using the market unless a substantial risk premium be paid. This is reported in the empirical results by the negative sign that most speculative components display. The forward contract presents more mixed results as far as the sign of the OHR speculative component is concerned. The latter is also generally lower than that of the futures contract. This finding may reinforce the preference of producers for forward contracts. The influence of the speculative element of OHR and HE might have certainly contributed to the variability of

[70] This variability may be undervalued on account of the use of national average for production data. Individual producers may indeed witness a greater variability in yield and a lower correlation between their individual yield and the market price.

the OHR and the HE.

The hedging effectiveness obtained through hedging on the futures market is very low. This, when compared to other commodities and financial futures markets such as the Chicago Board of Trade, may be judged as a poor performance. Yet, as pointed out earlier, such comparison is not fully valid. The low level, by American standards, of cash and futures income variance on the UK market may make further reduction of these variances a more difficult achievement.

The CAP, by lowering price risk has favoured the appearance of trading conditions in which the OHR is fluctuating widely, accompanied by a fairly high level of trade and very often showing reverse-hedging. This specific situation combined with a low HE may have altered the hedging ability of the futures market and may have deterred producers from entering the market.

4.6.2 Merchants

Sections 4.5.1.2 and 4.5.3 enable us to make the following remarks. The low price risk conditions have favoured a situation where the size of the hedging component of the futures OHR relative to the speculative component is smaller for merchants than for producers. This has led the way to a greater sensitivity of the futures OHR level to the degree of risk aversion of the trader. When risk reduction requirements are sufficiently lowered, the hedging component then takes on a level similar as compared to the speculative component. As explained earlier, this speculative component can be rather high owing to the institutional influence on the market. The level of the forward OHR and of HE may explain the observation that the use of forward contracts among merchants is more developed than that of futures contracts. The analysis suggests that futures market performs rather poorly and in a very irregular manner which makes its use rather difficult. The new approach to HE shows a great variability in the results. The influence of the risk aversion parameter justifies its use for situations where hedging components of OHR and HE are low.

4.6.3 Traders

Examination of trader's hedges for different length and over different samples in section 4.5.4 has provided evidence of influence of the CAP on the hedging performance of the futures market. The differences of the OHR values obtained from the three sampling periods

examined for each hedge may be explained by the changing relationship and levels over time of the statistical parameters derived from market prices. This may reflect the influence of institutional factors on the cash and futures markets which have made their relationship very variable and dependent on political and administrative decisions. Such finding is particularly reflected in the OHR results obtained from the portfolio where both cash and futures positions are simultaneously determined, which are very high and variable. The OHR, in the case of a given cash position hedge, slightly increases with the hedge length and becomes more stable. The greater stability in OHR values expresses a corresponding stability in the statistical parameters used in the OHR and the HE determination. The very low level of price risk on both futures and cash markets over a very short time period increases the sensitivity of OHR to any change in one of these parameters and makes OHR and HE very variable over time. This situation makes any short-run trading strategy on the futures market very difficult and uncertain.

The low HE which regularly increases with the hedge length comes from the growing variance of the basis. Very low for a one-week hedge, HE significantly increases for hedges over a longer time period. Here again note that the new approach of HE proves to be useful in highlighting the important influence of risk aversion in the HE determination.

4.7 Conclusion

This chapter was aimed at examining the influence of the CAP on the hedging function of the London wheat futures market. The analysis has first explored the optimal hedging ratio and then the hedging effectiveness of various hedging cases for three different market operators.

The low level of price risk has led to low values of the statistical parameters used in the determination of OHR and HE. Hence, this has in turn been reflected in the empirical assessment of the OHR and HE where variability over time and a significant sensitivity to the risk aversion coefficients was observed. The sign of the speculative component for producers and merchants suggests the existence of a risk premium paid by these two categories of operators to speculators for carrying institutional price risk. The sign of the speculative component, the production variability and low levels of statistical parameters have contributed to the appearance of reverse-hedging situations.

The institutional influence on the trader's hedge has been highlighted by the changing cash-

futures relationship over time and the consequent variability of the OHR and HE values obtained from samples of different length.

The low variance of the cash and futures income has led to low HE by traditional standard, since less variance has to be explained. To match these specific conditions, a new approach of HE has been adopted. Taking account of both risk and return opportunities, it has stressed the CAP influence on the HE performance of the futures market by pointing out the great sensibility of HE results to the risk aversion and, more generally, to speculative elements, especially in the merchant's and trader's cases. The regular investigation of the forward contract performance as an alternative to futures contract has given results supporting evidence of greater use of the forward market by producers and merchants.

The evidence therefore supports the second sub-hypothesis that the EC wheat regime has modified the effectiveness of the London wheat futures market in reducing price risk.

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CHAPTER 5

Investigation of the pricing performance

Through its regulations of market conditions by means of the intervention system, the institutional prices and the external trade, the CAP has greatly modified the wheat trading environment. This shift towards a highly regulated market is hypothesised to have distorted the futures market performance with regard to its informational efficiency, forecasting power and the existence and structure of a risk premium. Chapter 5 considers the impact of the CAP upon the price formation performance of the London wheat futures market. The analysis embraces both a short-term and a long-term perspective. The first part of the chapter deals with the daily price formation and the concept of informational efficiency. We then focus on the long-term price performance of futures markets by examining their forecasting power. The concept of risk premium and its assessment are finally related in the last part of the chapter.

5.1 Introduction to short-run price formation and expectation

The analysis of short-run price formation on futures markets takes place within the framework of informational theory. This theory focuses on differences in beliefs. Agents enter the market in order to profit from superior information they believe they possess. Streit (1983) and Hartzmark (1984, 1987), following Hirshleifer (1975, 1977) and Grossman (1977), suggest that traders take an open position on futures markets only if they anticipate a change in price from which they can profit. Under a dynamic approach, this implies that the futures price is an incorrect forecast of the future spot price. This ultimately means that the existence of futures trading is conditioned by trading at "false" prices determined by different, divergent beliefs and expectations[71].

[71] Streit (1983) claims that the favourable performance of the market would be the unintended outcome of numerous decisions of many participants who traded precisely because they estimated that changes in prices were inappropriate and unjustified and who intended to profit from these errors. He then argues (pp 8) that "the rationale for active market participation differs completely from the observable result".

Operators always try to gain profits from short-term variations in price. Therefore, whether short-term price fluctuations follow a trend or follow a random walk is of major importance. Prices vary in the short-run owing to new flows of information on the market (in its broad sense). Digested and processed by the market, every new piece of information modifies the level of the equilibrium price. Operators, in search of the new level of price, can create a phenomenon of price oscillation. Its intensity depends on operators' reaction. Working (1956) asserts that, since the appearance of new information is random, price variations it induces are also random. This concept of random walk (or martingale) has long been studied [72] and most theoretical work on the nature of futures price fluctuations in the short-run takes the "random walk hypothesis" as a point of departure. This hypothesis assumes that the price P_t is generated by the process :

(5.1) $P_t = P_{t-1} + E_t$ [73]

with $[E_t]$ is a sequence of independent identically distributed random variables.

A number of studies have provided general support for this model (Osborne, 1959, Granger and Morgenstern, 1963 and Kendall, 1963)[74]. Working's "theory of anticipatory prices" links these findings to the commodity price behaviour. In his view, prices form a martingale process (Mandelbrot, 1966). The random walk is a special case of a martingale in which price changes are distributed independently and identically. Meanwhile, empirical studies have been undertaken on the subject : Working (1954, 1956), Houthakker (1961), Smidt (1965), Rocca (1969), Brinegar (1970) and Labys and Granger (1970) show "imperfections" which consist of small low-order serial correlation coefficients in the series of daily price changes. Even if these imperfections are not large enough to form the basis of a profitable trading program, they represent a deviation from the theoretical model of martingale or random

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[72] From Bachelier (1900) to Samuelson (1965), who first proved that properly anticipated prices fluctuate randomly, and Granger (1968).

[73] This definition is very common (Feller, 1966) but some authors suggest another definition :

$$P_{t+1} = P_t.v_t$$

$$\log (P_{t+1}) = \log (P_t) + u_t \text{ with } u_t = \log (v_t)$$

$[v_t]$ and $[u_t]$ two sequences of normal and log-normal independent random variables with mean 1 and 0 and variance σ^2 and σ'^2 respectively. This definition seems to be justified if we take account of the condition that $P_t > 0$ and there is evidence that $[\log (P_{t+1}) - \log (P_t)]$ is stationary while $[P_t - P_{t-1}]$ is not, especially in the case of price rise.

[74] Cootner in 1964 summarizes a number of studies on the random walk hypothesis.

walk. Several theories have been advanced by Larson (1960), Taussig (1921), Cootner (1960) and Houthakker (1961) to explain the observed deviations. Each of them proposes an explanation which seems to be appropriate and particular to a specific market and to a precise point in time. More recent theoretical work has confirmed certain problems of the random walk and martingale hypothesis (among them Danthine (1977), Lucas (1978) and Stein (1980, 1981)).

5.2 Informational efficiency

5.2.1 The concept of informational efficiency

Efficiency can be defined relative to information. This view of market efficiency dominates the subject of finance and is sometimes called information-arbitrage efficiency (Tobin, 1984). Information-arbitrage efficiency suggests that, if the market is efficient, it is impossible on average to realize trading gains using available information; in other words, as underlined by Fama (1970, pp 383), at any moment in time, prices in the market always "fully reflect all available information". The hypothesis of efficiency can be tested in various forms. Fama summarized a trilogy of tests, namely the weak, the semi-strong and the strong form of market efficiency. Futures markets should not be profitably predictable from past prices (weak form efficiency), publicly available information (semi-strong efficiency), or all public and private information (strong form efficiency). The information-arbitrage concept has generated a great deal of research and the results are very mixed [75]. The efficiency of futures markets is an important issue with regard to its economic implications since agents trading in these markets will ensure an optimal allocation of resources (Fama, 1970, 1976).

In their early stages of trading, futures markets may not be fully informationally efficient but they then converge towards efficiency by an adjustment process (Sheldon, 1987). Evidence (Peck, 1975, Leuthold and Hartmann, 1979, and Just and Rausser, 1981) show that futures markets are generally efficient for agricultural commodities.

The information-arbitrage efficiency of futures markets can be linked to the intertemporal allocation of commodities through their effect on cash market efficiency and through their

[75] See among them, Conklin (1983), Gray (1962, 1972), Leuthold and Hartmann (1979, 1980) and Rausser and Carter (1983).

degree of reflection of publicly available information[76]. Effects on cash markets have been mainly examined by Powers (1970) and Cox (1976). Despite their early evidence of improvement of the informational efficiency of price formation during the presence of futures trading, Tomek (1979-80) suggests that additional work is needed to clearly define links between cash and futures prices regarding their informational efficiency performance.

Fama's definition of market efficiency requires three conditions:
. no transaction costs,
. all relevant information is costlessly available to all market participants,
. and all market participants agree on the implications of current information for the current price and the distribution of futures prices.

A direct implication of this concept is that all information is used for profits up to a point where these profits do not exceed "normal" returns available in other sectors. This can be translated into the following equation

$$(5.2) \qquad E_t(P^d_{t+1} / \Phi_t) = P_t$$

where P^d is the price discounted by the expected rate of return available at t_1 and Φ_t, the information set. Φ_t includes all past realization of prices. We can then derive from (5.2) that market efficiency for a price series can be expressed by a martingale or a sub-martingale process defined as follows,

Martingale : (5.3) $E_t\,(P_{t+1} / \Phi_t) = P_t$
Sub-Martingale : (5.4) $E_t\,(P_{t+1} / \Phi_t) \geq P_t$

Samuelson (1965) and Alchian (1974) criticize the translation of the market efficiency concept into the martingale process for commodity prices. Danthine (1977) claims that characteristics of the storage process and the non-martingale behaviour (a non-constant expected price differential) does not automatically lead to "inefficient" market. Danthine (1976), Leroy (1973) and Lucas (1978) also argue that non-zero expected price differential can characterize market equilibrium (due to risk aversion or decreasing returns). Danthine (1977, pp 15) asserts that analyzing tests of autocorrelations in return may represent, at the

[76] However, Stein (1981) argues that the weak form efficiency is not relevant to the welfare effects of futures markets.

same time, tests of market efficiency (in the Fama sense), risk aversion, technological change and competition degree in the market.

An implicit assertion lying behind Fama's trilogy of tests is the Rational Expectation concept. Minford and Peel's definition (1983) of the concept of Rational Expectations asserts that the market's subjective probability distribution of any variable is identical to the objective probability distribution, conditional on all available past information. In the case of non-rational expectations, we can expect a differentiation between the two models governing expected prices and actual prices, hence leading to potentially non-null excess returns expectations. Even if only defined as a sufficient condition for market efficiency, this "frictionless" market hypothesis as previously defined, may be expected to present some difficulties when applied to the relatively thinly traded London wheat futures market which we will be investigating later in this chapter.

5.2.2 The weak form test of informational efficiency

This test is based on the so-called random walk model described above. Leroy (1973) argues that certain empirical evidence, which does not support this hypothesis, does not necessarily wholly undermine weak form tests for efficiency. Results from the weak-form of the efficiency test may involve problems of interpretation given that they cannot prove that a series of price is random. They can only demonstrate the opposite, i.e. the existence of inefficiency. This is consistent with the market efficiency theory which does not claim a pure martingale model (as mentioned above). Several factors, of which the risk aversion of traders and the preliminary hypotheses such as no transaction costs, which are not observed in the real world, might be expected to generate evidence of inefficiency without allowing traders to profit from them (West and Tinc, 1971). Information collection[77] can also reasonably be assumed to involve cost. So, if the weak-form of informational efficiency holds, we may wonder why arbitrageurs might not be rewarded for their costly work[78]. Furthermore, the efficiency model implicitly makes the assumption of zero lag between time at which new information is available and the time at which it is incorporated into the price level (Larson, 1960). A fairly extensive literature on deviation from randomness under the

[77] Grossman and Stiglitz (1980) argue that costless information is not only, as commonly claimed, a sufficient condition for prices to fully reflect all information available but also a necessary condition. They claim that "there is fundamental conflict between efficiency with which markets spread information and the incentives to acquire information" (pp 405).

[78] Minford and Peel (1983) argue that arbitrage can occur at a continuous level while information is collected according to a discrete process.

weak form test has been developed. Departures from randomness have been found, but they appeared to be largely time period specific. This highlights the sensitivity of results to pricing characteristics in specific years (see Irwin and Uhrig, 1983, for a summary of this literature in the US). The specific environment of the London wheat futures market may favour the emergence of informational efficiency in the market pricing performance. Tests of informational efficiency constitute the focus of the next section.

5.2.2.1 Methodology for testing the weak form efficiency

Tests of the weak form are aimed at finding gain opportunities in past prices series. For that purpose, methods such as mechanical trading rules or statistical tests are available. The former generally use the method of filters as studied by Alexander (1964) and Houthaker (1961). Fama and Blume (1966) found that these mechanical tests do not perform better than statistical tests in the search for efficiency. Many different statistical tests can be found in the literature on efficiency analysis. The commonest are based on the examination of linear dependence in the series. They are the statistical significance of autocorrelations (Fama, 1965; Sweeney, 1978), the analysis of runs (Fama, 1965) and spectral analysis (Leuthold, 1972). The two first tests are here undertaken. The weak form of the efficient market hypothesis is first investigated by testing the Martingale hypothesis. Daily closing futures prices are transformed to log price changes which represent the return, under continuous compounding, from holding a contract. An estimate of the autocorrelation function is given by

$$(5.5) \quad r_k = \Sigma_{t=1}^{T-k} (x_t - X).(x_{t+k} - X) \; / \; \Sigma_{t=1}^{T} (x_t - X)^2$$

where

r_k denotes the estimated coefficient for a given lag k,

x_t the log price changes ($x_t = \ln P_t - \ln P_{t-1}$)[79],

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[79] Changes in log prices are used for three reasons:
. first, the change in log price is the yield, with continuous compounding, from holding the contract for that day. This can be shown as follows :

$$P_{t+1}/P_t = \exp(\log_e P_{t+1}/P_t)$$
$$P_{t+1} = P_t \,.\, \exp(\log_e P_{t+1}/P_t)$$
$$P_{t+1} = P_t \,.\, \exp(\log_e P_{t+1} - \log_e P_t)$$

. second, Moore (1962, pp 13-15), has shown that the variability of simple price changes for a given stock is an increasing function of the price level of the stock, resulting in heteroskedasticity. His work indicates that taking logarithms seems to neutralize most of this price level effect.

X the mean of x_t, and T the number of observations.

The market efficiency hypothesis implies that the autocorrelation coefficients approach zero, corresponding then to a "white noise" process. To test this hypothesis, we calculate the Box-Pierce (1970) statistic Q[80] defined as follows

$$(5.6) \quad Q = T.\Sigma_{i=1}^{k} r_k^2$$

where k is set large enough to include expected non-zero autocorrelations. In this study k equals 24 therefore autocorrelations can be detected over the past month. Under the null hypothesis, the Q-statistic, which is a sum of squared independent normal random variables N(0;1/T), is asymptotically Chi-Square distributed with k degrees of freedom. If the estimated X^2 is greater than the tabulated value of X^2 at a given significance level, then the null hypothesis is rejected. This test is often referred to as Q test.

Runs tests (or Z tests) are also computed on the same data series to complement the first analysis[81]. A run can be defined as a sequence of consecutive positive or negative price changes (no changes in price is considered as a negative price change). Under the null hypothesis of no serial dependence in the price change series, the expected number of runs E(m) of each type (negative or positive) is assessed as

$$(5.7) \quad E(m) = [T(T+1) - \Sigma_{i=1}^{2} n_i^2]/T = [1 + (2.n_1.n_2/T)]$$

and the standard error of m is defined as

$$(5.8) \quad \sigma_m = \left[\frac{\Sigma_{i=1}^{2} n_i^2.[\Sigma_{i=1}^{2} n_i^2 + T(T+1)] - 2.T.\Sigma_{i=1}^{2} n_i^2 - T^3}{T^2.(T-1)}\right]^{1/2}$$

where T denotes the total number of price changes, n_i the number of positive or negative price changes. Comparison of the actual and the expected number of runs involves the calculation of the variable Z defined as $Z = [(m + \frac{1}{2} - E(m))/\sigma_m]$, where m is the actual

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. third, for changes less than +/- 15 % the change in log price is very close to the percentage price change, and for many purposes, it is convenient to look at the data in terms of percentage price changes.

[80] There exists a revised Q statistics sometimes used in the literature (see 2.4.3.1).

[81] Some authors argue that runs tests are preferable to serial correlation tests because they are non-parametric, i.e. they do not depend on any finite variance assumption.

number of runs (the $\frac{1}{2}$ in the numerator is a discontinuity adjustment). When we have large values of T the sampling distribution of Z is approximately normal N(0,1). If there is evidence of serial correlation, we can expect the number of actual runs being different from the expected number and hence, Z being higher than 1.96 at the 5% level of significance. With positive first-order autocorrelation, the value of Z should take a negative value since price changes fluctuate in the same direction, thus reducing the number of runs. With negative first-order autocorrelation, the value of Z should give a positive value.

5.2.2.2 Data

We examine the weak form test of efficiency on all wheat futures contracts traded on the London wheat futures market from August 1980 to July 1988. The time span is expected to offer a temporal dimension to the examination of the impact of the various changes in the EC wheat regime arrangements on the wheat futures market efficiency. In that purpose, we use daily closing prices of the January, March, May, July, September and November futures contracts (Source : HGCA).

5.2.2.3 Results

All results of the weak form test of informational efficiency can be found in Appendix 5-A.1. Table 5.1 summarizes futures contracts which show evidence of inefficiency in their pricing performance with regards to both Z test and Q test.

Table 5.1 Futures contracts showing informational inefficiency (weak form) from 1981 to 1988[+]

Year	1981	1982	1983	1984	1985	1986	1987	1988
Z test	--	March	March July	--	--	Sept Nov	Jan Nov March	Jan
Q test	Nov Sept	Jan	Nov March July Sept	Sept March	Sept July	July Nov	July	May July Jan

[+] Jan, Sept and Nov stand for the January, September and November futures contracts respectively.

If we summarize the number of times each futures contract has been found significantly

inefficient (with the number of years in parenthesis), we obtain the following result: January 4 (3), March 5(4), May 1(1), July 6(5), November 5(4), September 5(5). These results appear to give evidence of informational inefficiency and so seem to support the third sub-hypothesis of the thesis that the CAP has altered the pricing performance of the London wheat futures market. Results from the Q test suggest that contracts maturing at the beginning of the season, namely the September and November contracts until 1986/87 and the July and September contracts afterwards, are more sensitive to serial correlation, and hence informational inefficiency than other contracts. These contracts suggest a systematic deviation from the market efficiency hypothesis. The Run test (or Z test) proves to be less sensitive than the Q test in its test of market efficiency. The March contract seems to show significant inefficiency for the 1982/1984 period while the January contract displays similar characteristics for the 1987/88 period. Two periods appear particularly affected by informational inefficiency: the end of 1983 and the 1986/88 period.

Market inefficiencies may have been driven by market and institutional uncertainty, particularly for the 1986/88 period. British exports, supported by an aggressive EC export policy, displayed a strong upward trend, thus provoking a surge in spot prices well above intervention price level. This is illustrated by the doubling of the wheat export volume between 1985/86 and 1986/87. During that period, the EC buying-in price came also into force while restriction on intervention deliveries began. The inefficiencies highlighted by the Q test and the Z test may thus reflect the cost of information requirements. Indeed search for information concerning institutional factors may prove to be more costly than for information on market conditions. In the light of somewhat different results, the use of Q test and Z test appears to be justified and would deserve further research.

5.2.2.4 Conclusion

Evidence seems to support the third sub-hypothesis (see section 1.6) that the EC wheat regime has affected the pricing performance of the wheat futures market. Every year, from 1980 to 1988, a number of futures contracts exhibit deviation from the market efficiency hypothesis, The 1983 and 1986/88 periods display particularly strong evidence of inefficiency. These time periods coincided with important changes in the British market and the EC wheat regime. British wheat exports and intervention stocks have significantly increased along side a tighter wheat intervention system. The combination of market-derived uncertainty and policy uncertainty may generate inefficiency in the behaviour of some futures contracts. While the CAP, by significantly reducing market price risk, might have

been expected to suppress any opportunity for market inefficiency, it appears to the contrary to have affected the efficiency of the wheat futures market by establishing a complex set of policy arrangements. While the price level may easily be determined by institutional prices, deviations from this level are more difficult to predict, thus enhancing the cost of any informational advantage and consequently creating opportunities for market inefficiencies.

5.3 Price forecasting performance of the wheat futures market

5.3.1 The price forecasting function of futures markets

We now turn to the examination of the price forecasting function of the wheat futures market. In the light of the analysis in the first part of the chapter, we investigate whether the forecasting performance of the wheat futures market exhibits inefficiency. Many authors (eg Edwards, 1981) consider forward pricing as the most important economic function of futures markets, especially for non-storable commodities[82]. Tomek and Gray (1970), later confirmed by Gray (1972), show that futures prices at planting time are better forecasts of immediate post-harvest prices for commodities which have continuous inventories, than for those which do not. There have been a number of evaluations of the forecasting performance of futures prices. Leuthold (1974) and Martin and Garcia (1981) study cattle and hog futures prices. They conclude that futures prices are unbiased estimates of the eventual spot prices but that their degree of predictability declines with distance to maturity. When the forecasting performance proves to be poor, authors argue that the futures prices are rational and optimal in a welfare sense. Just and Rausser (1981) show that futures prices are accurate forecasters of future spot price in comparison with econometric forecasts (except for non-storable products).

5.3.2 Methodology for the assessment of price forecasting function assessment

Our examination of the forecasting power of futures markets takes place in two parts. First, we operate a regression of the futures price at maturity by the futures price lagged several months before. Hence we estimate the forecasting power of futures prices through the values and the significance of the regression parameters. We also consider the significance of the relationship between the forecasting ability of the futures price and the lag length. Then, we

[82] Numerous studies of producers' supply response have found that producers form their expectations of next year's price on the basis of current and past prices (one of the most successfully used model is Nerlove's adaptative model, 1958).

carry out a comparative analysis with four other forecasting methods : a SARIMA model, a forward price, a naive forecast and the EC Intervention price. The accuracy of the forecast is evaluated by computing the Root Mean-Squared Error and the Root Mean-Squared Percentage Error[83].

5.3.2.1 Linear Regression Method

The examination of the predictive power of futures markets for seasonal products has led many authors (eg Yamey 1983) to follow a specific approach based on an econometric model. They regress, for instance, the harvest-time futures price on the planting-time futures price. Under the hypothesis that the futures price is an efficient forecast of the spot price, we obtain an equation of the form :

$$(5.9) \qquad P^f_t = a + b.P^f_{t-k} + u_t$$

where P^f_t is the futures price at harvest-time and P^f_{t-k} the futures price at planting-time (k months behind), and results equivalent to R^2 close to 1, with $a = 0$ and $b = 1$.

The various studies based on this model tend to implicitly assume that there are no purely random events which can cause the forecast price to differ from the eventual price (or that, over the sample, all these individual disturbances cancel each other out[84]). However, in practice, some influences derived from events such as government interventions do exist. In the particular context of the CAP, features such as the EC price-fixing regime are expected to provide a significant impact on the futures price process. We assume here that the error term u_t is a stationary process, i.e. the P^f_t and the P^f_{t-k} are two co-integrated[85] processes, and that it is normally distributed $(0;\sigma^2)$.

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[83] Additional information could be obtained by decomposing the forecast error. Just and Rausser (1981) decompose the mean squared error into the bias squared, the variance of the forecast, the variance of the spot price, minus twice the covariance between the two. Hence, they suggest that the futures market is generally more accurate in terms of bias, while the econometric models were more accurate in terms of variance.

[84] Working (1949) differentiates "necessary" and "objectionable" inaccuracy of futures price. A constant presence of a minimum of "necessary" inaccuracy comes from price response to unpredictable changes in supply and consumption demand schedules. Every excess over this minimum would be the "objectionable" inaccuracy (or avoidable inaccuracy). Studies based on linear regression seem to consider that all deficiencies in forecasting power are derived from "objectionable" inaccuracy.

[85] Analysis of co-integration takes place in Chapter 6 where it is considered in the examination of the causality between price series.

This method assumes that the futures price at maturity is equal, on average, to the spot price at maturity. Elements of risk premium (or bias) and of basis risk such as transportation cost and quality differences, are not taken into account. Focus is made on the forecasting accuracy of the futures market as an hedging tool. We also choose to adopt a fully disaggregated approach in our analysis (i.e. a fixed lag with a specified single contract). This gives us equations with just one observation on each contract month per year. The pooling of data for the same length across different contract months presents several difficulties. It may first amplify the influence of a single event. The introduction of new information on the futures market influences the entire system of prices and not just a single contract month (Working, 1942, 1948). Prices for different contract months are more or less correlated (slightly more for storable products according to Tomek and Gray, 1970, who studied potatoes and corn). Pooling may also increase the t-value of coefficients and amplify the results obtained from "disaggregated" data (Kahl and Tomek, 1986). The pooling of data also assumes that market efficiency does not vary from contract month to contract month. This has been questioned by Leath and Garcia (1983) on corn futures, Leuthold (1974), Martin and Garcia (1981) on cattle futures and Kahl and Tomek (1986) on corn and soyabean futures. Finally, pooling may introduce the presence of overlapping data[86] and therefore of serial disturbances which are difficult to analyse.

We adopt a Seemingly Unrelated Regressions model (SUR) which is generally given as theoretically superior both to pooling data across contract months and estimating equations for each contract and each lag independently (Zellner, 1962) (see Chapter 3).

We base our study on the period of time 1975/89 which gives us 15 annual data per equation. First we proceed with an analysis of each contract month for each lag by OLS (Ordinary Least Squares). We investigate four different lags, i.e. one-, three-, six- and nine-month lags, on the six wheat futures contracts traded on the London wheat futures market. We consequently study a system of 24 equations with 15 data points each. The SUR systems can be operated according to three options[87]. These options consist in either fixing a common lag, or fixing an identical maturity month or fixing a common date for the lagged month. The last option is the only one that does not present problems of correlation between the P^f_i and the u_i and, owing to the different lags studied here, we have computed six systems of

[86] Except if the lag is smaller than or equal to the data frequency used.

[87] The system of equations applied by Kahl and Tomek (1986) is made of four equations per SUR system of four lags for a given contract with a common maturity month. However, this system can present some correlation between u_t and P^f_t.

three equations, each fulfilling these conditions as shown in Table 5.2. Results from six equations could not be improved in terms of efficiency due to the impossibility of fitting them in a SUR system because of the lags choice. In order to test the H_o joint hypothesis (a=0 and b=1), we undertake a F test. For the OLS regressions, the F statistics is defined as $[[RSS_r - RSS_u]/RSS_u . ((N-2)/2)]$ where RSS_r and RSS_u are the sum of squared residuals of the restricted model ($P^f_t = b.P^f_{t-k}$) and of the unrestricted model ($P^f_t = a + b.P^f_{t-k}$) respectively. We extend the F test estimated under the OLS assumptions to fit the new SUR assumptions using the Variance-Covariance matrix of the disturbance terms (see Johnston, 1984, pp 339).

5.3.2.2 The comparative analysis

The comparative analysis of the forecasting power of futures markets examines the relative accuracy of the wheat futures market when compared to other forecasting methods in predicting future cash prices. These forecasting methods are based on the forward market, SARIMA models, naive forecast and the EC intervention price.

Table 5.2 SUR systems used in the analysis of the forecasting function

System 1	System 2	System 3
March = $a_{11} + b_{11}$ March $_{-1}$	May = $a_{21} + b_{21}$ May $_{-1}$	July = $a_{31} + b_{31}$ July$_{-1}$
May = $a_{12} + b_{12}$ May $_{-3}$	July = $a_{22} + b_{22}$ July $_{-3}$	Sep = $a_{32} + b_{32}$ Sep $_{-3}$
Nov = $a_{13} + b_{13}$ Nov $_{-9}$	Jan = $a_{23} + b_{23}$ Jan $_{-9}$	March = $a_{33} + b_{33}$ March $_{-9}$

System 4	System 5	System 6
Sep = $a_{41} + b_{41}$ Sep $_{-1}$	Nov = $a_{51} + b_{51}$ Nov $_{-1}$	Jan = $a_{61} + b_{61}$ Jan $_{-1}$
Nov = $a_{42} + b_{42}$ Nov $_{-3}$	Jan = $a_{52} + b_{52}$ Jan $_{-3}$	March = $a_{62} + b_{62}$ March $_{-3}$
May = $a_{43} + b_{43}$ May $_{-9}$	July = $a_{53} + b_{53}$ July $_{-9}$	Sep = $a_{63} + b_{63}$ Sep $_{-9}$

Jan, Sep and Nov stand for January, September and November futures contracts. March$_{-k}$ refers to the futures price for delivery in March, quoted k months before.

In this analysis, the futures price needs to be adjusted by the basis at maturity in order to give a forecast of the future spot price. The basis at maturity is estimated by the average of the basis over the last five years. The forward price is an obvious choice for comparison since most British farmers use the forward market in their marketing of grain. The forward market in the UK is well developed and can be thought of as being a fairly accurate measure of the expected future spot price. SARIMA models may also be expected to represent an accurate forecast of the expected future price as claimed in Chapter 2. SARIMA models

obtained in that chapter are used here to ensure consistency with the definition of risk. The naive forecast is tested as a benchmark. It assumes that

(5.10) $E_t(p_{t+n}) = p_t$

The use of the EC intervention price as price forecast is derived from the EC wheat regime for which the intervention price is supposed to represent a price-floor. The current situation of overproduction makes market prices very tightly bound to this institutional price and its use as price forecast can also be viewed as a benchmark.

Comparison is made using two statistical instruments, the Root Mean Squared Error (RMSE) and the Root Mean Squared Percentage Error (RMSPE) which are defined as follows
RMSE = $\sqrt{(1/N.\Sigma(\text{forecast price - spot price})^2)}$ and
RMSPE = $\sqrt{(1/N.\Sigma((\text{forecast price - spot price})/\text{spot price})^2)}$ with N the number of data.

Computation of results takes place for each year of the 1980/88 period. It enables us to assess the forecasting power of each method every year and to examine the development of this forecasting ability over the whole period.

5.3.3 Data

Data used in the linear regression approach are monthly averages of Friday closing prices from 1974/75 to 1988/89 (source : HGCA). However, a second set of data representing the closing price of the first Friday of the month is examined but on the period 1980/81 to 1988/89.

The comparative analysis uses closing prices of the first Friday of the month over the 1980/81 to 1988/89 period of time, for futures prices. Forward and spot prices are weekly averages. SARIMA forecasts are obtained from the models presented in Chapter 2 and are adjusted by the prevailing EC intervention price.

5.3.4 Results

5.3.4.1 Linear regression method

Since the July contract was not quoted before 1980, any SUR system involving the July

contracthave their time period limited from 1981 to 1988. Therefore, estimation of these SUR systems on a longer period has been operated from 1975 to 1988, but excluding the July contract. Results are displayed in Tables 5.3 and 5.4. As far as the six-month lag is concerned, none of the contract month equation could be inserted in a SUR system. The July contract is the only contract to show a significant intercept and a slope coefficient significantly different from unity (Table 5.3). This is confirmed by results obtained from the same regression using the Friday closing price of the first week of maturity month and of the lagged month instead of the monthly average of these Friday closing prices currently used in the results exhibited in Tables 5.3 and 5.4. However, this second set of data over the 1981/88 period present somewhat different results. While the March, May and September contracts have neither of their coefficients a or b significantly different from zero and one respectively, the January and November contracts show both a and b coefficients significantly different from zero and unity.

The analysis considering other lags, i.e. one-, three- and nine-month lags, has used a SUR system. All contracts show a slope significantly equal to 1 and the intercept non-significantly different from zero (Tables 5.3 and 5.4). Using the second set of data, some contracts, November (for lags of one, three and nine months), January (for lags of one and nine months), September (for lags of one and nine months) and May (for a nine-month lag) show an intercept significantly different from zero and a slope coefficient significantly different from unity. Yet, test of H_o (a=0 and b=1) gives evidence that all contracts, whatever the set of data, support the null joint hypothesis.

In addition to the SUR analysis, a comparison of the results between the 1975/80 and the 1981/88 time periods has been undertaken using the Chow test. Indeed, the London wheat futures market may be expected to show a learning process since it started trading in 1964/65. In addition to this learning process, the impact of the UK accession to the EC in 1973 on the market activity and the consequent change in the British physical market after the 1980/81 season may have significantly influenced the forecasting performance of the futures market. The results of the Chow test are given in Table 5.5.

Table 5.3 Results from the analysis of the forecasting performance using the linear regression method for the July, September and November contracts, with monthly average prices[++]

July			
1-month lag :	P^f_t = 5.24 + 0.96 P^f_{t-1}	R^2 Adj = 0.82 ; DW = 2.79;	F_{Ho} = 0.08
	(0.29) (-0.23)		
3-month lag :	P^f_t = 5.81 + 0.94 P^f_{t-3}	R^2 Adj = 0.57 ; DW = 2.62;	F_{Ho} = 0.01
	(0.18) (-0.23)		
6-month lag :	P^f_t =-193.84 + 2.61 P^f_{t-6}	R^2 Adj = 0.66 ; DW = 2.51;	F_{Ho} = 0.91
	(-2.36)* (2.36)*		
9-month lag :	P^f_t = -79.25 + 1.66 P^f_{t-9}	R^2 Adj = 0.61 ; DW = 2.20;	F_{Ho} = .81
	(-1.67)** (1.68)**		
September			
1-month lag :	P^f_t = 2.39 + 0.98 P^f_{t-1}	R^2 Adj = 0.98 ; DW = 2.30;	F_{Ho} = 0.00
	(0.71) (-0.47)		
3-month lag :	P^f_t = 4.97 + 0.97 P^f_{t-3}	R^2 Adj = 0.90 ; DW = 2.15;	F_{Ho} = 0.01
	(0.63) (-0.34)		
6-month lag :	P^f_t = 10.52 + 0.92 P^f_{t-6}	R^2 Adj = 0.87 ; DW = 2.30;	F_{Ho} = 0.65
	(1.19) (-0.85)		
9-month lag :	P^f_t = 4.38 + 0.97 P^f_{t-9}	R^2 Adj = 0.83 ; DW = 2.63;	F_{Ho} = 0.02
	(0.42) (-0.23)		
November			
1-month lag :	P^f_t = -1.52 + 1.02 P^f_{t-1}	R^2 Adj = 0.99 ; DW = 2.13;	F_{Ho} = 0.11
	(-0.56) (0.88)		
3-month lag :	P^f_t = 0.81 + 0.99 P^f_{t-3}	R^2 Adj = 0.94 ; DW = 2.18;	F_{Ho} = 0.01
	(0.12) (-0.09)		
6-month lag :	P^f_t = 11.16 + 0.90 P^f_{t-6}	R^2 Adj = 0.99 ; DW = 1.82;	F_{Ho} = 0.96
	(1.44) (-1.19)		
9-month lag :	P^f_t = 14.20 + 0.88 P^f_{t-9}	R^2 Adj = 0.79 ; DW = 2.27;	F_{Ho} = 0.66
	(1.29) (-1.06)		

[++] The t values of the intercept and the slope coefficients are in brackets and correspond to the test of the null hypothesis H'_o : a=0 and H''_o : b=1 respectively.
* t values significant at 5%; ** t values significant at 10%

Table 5.4 Results from the analysis of the forecasting performance using the linear regression method for the January, March and May contracts, with monthly average prices[++]

January	
1-month lag :	$P^f_t = 0.86 + 0.99\ P^f_{t-1}$ (0.30) (-0.18) R^2 Adj = 0.99 ; DW = 1.95; F_{Ho} = 0.01
3-month lag :	$P^f_t = -4.95 + 1.05\ P^f_{t-3}$ (-0.86) (0.92) R^2 Adj = 0.96 ; DW = 1.91; F_{Ho} = 0.28
6-month lag :	$P^f_t = -0.43 + 1.01\ P^f_{t-6}$ (-0.07) (0.22) R^2 Adj = 0.95 ; DW = 2.09; F_{Ho} = 0.01
9-month lag :	$P^f_t = 7.94 + 0.93\ P^f_{t-9}$ (1.01) (-0.86) R^2 Adj = 0.89 ; DW = 2.38; F_{Ho} = 0.44
March	
1-month lag :	$P^f_t = -1.51 + 1.02\ P^f_{t-1}$ (-0.56) (1.05) R^2 Adj = 0.99 ; DW = 2.31; F_{Ho} = 0.20
3-month lag :	$P^f_t = -10.39 + 1.10\ P^f_{t-3}$ (-1.22) (1.22) R^2 Adj = 0.92 ; DW = 2.21; F_{Ho} = 0.84
6-month lag :	$P^f_t = -9.84 + 1.09\ P^f_{t-6}$ (-1.13) (1.15) R^2 Adj = 0.92 ; DW = 2.63; F_{Ho} = 0.60
9-month lag :	$P^f_t = -10.99 + 1.12\ P^f_{t-9}$ (-1.14) (1.27) R^2 Adj = 0.90 ; DW = 2.62; F_{Ho} = 0.55
May	
1-month lag :	$P^f_t = 2.46 + 0.97\ P^f_{t-1}$ (1.14) (-1.21) R^2 Adj = 0.99 ; DW = 2.53; F_{Ho} = 0.72
3-month lag :	$P^f_t = 6.56 + 0.95\ P^f_{t-3}$ (1.20) (-0.84) R^2 Adj = 0.96 ; DW = 2.31; F_{Ho} = 0.41
6-month lag :	$P^f_t = -1.49 + 1.02\ P^f_{t-6}$ (-0.11) (0.14) R^2 Adj = 0.79 ; DW = 1.85; F_{Ho} = 0.01
9-month lag :	$P^f_t = -6.98 + 1.07\ P^f_{t-9}$ (-0.58) (0.61) R^2 Adj = 0.85 ; DW = 2.18; F_{Ho} = 0.01

[++] The t values of the intercept and the slope coefficients are in brackets and correspond to the test of the null hypothesis H'_o : a=0 and H''_o : b=1 respectively.
* t values significant at 5%; ** t values significant at 10%

Table 5.5 Chow test results for the linear regressions covering the 1975/80 and the 1981/88 periods

Contract month	Sept	Nov	Jan	Mar	May
Lag					
1	2.49	1.13	0.89	1.18	0.93
3	2.37	6.44*	1.02	0.04	0.01
6	2.14	2.93	3.51	0.06	0.11
9	1.56	3.06	3.95	0.41	1.06

* Coefficient significant when compared with the Tabulated value of $F_{2,11} = 3.98$ at 5 %

None but the November contract with a three-month lag shows significantly different results. From 1974 to 1980, the November futures contract with a three-month lag has an intercept not significantly different from zero and a slope equal to 1, while from 1981 to 1988, the intercept is significantly different from zero and the slope different from 1. Evidence from the results shown in Tables 5.3 and 5.4 suggests that there is little influence of the CAP on the forecasting power of the wheat futures market. The July and the November contracts in the 1981/88 time period showed some inefficiency in their forecasting ability. Yet referring to the end and beginning of the season respectively, these contracts may be affected by factors such as late institutional price settlements, lower intervention system availability at the end and beginning of the season, an active export market and the shift from the old crop to the new crop trade. The institutional factors may have created uncertainty about cash market development hence inducing lower forecasting ability[88].

Analysis of the forecasting performance of futures markets with the second set of data provides evidence of forecasting inaccuracy for most of futures contracts for the six- and nine-month lag and for the September, November and January futures contracts for other lags. This difference may be due to the characteristics of monthly averages, which smooth intra-month price fluctuations. These results, which may express the impact of the intra-month variability of the futures price on the contract forecasting performance, cast doubt on the forecasting ability of the futures market from 1980/81 to 1988/89. Nevertheless test

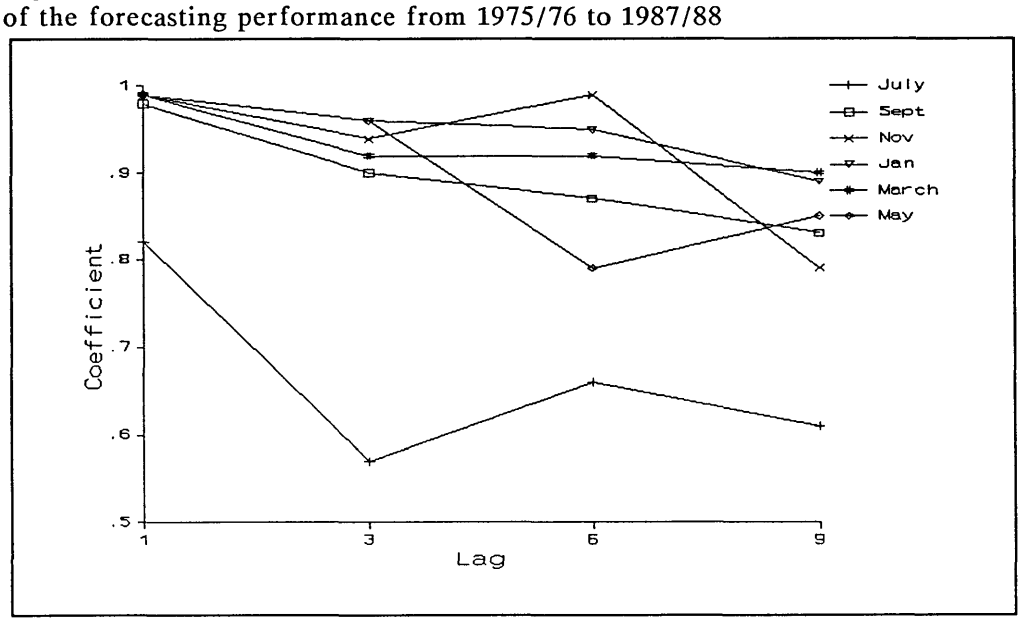
[88] Note that the characteristics of the July contract is very specific since this contract refers, untill the 1986/87 season, to the end of the marketing season and, from that date onwards, to the beginning of the marketing season. This institutional change, crucial for the availability of the intervention system, may have distorted the results of this regression.

of the joint hypothesis H_0 does not confirm these results.

Chow tests show a significant change in the performance of the three-month lag November contract between the late 1970's and the 1980's. Such a result may be due to the UK export market which was very active in the beginning of the season in the 1980's. Moreover, the lower availability of the intervention system early in the season may create more uncertainty about spot price development and hence increase the difficulty of forecasting spot prices. Note that some price-fixing decisions are delayed so long that forecasting the spot price in August may be made even more difficult.

To analyze the forecasting power of the futures market using this method of simple linear regression enables us to consider three criteria of futures market performance in its forecasting function: the intercept and the slope of the simple linear regression and R^2. The R^2 of the simple linear equation may be used as a measure of market performance. The higher the R^2, the higher the reliability of the price forecast[89]. In that view, we examine the evolution of the R^2 from a one-month to a nine-month lag for the six futures contracts.

Figure 5.1 Coefficient of determination of simple linear regressions for the assessment of the forecasting performance from 1975/76 to 1987/88



The July futures contract displays a relatively low forecasting performance while the January

[89] Note that despite its common use (Yamey, 1983 and Kahl and Tomek, 1986), this assertion is not fully valid since ex post goodness of fit is different from forecast ability.

and March contracts have a fairly constant high forecasting power. A significant drop affects the May and the November contracts' performance for a six- and nine-month lag respectively. On the whole and except for the July contract which is somewhat specific due to the new/old crop trade and the implementation of the new set of institutional prices, futures contracts are fairly accurate forecast of future spot prices when expressed with R^2 values.

5.3.4.2 The comparative analysis

Results from the comparative analysis are displayed in Appendix 5-A.2. Futures and forward prices appear to have similar performance for one-month lag forecast while the naive forecast surprisingly shows a better result than SARIMA models and the method based on the EC intervention price. The two-month lag forecast analysis gives a more clear-cut view of the attractiveness of each forecasting method. Futures, forward and SARIMA methods give rather similar results while naive forecasts and intervention price can be classified as poor forecasting methods. The three-month lag differentiates forward and futures-based method : forward forecasts seem to be slightly better than futures price-based forecasting method. This, as well as in the case of the one- and two-month lags, is particularly pronounced during the seasons 1982/83, 1983/84, 1986/87 and 1987/88. SARIMA models, while showing similar performance before, prove to be less powerful during the seasons 1985/86 and 86/87. This may come from a greater difficulty of forecasting the price gap between intervention price and the market spot price after the 1985/86 season on the basis of previous seasons. Indeed, institutional changes took place which may have consistently affected the determination of this gap and then its forecast. The better performance of the forward market may be due to its greater liquidity than that of the futures market.

5.3.5 Conclusion

Evidence from these results is rather mixed. While they attest that the performance of individual contracts in forecasting the expected spot price at maturity is good with price averages, apart from the July and the November contracts after 1981, they exhibit some forecasting inefficiency when obtained from Friday closing prices, even if these results are not confirmed by the joint hypothesis. The wheat futures market performs better than the SARIMA models and almost as well as the forward market as price forecaster. We may assert that, despite significant interference caused by the CAP, futures markets still perform well as regards their forecasting function.

5.4 The cost of trading and risk premium

The third and last part of the analysis of the pricing performance of the wheat futures market is concerned with the cost of trading. The cost of trading on a futures market reflects various elements. Transactions costs paid by off-floor traders take the form of brokerage fees and execution costs due to price changes which occur with the placement of a market order. When a market order to buy follows a sell order, the former is executed at a slightly higher price than the previous sell orders (Thompson and Waller, 1987). The bid-ask spread is the difference between bid prices and offer prices quoted by scalpers in the futures market place. Very low when compared to the total value of the contract, the bid-ask spread represents a negligible cost for agents[90]. In addition to these costs, there are the deposit margin and the daily margin call during the life of the contract.

However, the only cost component that we analyse here is the "price of risk" or risk premium. The size of the wheat futures market, relatively to the British or EC production, which may be considered as thin, combined with a low but institutionally-derived market price risk, may be expected to contribute to the existence of a risk premium. The risk premium concept, which should be distinguished from the portfolio approach, reflects whether on average hedgers lose or win on futures markets. This point is related to the problem of the remuneration of risk and, consequently to the existence of bias[91].

5.4.1 Introduction to the risk premium

The existence of risk premium and its study arises from the belief that the futures price may be different from the expected spot price at a later delivery period. This difference is called the bias or the risk premium and can be expressed by :

$$(5.11) \qquad p^f_o = E_o(p_1) - R$$

with p^f_o the futures price at t_o for the delivery period t_1, $E_o(p_1)$ the expected spot price at t_o for the delivery period t_1 and R the risk premium.

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[90] However, further research on the London wheat futures market would be relevant with respect to the level of this cost, given the thinness of the market. The low volume of trade could induce higher spreads which in turn could lead to significant transaction costs. We might then expect a "higher than normal" transaction cost in the London market.

[91] Note that the inventory allocation implications of the bias are not investigated here.

All tests for risk premium depend on the spot price expectations that we adopt. Conclusions regarding the risk premium existence are then conditional to the expectation proxy used and may be due to systematic differences between the expectation used and the real expectation model of market agents. The concept of risk premium can be analyzed under two approaches. The first one is derived from Keynes's concept of "normal backwardation" which supposes that agents' behaviour on futures markets only depends on their physical positions and is independent from other financial institutions. Keynes and his followers consider that risk on a futures market asset is only related to its own price variability. The second approach deals with the futures contract when reintegrated in a portfolio of financial assets and suggests that risk from a futures contract, or from any other risky asset, arises from its contribution to the overall risk of a large and well-diversified portfolio of assets.

We choose to adopt the first approach since it is more likely to reflect the state of the London wheat futures market by treating it as a market separate from other commodities and financial markets. Nevertheless, this situation is likely to change. All commodities traded in the Baltic Exchange have recently started to be traded on the same floor to boost volume of trade by enhancing potential synergy and multicommodity trading strategies[92]. Financial institutions also begin to consider trading in agricultural commodities, an asset class that they have been ignoring in recent past and through which they could attain portfolio diversification (NYFE, 1990).

The first theoretical work on futures price behaviour in relation to the existence of a risk premium was undertaken by Keynes in 1930. In his theory of normal backwardation Keynes suggests that markets sometimes reflect contango and sometimes backwardation[93], but in either case, a risk premium is a normal component of the difference between spot and forward prices. It represents the speculator's reward for bearing the risk of price change during the time of holding the futures contract. Kaldor (1939-40a, b), Dow (1939-40) and Working (1958) go further in the analysis of risk premium. Although Working denies the importance of risk premium as measured by Keynes, he does not reject the risk premium hypothesis on the basis of his empirical studies. Houthakker (1957) and Telser (1981)

[92] Further expansion is planned since talk of merger proposals between the Futures and Options Exchange and the Baltic Futures Exchange have been put forward (Financial Times, 26/09/1990).

[93] Contango is used for a "normal" market where deferred months are priced higher than those nearby. Backwardation refers to a situation where the near futures prices exceed those for the deferred delivery months. Also known as a "premium market" or an "inversion" (Savaiko, 1985).

conclude that the Keynesian estimate of normal backwardation was reasonably correct. This approach of risk premium assumes the dichotomy of the futures market between hedgers and speculators. It does not take into account the transfer of risk in a general equilibrium setting.

It seems, as Gray[94] argued (1960 and 1961), that there is not so far significant evidence of the existence of a risk premium in the major futures markets under normal conditions. Some bias observed in some markets can be induced by a low volume of open interest or by some institutional factors. This interpretation is backed by Tomek and Gray (1970) who provide further empirical evidence of unbiased futures markets. The debate over the existence of risk premium in agricultural futures markets has not been clarified despite recent studies by Dusak (1973), Bodie and Rosansky (1980), Carter and Rausser (1983), Carter, Rausser and Schimtz (1983) and Hazuka (1984).

To sum up we assert that, despite the extensive literature, evidence generally shows that bias is not characteristic of futures prices and simply reflects particular market circumstances. Even if it may exist in theory, its empirical assessment has never been proved except in some particular cases of "narrow" markets. Being a highly subjective concept, results from empirical studies must be examined as regards to the problem of identification of the trading strategies, to the possibility of variation in its assessment between commodities, exchanges and time period and finally, to the potential existence of a risk on the risk premium evaluation.

5.4.2 Methodology of assessment of the risk premium

Two methodologies are here applied to investigate the existence of risk premium in the London wheat futures market. Nevertheless we first apply Gray's simulation of long trading operations[95] in order to have an overview of any bias existence. This method simulates long trading positions in the futures market to determine whether significant profits or losses may be generated over time. We undertake a scheme of buying a contract on the Friday of week i and selling it n weeks later. When transactions are completed, we determine the average return defined as $[P^f_1 - P^f_o]/P^f_o$ from each time interval and use the t-test to examine whether the profit (or loss) is significantly greater (smaller) than zero. These results from trading strategies are simulated with the nearby contract and the next to nearby contract.
We assume here that hedgers are always on the short side of the market.

[94] Gray summarized much of the evidence and added his further findings.

[95] This procedure has long been used, Martin and Storey (1975) and Veeman and Taylor (1987).

Table 5.6 Results from a long trading position using the nearby and next to nearby contracts from 1980/81 to 1988/89

Nearby contract	Mean of rate of return	Number of trading positions	Standard deviation	Coefficient of variation	t values
One week	.0007531	410	.011231	14.91	1.35
Two weeks	.0001926	205	.0186506	96.35	.15
One month	.0044228	82	.028132	6.36	1.42
Two months	.0033913	47	.0370255	10.91	.62
Next to nearby contract					
One week	.0004206	410	.009715	23.10	.87
Two weeks	.0014007	205	.0135149	9.64	1.48
One month	.0015621	82	.0206423	13.21	.68
Two months	.0068048	47	.0319112	4.68	1.46

Table 5.6 shows no evidence of the existence of risk premium. The trading strategy which consists of constantly buying and selling a contract one week, two weeks, one month or two months later, does not apparently show any opportunity for systematic profit or loss. None of the means proves to be significantly different from zero. We now turn to the two main methods used in the section. The first one deals with a system of linear regressions and is introduced below.

5.4.2.1 Linear regression model

An initial way of examining for the existence of a bias is to test equation (5.11) by regressing the expected spot price at t+1 on the futures price at t. Intercept and slope regression not significantly different from 0 and 1 respectively imply a zero risk premium, if agents are risk neutral and incur no transactions costs. As $E_t(p_{t+1})$ is unknown, previous studies have generally used the realized spot price. This proxy is based on the standard approach of the Theory of Rational Expectations. This theory claims that if agents efficiently process all information, then the realized spot price will differ from prior expectations by a zero mean, serially uncorrelated random variable. Jacobs (1982) criticized the use of this proxy by pointing out the failure at taking account of the existence of errors-in-variables in the

regression and the weakness of this proxy to represent the expected spot price. While working on risk premia on forward exchanges rates, he argued that these problems make difficult to reject the null hypothesis of zero risk premium. Errors-in-variables imply that ordinary least-squares estimates are not only biased but also inconsistent.

If we consider the following equation

(5.12) $p^f_t = a_o + a_1.E_t(p_{t+1}) + e_t$

where e_t is a serially uncorrelated random variable with zero mean and variance Var(e). This equation cannot be directly tested because we do not know $E_t(p_{t+1})$. We then choose a proxy p_{t+1}^* for $E_t(p_{t+1})$ such that

(5.13) $p_{t+1}^* = E_t(p_{t+1}) + u_t$ with $E(u_t)=0$ and $var(u_t)= \sigma^2_u$

A small σ^2_u is important for accurate results. We assume for completeness that, due to observation errors,

(5.14) $p^{f*}_t = p^f_t + v_t$ with $E(v_t)=0$ and $var(v_t)= \sigma^2_v$

we determine a_o and a_1 in (5.12) from their estimated values, a'_o and a'_1, in (5.15). But we cannot determine unbiased estimates of a_o and a_1. Therefore, we follow a standard approach which is aimed at bounding the estimates a'_o and a'_1 by solving the system made of the two following equations

(5.15) $p^{f*}_t = a_o + a_1.p^*_{t+1} + z_t$ (OLS : Ordinary Least Squares)

(5.16) $p^*_{t+1} = b_o + b_1.p^{f*}_t + w_t$ (RLS : Reverse Least Squares)

and by comparing evaluation of the coefficients. We assume that z_t and w_t have zero mean and variance σ^2_z and σ^2_w respectively and that they are both mutually uncorrelated and uncorrelated with the systematic parts, i.e. p^*_{t+1} and p^{f*}_t respectively. This system provides boundaries for a_o and a_1. b_o and b_1 are the parameters of the RLS with b'_o and b'_1 their estimated values. Estimates a'_o and a'_1 have the following properties which are derived from classical models in most econometrics books (Maddala, 1987, pp 292).

$$\text{(5.17)} \quad \text{Plim } (a'_o) = a_o + \frac{a_1.\text{Var}(u)}{\text{Var}(E) + \text{Var}(u)}.E^-$$

$$\text{(5.18)} \quad \text{Plim } (a'_1) = a_1 - \frac{a_1.\text{Var}(u)}{\text{Var}(E) + \text{Var}(u)}$$

and it can be shown that (Intriligator, 1978, pp 190)

$$\text{(5.19)} \quad \text{Plim } (a''_o) = \frac{-\text{Plim}(b'_o)}{\text{Plim}(b'_1)} = a_o - \frac{\text{Var}(e) + \text{Var}(v)}{a_1.\text{Var}(E)}.E^-$$

$$\text{(5.20)} \quad \text{Plim } (a''_1) = \frac{1}{\text{Plim}(b'_1)} = a_1 + \frac{\text{Var}(e) + \text{Var}(v)}{a_1.\text{Var}(E)}$$

where E^- and Var(E) are the mean and variance of $E_t(p_{t+1})$ respectively. a'_1 and a''_o tend to asymptotically underestimate a_1 and a_o respectively, and a'_o and a''_1 overestimate them. Parameter bounds determined are strictly valid for null hypothesis tests for large samples. In the case of smaller samples, convergence of parameter estimates towards the real parameter only occur in expected value. We may assume that var(e) and var(v) are both relatively small which tends to link the range of parameter bounds to the values of var(u). A more accurate proxy p^*_{t+1}, in the sense of lower var(u), shrinks the bounds and gives a more powerful test.

Conventional tests for risk premium use p_{t+1} as a proxy for $E_t(p_{t+1})$ and, even with the correction of the errors-in-variables, generally support the null hypothesis of zero risk premium. However, Jacobs (1982) found evidence of risk premium by using a proxy obtained by an ARMA (1,1) model. We choose to use two other proxies of agents' expectations of the market price at t+1. The first one is based on forward prices while the second one is derived from SARIMA models. The SARIMA models used here are similar to the models shown in Chapter 2 and refer to the modelling of the price gap between the market price and the EC intervention price. The quality of an estimate of spot price expectation depends on the values of u^2_t or $(\text{proxy}-E_t(p_{t+1}))^2$. These bounds provide a useful test only if they are significantly different from the null hypothesis. The method establishes

bounds for the evaluation of a_o and a_1 but does not give any precise value of the bias (if any).[96]

To get a precise estimate of these parameters, we also implement an "Instrumental Variables" method. We use Wald's grouping method (1940). This method, so-called the "Two-group method", can be viewed as a special case of the application of the method of "Instrumental Variables". It can provide, for large samples, a consistent and better estimate of the coefficients a_o and a_1 as long as a suitable instrument can be found, i.e. an instrumental variable uncorrelated with the error term (here the error between $E_t(p_{t+1})$ and the proxy) but correlated with $E_t(p_{t+1})$. However note that variance of the coefficients obtained by this method is not minimised. We may rank the p^*_{t+1} and the p^{f*}_t by splitting each sample into two groups over the median. Then

(5.21) $a_1' = (p^{f*}_{t,2} - p^{f*}_{t,1}) / (p^*_{t+1,2} - p^*_{t+1,1})$

with $p^{f*}_{t,1}$, $p^*_{t+1,1}$ and $p^{f*}_{t,2}$, $p^*_{t+1,2}$ the means of the two lower and higher groups respectively. This amounts to using the instrument variable Z_i with $Z_i = 1$ if p^*_{t+1} (or p^{f*}_t) is superior to the median and $Z_i = -1$ if p^*_{t+1} (or p^{f*}_t) is inferior to the median, and calculating the estimator $a'_1 = [\Sigma p^{f*}_{t,i} \cdot Z_i / \Sigma p^*_{t+1,i} \cdot Z_i]$. Leamer (1978) has shown that if the OLS, RLS and Instrumental Variables estimates of a_1 have the same sign then the Instrumental Variables estimates is the maximum likelihood estimate of a_1, provided that it satisfies the parameter bounds obtained by OLS and RLS regressions. The median value can otherwise be taken as the maximum likelihood in the opposite case.

We test the existence and the size of the risk premium by varying the length of the time periods analysed. We may expect a positive link between the size of the risk premium and the length of the hedge, because of the greater risk and the thinness of trade involved in long hedge (with respect to time). However, we should recall that these results may be due to differences between the forecasting method used and the real expectations of market agents and are thus conditional on these forecasting methods. The foregoing methodology should elucidate the existence of the bias. We must now try to analyse its structure.

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[96] Conventional tests for risk premium have used non-overlapping data in order to avoid serial correlation problems, but at the sacrifice of efficiency derived from the observations left unused in the process. In our study of risk premium analysis based on monthly data, a certain number of data are to be lost under the hypothesis of a strict OLS regression. An estimation technique has been set up by Hansen and Hodrick (1980) in order to integrate all available information (in particular overlapping data).

5.4.2.2 Methodology for the identification of premium models

We can analyze the risk premium as the difference $P_{t,n}$[97], equal to $[p^f_t - E(p_{t+n})]$[98], with P_{t+n} the spot price at t+n and p^f_t the futures price at t for t+n maturity. We examine whether it is possible to determine a modelling process in this difference in order to achieve efficient forecasts. The determination of a pattern in the risk premium is realized by extracting an ARMA model to represent the premium process. If this model can be established, traders are able to anticipate the premium value. If we start from the definition of $P_{t,n}$, we have the following equation,

(5.22) $p^f_t = E(p_{t+n}) + P_{t,n}$

As we do not know how agents form their expectations, we propose to use two expectations models : the first one, and the easiest, is the Full Information Rational Expectation Model (FIREM hereafter) as described above. The second one is based on forward prices and satisfies the equation $E(p_{t+n}) = P^F_{t,n} + j_t$ where j_t is an uncorrelated and zero-mean process. In the following, we use the FIREM in the description of our methodology but the same description could have been undertaken with forward prices proxy of $E(p_{t+n})$.

If we subtract p_{t+n} from both sides of the definition of $P_{t,n}$, we obtain the following

(5.23) $D_{t,n} = p^f_t - p_{t+n} = P_{t,n} + w_{t+n}$

where $w_{t+n} = (E(p_{t+n}) - p_{t+n})$ with $Cov(w_t;w_{t+i})=0$ if i#0 and with (i>n) and σ^2 if i=0, and $E(w_t)=0$.

If we specify an ARMA(n',n") model for $P_{t,n}$, then we obtain

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[97] $P_{t,n}$ can be described as the difference between the forecast error of the futures market and the forecast error of agricultural agents. $P_{t,n} = [p^f_t - p_{t+n}] - [E(p_{t+n}) - p_{t+n}]$, with $[p^f_t - p_{t+n}]$ as the error of price determination of the futures market and $[E(p_{t+n}) - p_{t+n}]$ the forecast error of agricultural agents. We can also express the variance of $P_{t,n}$ by
$Var(P_{t,n}) = Var[p^f_t - p_{t+n}] + Var[E(p_{t+n}) - p_{t+n}] - 2.Cov([p^f_t - p_{t+n}];[E(p_{t+n}) - p_{t+n}])$
There exists a trade-off between the accuracy ability of these two entities. If agents on the spot market and the futures market bias their forecasts in the same direction, then the impact on the risk premium is null or limited. The latter exists when agents' expectations are not fully reflected in the futures price.

[98] This approach has also been adopted by Wolff (1987) in his study on premia for forward foreign exchange rates.

$$(5.24)\quad P_{t,n} = \phi_1.P_{t-1,n} + \phi_2.P_{t-2,n} + \ldots + \phi_{n'}.P_{t-n',n} + \Phi_1.\epsilon_{t-1} + \Phi_2.\epsilon_{t-2} + \ldots + \Phi_{n''}.\epsilon_{n''}$$

and hence from (5.23) we derive

$$(5.25)\quad D_{t,n} = \phi_1.D_{t-1,n} + \phi_1.w_{t+n-1} + \phi_2.D_{t-2,n} + \phi_2.w_{t+n-2} + \ldots + \phi_{n'}.D_{t-n',n} + \phi_{n'}.w_{t+n-n'} + \Phi_1.\epsilon_{t-1} + \Phi_2.\epsilon_{t-2} + \ldots + \Phi_{n''}.\epsilon_{n''}$$

with $[\epsilon_t]$ a sequence of normal independent random variables $(0,\sigma^2_\epsilon)$, then with B, backward shift operator,

$$(5.26)\quad D_{t,n}.(1 - \phi_1B - \phi_2B^2 - \ldots - \phi_{n'}B^{n'}) = w_{t+n}.(1 + \Phi_1B + \Phi_2B^2 + \ldots + \Phi_{n'}B^{n'}) + \epsilon_t.(1 + \Phi_1B + \Phi_2B^2 + \ldots + \Phi_{n''}B^{n''})$$

Thus an ARMA (n',n*) with $n^* = \text{Max}(n',n'')$ to represent $D_{t,n}$ is consistent with an ARMA (n',n'') or ARMA (n',n') for $P_{t,n}$[99]. We define an ARMA model for each risk premium time series on a twelve-year initial sampling period for four lag lengths of one, three, six and nine months. Forecasts are then undertaken and we test by the RMSE statistical parameter whether any efficient prediction of the risk premium can be realized.

5.4.3 Data

The linear regression analysis is undertaken with a one-, two- and three-month lag with realized and forecast data and over two sets of data. The first set refers to monthly data (average of Friday closing prices) from 1974/75 to 1988/89 with realized data and forecast data. The second set deals with the period 1982/83 to 1986/87 and only considers the closing price of the first Friday of the month. It also uses realized data and forecasts derived from SARIMA prices and forward prices.

The second method uses monthly averages from 1975 to 1989 in order to use a long time series. Forward prices, for lags up to two months, and realized data are used as proxies. SARIMA model-based proxies cannot be used in the analysis given the short time series available.

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[99] Ansley, Spivey, and Wrobleski (1977) state that the summation of two uncorrelated moving average processes of orders n' and n'' has a moving average representation of n* where n* is $\leq$ Max(n',n'').

5.4.4 Results

5.4.4.1 Linear regression method

Table 5.7 displays evidence of risk premium during the 1980/81 to 1988/89 period for a two-month lag and with forward prices used as proxies for the expected future spot price. Proxies based on forward prices narrow the variances of coefficients and then the parameters bounds to make all coefficient regression parameters significant for a two month-lag and during the 1980/81 to 1988/89 period while there were not all significant with realized data.

While with realized data we have been unable to detect a difference in the risk premium assessment between the time period before and after 1980, the use of forward price as proxy for agents' expectations of the future spot price gives a significant Chow test (of 5.59 when the tabulated value is $F_{2,77} = 3.07$ at 5%). The use of forward price allows us to have a more clear-cut assessment of the risk premium existence.

Table 5.8 shows that by using a different set of data, supposedly more precise, on a shorter time period, we obtain results which only partly confirm the existence of risk premium for a two-month lag period. Evidence of risk premium is only found with SARIMA-models based proxies and not with realized data nor with forward prices. Nevertheless this finding is not complete since the b'_1 coefficient is not significantly different from 1, preventing us from drawing a definite conclusion. SARIMA-models based proxies also allow the detection of a risk premium for a three-month lag but the significance of the two coefficient b'_0 and b'_1 relatively to the null hypothesis H_0 as well as the small size of the sample (14 data) prevent us from reaching any significant conclusion. An F-test to determine if the lower bound, established by the OLS regression, is significantly different from the zero risk premium values confirms these results in Tables 5.7 and 5.8 at the 5% level of significance.

Table 5.7 Risk Premium Assessment* by linear regression with monthly data from 1974/75 to 1988/89.

1974/75 to 1988/89	$p^{f*}_t = a_o + a_1.p^*_{t+1} + e_t$					$p^*_{t+1} = b_o + b_1.p^{f*}_t + w_t$	
	Direct Regression			Deducted from Reverse Regression		Reverse Regression+	
	a'_o	a'_1	F_{Ho}	a''_o	a''_1	b'_o	b'_1
With realized price as proxy for the expected future spot price#							
One-month lag (81)w	.492 (.35)	.988 (-.83)	.01	-.964	1.004	.961 (.69)	.996 (-.23)
Two-month lag (81)	7.169 (3.68)*	.933 (-3.51)*	6.77*	4.12	.963	-4.277 (-1.97)*	1.03 (1.79)
Three-month lag (44)	2.29 (.66)	.961 (-1.14)	.23	-2.55	1.010	2.52 (.73)	.989 (-.30)
With forward price-based forecast as proxy for the expected future spot price							
One-month lag (81)w	-1.06 (-.32)	1.005 (.17)	.01	-5.177	1.041	4.972 (1.61)	.935 (-1.45)
Two-month lag (81)	5.71 (1.04)	.951 (-4.81)*	15.4*	4.849	.959	-5.05 (-4.39)*	1.041 (3.778)*
Three-month lag (44)	-.33 (-.19)	1.001 (.05)	.11	-1.48	1.013	1.505 (.89)	.987 (-.76)
With forward price-based forecast as proxy for the expected future spot price, two-month lag							
1974/75 to 1979/80 (28)	2.38 (.96)	.992 (-.25)	.42	.397	1.017	-.39 (-.15)	.982 (-.55)
1980/81 to 1988/89 (53)	13.56 (6.37)*	.882 (-6.27)*	20.5*	11.26	.9025	-12.48 (-4.66)*	1.107 (4.58)*

Monthly data (average of Friday closing prices).

* All futures contracts (except for a three-month lag where only January, May and September futures contracts are considered); t values in brackets are Student tests of $H'_o : a_o$ or $b_o = 0$ and $H''_o : a_1$ or $b_1 = 1$. H_o is the F test of the joint hypothesis (a_o=0 and a_1=1).

+ Obtained by the relation $a''_o = -b'_o/b'_1$ and $a''_1 = 1/b'_1$.

** only from 1981/82 to 1988/89, data not available in 1979/80 and 1980/81.

w number of data.

Table 5.8 Risk Premium Assessment* by linear regression with monthly data from 1982/83 to 1986/87.

	$p^{f}_{o} = a_o + a_1 \cdot p^{*}_{1} + e_t$					$p^{*}_{1} = b_o + b_1 \cdot p^{f}_{o} + w_t$	
	Direct Regression			Deducted from Reverse Regression		Reverse Regression+	
	a'_o	a'_1	F_{Ho}	a''_o	a''_1	b'_o	b'_1
With realized price as proxy for the expected future spot price#							
One-month lag (30)q	7.504 (1.41)	.927 (-1.60)	.68	.491	.987	-.497 (-.08)	1.012 (.26)
Two-month lag (30)	10.69 (1.11)	.897 (-.15)	.65	-10.65	1.099	11.721 (1.21)	.909 (-1.09)
Three-month lag (14)	9.49 (.75)	.898 (-.93)	.42	-7.77	1.056	8.20 (.63)	.946 (-.46)
With SARIMA-models based forecast as proxy for the expected future spot price							
One-month lag (30)w	8.203 (.97)	.921 (-1.1)	.36	-7.391	1.084	8.523 (1.02)	.935 (-.89)
Two-month lag (30)	27.24 (2.86)*	.759 (-2.94)*	4.24*	-.234	.996	.235 (.02)	1.01 (.035)
Three-month lag (14)	29.73 (2.59)*	.729 (-2.71)*	4.11*	10.99	.893	-12.31 (-.70)	1.119 (.77)
With forward price-based forecast as proxy for the expected future spot price							
One-month lag (30)	-.810 (-.16)	.998 (-.04)	.05	-6.684	1.048	6.37 (1.35)	.953 (-1.14)
Two-month lag (30)	2.16 (.45)	.974 (-.63)	.09	-3.511	1.023	3.431 (.72)	.977 (-.54)
Three-month lag (14)	-6.31 (-.94)	1.047 (.84)	.48	-9.16	1.086	9.96 (1.70)	.920 (-1.54)

* All futures contracts (except for three-month lag where only January, May and September futures contracts are considered); t values in brackets are Student tests of $H'_o : a_o$ or $b_o = 0$ and $H''_o : a_1$ or $b_1 = 1$. H_o is the F test of the joint hypothesis (a_o=0 and a_1=1).

Friday closing price of the first week of the month considered.

+ Obtained by the relation $a''_o = -b'_o/b'_1$ and $a''_1 = 1/b'_1$.

q number of data.

Table 5.9 Ordinary Least Squares, Reverse Least Squares and Instrumental Variables estimates of a_1, from 1974/75 to 1988/89 with monthly data*.

Prices	OLS	IV	RLS
Realized prices			
One-month lag	.988	.996	1.004
Two-month lag	.933	1.026	.963
Three-month lag	.961	1.001	1.010
Forward prices			
One-month lag	1.005	1.059	1.041
Two-month lag	.951	.978	.959
Three-month lag	1.001	1.007	1.013

* The Maximum Likelihood is underlined.

Tables 5.9 and 5.10, with the Instrumental variables (IV) estimates, provide supporting evidence in the assessment of the a_1 coefficient. specially for the two-month lag for forward proxies, over the 1974/1989 time period, and SARIMA proxies, over the 1982/1987 period, and for the three-month lag for SARIMA proxies where it is well below 1. Evidence of existence of a risk premium is found with forward monthly data for the 1980/81 to 1988/89 time period while this was not totally clear with realized data. Use of forward prices as proxy displays a significant Chow test to show that this risk premium occurs during the 1980/81 to 1988/89 time period, i.e. when the CAP takes full effect on the wheat marketing in the UK.

As far as the three-month lag is concerned, no definite evidence of risk premium is found despite significant coefficients obtained in the OLS regression.

These results demonstrate that by using forward prices (or prices based on SARIMA models) as proxies for the expected future spot price we can detect the existence of a risk premium while this was not possible with realized data. This does not mean that realized data are a biased measure of $E_t(p_{t+1})$ but rather that its deviation from the $E_t(p_{t+1})$ real value is significantly greater than with forward prices.

Table 5.10 Ordinary Least Squares, Reverse Least Squares and Instrumental Variables estimates of a_1, from 1974/75 to 1988/89 with first Friday closing prices*.

Prices	OLS	IV	RLS
Realized prices			
One-month lag	.927	.968	.987
Two-month lag	.897	1.033	1.099
Three-month lag	.898	.991	1.056
SARIMA prices			
One-month lag	.921	1.046	1.084
Two-month lag	.759	.933	.996
Three-month lag	.729	.840	.893
Forward prices			
One-month lag	.998	.996	1.048
Two-month lag	.974	.976	1.023
Three-month lag	1.047	.968	.920

* The Maximum Likelihood is underlined.

Therefore, with these more accurate forecasts, in the deviation sense, and assuming that they represent market agents' expectations, we show the existence of a risk premium for a two-month lag futures trade during the time period 1980/88. This risk premium may be due to institutionally-derived market uncertainty arising in response to an overproduction situation on the British wheat market and a greater reliance of market operators on the EC wheat regime and its administrative management.

5.4.4.2 Premium models

Statistical characteristics and Figures relating the monthly series of the risk premium are displayed in Appendix 5-A.3. ARMA models developed to examine the structural pattern of the risk premium are given in Table 5.11. Forecast results obtained from these models are then presented in Table 5.12. RMSE (Root mean squared error) results are given along with the actual times series statistical characteristics.

Table 5.11 ARMA models[+] developed on the risk premium, defined as the difference between the futures price and the realized price from 01/1975 to 05/1987 for a two-, three-, six- and nine-month lag[100].

With realized prices as proxy of $E(P_{t+n})$	
Two-month lag	$D_{t,2} = (1 - 0.396B^7).a_t$ (3.24) R^2 Adj = 0.115 and X^2 (18,1) = 11.63
Three-month lag	$D_{t,3}.(1 - 0.365B^1) = a_t$ (3.38) R^2 Adj = 0.097 and X^2 (18,1) = 8.91
Six-month lag	$D_{t,6}.(1 - 0.365B^1 + 0.174B^2) = (1 - 0.815B^{15}).a_t$ (3.38) (-2.01) (-6.85) R^2 Adj = 0.542 and X^2 (18,3)= 10.78
Nine-month lag	$D_{t,9}.(1-B) = (1 - 0.303B^4 - 0.364B^6 + 0.423B^{13}).a_t$ (2.45) (3.67) (-2.21) R^2 Adj = 0.387 and X^2 (18,3) = 10.61
With forward prices as proxy of $E(p_{t+n})$	
Two-month lag	$D_{t,2} = (1 - 0.291B^7 + 0.391B^{12}).a_t$ (2.21) (-2.98) R^2 Adj = 0.127 and X^2 (18,2) = 10.70

[+] where a_t a white noise process (equivalent to $(w_{t+1} + \Phi_t)$ in our hypothesis).

While we could have expected a seasonality of five since we have five data per year, no clear seasonal structure is obtained (the July futures contract having been excluded because of its relatively recent existence). Series other than the one-month lag risk premium series show a distinct pattern, in particular the risk premium estimates for six- and nine-month lags (Table 5.11). No deterministic structure such as seasonality or trend in the risk premium, is detected. The lack of seasonality may be due to the large sample. The CAP seems to affect some futures contracts by creating risk at particular time. Over a long period, these effects cannot be highlighted but they may obstruct any "normally-existing" seasonal pattern.

Forecasts derived from these models nevertheless prove to be fairly poor. They suggest that most of the risk premium components follow a strict stochastic process and hence are very difficult to forecast with accuracy. Since we have pooled all the data, it becomes difficult to highlight a particular characteristic of the risk premium assessment which could potentially be derived from the EC wheat regime. Despite apparently interesting models

[100] No pattern has been extracted from the one-month lag risk premium time series (either from the realized data or forward prices data).

obtained from the six-month lag and the nine-month lag time series, no real forecasting performance has been achieved. The statistical parameter RMSE shows in Table 5.12 that, when compared to the mean and standard deviation of the price differential ($D_{t,n}$ in equation 5.23) during the last two seasons, our forecasts of the risk premium present a very poor accuracy.

Table 5.12 Root mean squared error of the risk premium forecast and time series characteristics of the risk premium in 1987/88 and 1988/89.

	Root mean squared error		Times series characteristics			
	1987/88	1988/89	1987/88		1988/89	
Realized data as proxy of the risk premium			Mean	Standard deviation	Mean	Standard deviation
Two-month lag	3.98	1.21	1.55	4.66	.71	1.15
Three-month lag	7.30	1.72	.22	8.34	-.93	1.28
Six month lag	5.11	9.97	.09	9.09	-1.88	3.82
Nine-month lag	5.51	5.97	-2.06	5.76	-3.48	3.23
Forward prices as proxy for the risk premium						
Two-month lag	4.88	1.90	.06	5.13	.72	1.87

Note that the analysis is subject to the initial hypothesis that W_t is an uncorrelated white noise process. If we had perfect knowledge of $E(p_{t+n})$, w_{t+n} would be a "white noise" process and we would be able to assert that the ARMA structure extracted from $D_{t,n} = (P_{t,n} + w_{t+n})$ is only derived from the $P_{t,n}$ process and fully represents the modelling of the risk premium. In the analysis we rely on the assumption that w_{t+n} is a white noise process and thus we cannot be totally sure that the ARMA process fully represents $P_{t,n}$. Especially in the case of six- and nine-month lag, the equivalence between $E(p_{t+n})$ and p_{t+n} may be questioned, thus leading to some potential distortion in the extracted ARMA models. This problem is identical to the extraction of a "signal" contaminated by a "noise". The reconstruction of the "signal" is often called "smoothing" or "filtering" and its prediction referred to as "filtering". Such a path was followed by Wolf (1987) when he used a Kalman filter.

5.5 Conclusion

The aim of this chapter is to test the third sub-hypothesis of the thesis which states that the CAP has affected the pricing performance of the London wheat futures market. The test of this sub-hypothesis takes place at two different levels. A short-term approach considers the informational efficiency (in Fama sense), while a long-term perspective is concerned with the forecasting performance of the market and the existence of a risk premium.

Evidence is found that some futures contracts display informational inefficiency. Deviation from the market efficiency hypothesis is particularly strong during the 1983 and 1986/88 time periods. The wheat futures market appears to be a fairly efficient forecasting mechanism. However some futures contracts, namely the July and November contracts, seem to show some deficiencies in their forecasting performance over the 1980/88 period. Such results are confirmed by a second set of data based on Friday closing prices. When compared to other forecasting methods the London wheat futures market seems to perform well. Nevertheless it is outperformed by the forward market. This may reflect the futures market's lack of liquidity and volume of trade relative to that of the forward market.

Evidence of the existence of a risk premium is found during the 1980/88 period for a two-month lag and when the forward price is used as proxy for the expected spot price. Investigation and search for a modelling process in the risk premium, using an extraction approach, on which premium forecast could be built, gives poor results.

These results suggest that the EC wheat regime, by increasingly strengthening its grip over the marketing of wheat in the UK, has played a certain role in the pricing performance of the London wheat futures market. Findings from the investigations of informational efficiency and forecasting performance may reflect the influence of these institutional factors and illustrate the way in which the CAP has affected the futures market pricing performance. The presence of an institutionally-derived price risk may be responsible for the emergence of a risk premium paid by hedgers to speculators as a reward for bearing this risk.

The London wheat futures market appears efficiently to perform its pricing function, despite exhibiting some time-specific deficiencies. These do not give strong support to the third sub-hypothesis of the thesis.

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CHAPTER 6

Analysis of the informational role of the London wheat futures market

6.1 Introduction

Chapter six focuses on the informational role of the wheat futures market in the price formation process. The knowledge and the understanding of the interactions between agricultural markets and their individual performance as far as their information collection, processing and dissemination functions are concerned, are of interest for many operators in the EC wheat chain. We may expect that these functions have been weakened and so have become less relevant in the current working of EC wheat markets due to the implementation of the EC wheat regime.

While the validity of this assertion is straightforward when dealing with spot and forward markets, little evidence (apart from van Dijk and Mackel, 1983) exists concerning the informational dynamics of the London wheat futures market within a grain commodity markets system. Analysis of the wheat markets system operating in the EC, composed by the spot, forward and futures markets and using causality tests, allows the testing of the fourth sub-hypothesis of the study (section 1.6) which states that the annual price-fixing and the implementation of institutional prices have affected the informational role of the futures market. The theoretical background is given in the first part of the chapter where an introduction to informational analysis and to the concept of causality is discussed and literature reviewed. Characterization and detection of causality and empirical investigation are then considered in the second and third part of this chapter respectively. A summary of findings and their degree of support to the fourth sub-hypothesis are presented in the last part of the chapter.

6.2 Theoretical background

6.2.1 Informational analysis of futures markets

Changes in price occur in response to individual agents' behaviour. They seek to reflect all available information so as to achieve informational efficiency, as defined in Chapter 5. While Chapter 5 focuses on the degree to which futures prices are determined by all information collected, the speed with which prices incorporate and disseminate information is considered here. Grossman and Stiglitz (1980) claim in their impossibility theorem that a static equilibrium analysis is not relevant in the analysis of futures markets' price formation activities. Examining the link between the conveying of information and the informational efficiency of markets, they argue that speculative markets can only exist if such markets are not informationally efficient. Indeed if the price conveys all the information that informed traders collect, then other traders can obtain this information freely by just looking at the price development. Yet, their argument ignores time as an essential dimension of futures markets. Without the abstraction of time, informed traders would have been able to gain from their information during the short period of time in which that information is not publicly known. It thus implies that futures markets cannot be informationally efficient at every point in time. Inefficiency, in this view, is part of the process of discovery and communication of information.

Both the informational quality of prices and the speed at which beliefs and underlying information are disseminated are determined by the competition for an informational monopoly. Streit (1983) asserts that "inefficiency from a static point of view reflects in a competitive market the generated incentives that are the sources of its dynamic efficiency" (pp 10). Information collection and dissemination are two informational functions of futures markets. Futures markets have to find an equilibrium between the information premium and their erosion through competition to achieve these two functions. Indeed, this dynamic inefficiency can be interpreted as a deviation from Pareto optimality under a static approach (Grossman, 1976 and Fliglewski, 1978). Given the wider concept of market efficiency, balance has to be reached in a general framework. The appropriate degree of competition is rather complex to estimate by empirical means. Analytical assessment is made difficult by several factors. The inadequacy of available data and the inference between observable data

and the unobservable expectations of traders are difficult to deal with analytically.[101]

6.2.2 Analysis of a system of commodity markets

This investigation of a system of commodity markets seeks to assess the informational relationship between distinct markets. Study of the lag/lead structure of this dynamic relationship is of major importance for trading operators. Indeed it gives empirical answers to whether prices quoted on one market can provide redundant information or can be used in the determination of price forecasts relative to other markets and whether any profit opportunity may arise from examination of this structure. Using a theoretical model, Stein (1961) showed that futures and cash prices for a given commodity are determined simultaneously. Yet Brorsen et al. (1984) argued that prices generated in one market might lead those in the other. Futures markets, due to their central organization and their (theoretically derived) greater liquidity, might be expected to lead spot and forward prices in reflecting and generating new information. This argument relies upon several concepts: transaction cost, access to the market, market information and restriction on borrowing or short selling. If the information was identical across markets we would expect simultaneous price generation. However, due to their size futures markets may be thought to have lower transaction costs than the spot and forward markets. Access to the market is easier and trade facilities are also greater in futures markets than in the two other markets. Short selling in the wheat spot or forward market may be more difficult as compared with the wheat futures market, at least for the reason of limited physical supply. Price speculation based on informational advantage is more difficult on spot market or on forward market than on futures markets due to the physical burden of owning the grain itself. Yet the London wheat futures market, in which there is a particularly high degree of physical delivery and which operates in a specific environment, may offer distinct characteristics and its study must take account of some specific features which might also influence wheat markets interactions. EC national markets are mainly influenced by domestic market conditions of supply and demand, the EC regime which fixes institutional prices, the intervention system policy* and the external trade policies, and the world market conditions of supply and demand. Relationships between wheat markets operating under free-market conditions may be expected to differ significantly from those found between EC markets. The volume of trade on the London wheat futures market is not as large as that on the forward market. Likewise,

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[101] On this point, the method developed by Friedman, Harrison and Salmon (1983) seems to be of most interest since it enables the isolation of the individual influences of traders.

* Note should be done that the quality specifications of the futures and intervention contracts are very similar and do not distort the relationship between spot markets and the futures market.

transaction cost on the futures market may not be expected to be lower than on the forward market. Nevertheless, the transaction cost element need not systematically lead to a formal lead/lag ranking between markets. Access to these markets is also an important feature of price discovery and agents in the market for information might be more willing to operate on the futures market.

The supply of arbitrage service between markets is of major importance. If such service is very elastic, prices will tend to be generated simultaneously in all markets (Garbade and Silber, 1981). For non-UK markets, we may suspect a rather inelastic supply of arbitrage on the London futures market given the relative isolation of EC national wheat markets. An arbitrage condition[102], described below, links the three markets:

(6.1) $Basis_t = P^f_t - P_t$ = Carrying cost between t and t+1

with P^f_t = futures price at t for t+1 and P_t = spot price at t. The basis, for a storable commodity and under pure competition, equals the carrying charge from t to t+1. This carrying cost is assumed to reflect the cost of storage (physical and financial costs), the convenience yield and the cost of bearing the commodity price risk. The presence of infinite supply of arbitrage services leads to a perfect equality between the basis and the cost of carry. Should the basis exceed the carrying cost, a profit opportunity will exist such that an arbitrageur can buy the cash commodity and simultaneously sell the futures contract. Holding the cash commodity until t+1, he will incur the carrying cost but the latter will be more than offset by the futures price. Likewise spatial arbitrage between similar types of markets takes place so that, in a perfect market, prices do not differ by more than transfer costs (see Gupta and Mueller, 1982). This arbitrage relation that links the three markets may be difficult to exercise if some specific market conditions relative to access to the market and large transaction costs exist.

6.2.3 Literature Review

Analysis of the market system has often been carried out on agricultural markets but, for most of these studies, has been limited to the examination of the relationship between spot markets. Indeed, few (apart from Ng, 1987, Oellermann and Farris, 1985 and Laatsch and

[102] Note that this arbitrage condition is a simplification and this relationship is more formally presented by Galbarde and Silber (1983, pp 290).

Schwarz, 1988) have analyzed a markets system involving a spot, forward and futures markets. The literature review has been reviewed in various studies: meat price formation (van Dijk, 1980), the changes in the grain markets due to the entry of the UK in the EEC (van Dijk and Mackel, 1983), the pricing efficiency in spatial markets for slaughter hogs (Gupta and Mueller, 1982), the relationship between farm, wholesale and retail prices (Miller, 1979), price quotes for eggs (Bessler and Schrader, 1980), the international soyabean meal market (Cordier, 1982), rice import prices (Brorsen et al., 1984), causality tests in livestock markets (Bessler and Brandt, 1982,1983), wheat acreage allotments and finally acreage supply response (Weaver, 1980). Most of these studies have used the Pierce and Haugh and Sims procedure for causality testing.

6.2.4 The concept of causality

Following Wiener's suggestion (1956), Granger (1969) introduced a formalization of the concept of "causality" in a time series. A time series $\{X_t\}$ "Granger causes" another time series $\{Y_t\}$ if present Y_t can be better predicted using past values of X_t than not by doing so, other relevant information (including past values of Y_t) being used in either case. Since we wish to know whether futures price changes can detect or predict future spot price and future forward price changes, this Granger test appears to be relevant and well-suited for our purpose.

Following Granger's definition, we may define three types of causal situations. If we adopt the following:

. A_t is the set of all relevant information at time t (including $\{X_t\}$ and $\{Y_t\}$)
. $A^{**}_t = \{A_s / s<=t\}$
. $A^{*}_t = \{A_s / s<t\}$
. X_t, Y_t are the values of $\{X_t\}$ and $\{Y_t\}$ and X^{*}_t, X^{**}_t, Y^{*}_t, Y^{**}_t similarly defined.
. Var (Y_t/Z_t) is the variance of the forecast error of the optimum and unbiased least-squared predictor of Y_t, conditional on the Z_t information set.

1. Y causes X : $\text{Var}\,(X_t / A^{*}_t) < \text{Var}\,(X_t / A^{*}_t - Y^{*}_t)$
and Y causes X instantaneously : $\text{Var}\,(X_t / A^{*}_t, Y^{**}_t) < \text{Var}\,(X_t / A^{*}_t)$

2. Feedback or bidirectional movement; that is when X causes Y and Y causes X :

$\text{Var}(Y_t / A^*_t) < \text{Var}(Y_t / A^*_t - X^*_t)$ and $\text{Var}(X_t / A^*_t) < \text{Var}(X_t / A^*_t - Y^*_t)$

3. Independence or neither causes the other

$\text{Var}(X_t / A^*_t, Y^{**}_t) = \text{Var}(X_t / A^*_t) = \text{Var}(X_t / A^*_t - Y^*_t)$

and

$\text{Var}(Y_t / A^*_t + X^{**}_t) = \text{Var}(Y_t / A^*_t) = \text{Var}(Y_t / A^*_t - X^*_t)$

We must emphasize that Granger causality is defined with respect to a specific information set : therefore, the exclusion of one variable can lead to spurious conclusions on causality. This problem has been examined by Skoog (1976), Hsiao (1982) and Lutkepohl (1982). These definitions of causality have been criticized (Zellner, 1978 and 1979) mainly because they differ from the usual philosophical definition of causality. Nevertheless under certain restrictions and simplifying assumptions, they do offer an empirically testable definition which has been useful in econometric modelling (Geweke, 1980). Granger causality refers more to the concept of predictability since it is based on the criterion of the incremental predictability and hence on the "usefulness" of one series $\{X_t\}$ to predict another series $\{Y_t\}$. Therefore X is said to cause Y if the series X_t contains information in its past values that is useful in the prediction of Y_t, and if this information is contained in no other series that is being used to predict Y_t. To assess the "usefulness" of $\{X_t\}$ in the prediction of $\{Y_t\}$, Granger's proposal was to assess whether the variance of the predictive error is reduced when past X_t is used in the prediction of Y_t. Pierce and Haugh (1977) have applied the criterion of the mean squared error.

Critics of Granger's concept argue that the test of causality does not measure the strength of the relationship but just classifies it. Blank (1987, pp 307) argues that "a negative result in a Granger causality test may be used to argue that the relevant variables are not causally related, but a positive result is not sufficient evidence of a causal ordering".

6.3 Characterization and detection of causality

There exist different approaches to the testing of causality. These tests can be classified according to the dimension of the analysis. The first type of tests relates the univariate estimation of the dynamic relationship between two variables and includes the Pierce and Haugh test (1977), Sims test (1972) and Geweke test (1980). The second type of test considers a dynamic multivariate approach exemplified by Tiao and Box (1981).

6.3.1 The Pierce and Haugh causality test (or Q test)

This test was first suggested by Haugh (1972) and subsequently applied by Pierce (1977) to the relationship between money and interest rates. The test entails fitting a univariate model to each time series $\{X_t\}$ and $\{Y_t\}$ and calculating the cross-correlation function of the univariate innovation[103] of the two series. Presence of serial correlation in the series may inflate the variance of the cross-correlation estimates and hence the statistical significance of the estimates.

The first step of the Haugh method is aimed at whitening the series [104] by the Box and Jenkins (1970) methodology which estimates the adequate univariate ARMA model to each series. We then get a purely stochastic time series. If we suppose that the time series X_t and Y_t have the univariate autoregressive representations

(6.2) $a.(B).X_t = x_t$ and $a'.(B).Y_t = y_t$ respectively,

where B is the backshift operator such that $BX_t = X_{t-1}$ and $B^pX_t = X_{t-p}$.
x_t and y_t are the innovations for X_t and Y_t, respectively, with finite variances $E(x^2_t) = Var(x_t)$ and $E(y^2_t) = Var(y_t)$. We define $r_{xy}(k)$, which denotes cross-correlation with k lags (or leads), as

(6.3) $r_{xy}(k) = [E(x_t;y_{t+k})/(E(x^2_t).E(y^2_t))^{1/2}]$

In the second step, these sample innovations are used to estimate the cross-correlations. From these results, and assuming that the ARMA representations are true and of finite order[105], we may draw inferences about population cross-correlations.

If x_t and y_t are the two estimated white noise levels of the sample price time series, the

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[103] The innovation of a time series refers to that part which cannot be explained in terms of its own past.

[104] As the optimum predictor of Y_t (or X_t) in Granger's definition is linear in the information set, we seek causality preserving whitening methods : they can be linear such as ordinary or seasonal differencing, or nonlinear such as logarithm or detrending (Pierce, 1977). Feige and Pearce (1979) and Gupta and Mueller (1982) claim that the use of particular filters can affect the results.

[105] Haugh (1972) has shown that under the null hypothesis that x_t and y_t (the whitened series) are not causally related, the residual cross-correlations from the ARMA filter have the same asymptotic distribution as the white noise cross-correlations of the true two filters.

Haugh test suggests that, under the null hypothesis of no causality, the cross-correlations are asymptotically independently and normally distributed with mean zero and variance 1/N (N denoting the number of observations).
Then, the statistic S, defined by [106]

(6.4) $S = N \cdot \Sigma^{P}_{k=-q} r^2_{xy}(k)$

is asymptotically distributed as X^2 with (p+q+1) degrees of freedom (Haugh, 1972); p and q are chosen large enough in order to include coefficients which could be expected to be statistically different from zero. If S exceeds the critical $X^2_{95\%}$ (p+q+1) value, the hypothesis of independence is rejected. The use of the Haugh test is strictly valid as test of independence between series. Then, Pierce (1977) has modified it to include tests for the determination of the actual direction of causation. The test then takes the following form : the null hypothesis "X does not cause Y" can be tested against the hypothesis "X causes Y" by referring to the statistic S_1, defined as

(6.5) $S_1 = N \cdot \Sigma^{P}_{k=1} r^2_{xy}(k)$ with $p > 0$

to a $X^2_{95\%}$ distribution with p degrees of freedom (and vice versa for the null hypothesis "Y does not cause X"). If S_1 is inferior to $X^2_{95\%}$ (p), we accept the null hypothesis. To detect instantaneous causality between X_t and Y_t, we use only the statistic $S_2 = n.r^2_{xy}$ (0) in case of unidirectional causality (no feedback) from X_t and Y_t.

This test presents four main drawbacks. First, we need to specify m, the positive integer chosen, in the estimation. Second, we only obtain pairwise comparison and thirdly, the test interpretation is complex. Fourthly, results are conditional on the correct modelling of the ARMA. Nelson and Schwert (1982), Guilkey and Salemi (1982) and Geweke et al. (1983) showed that causality tests from univariate modelling are less powerful than the causality tests from multivariate modelling. Sims (1977) and Pierce and Haugh have pointed out the problem that, in some cases, the Pierce and Haugh test fails to reject the null hypothesis of series independence when it should reject it because of the series pre-filtering. In particular, when a one-way dependence has been found, this test tends to underestimate the level of

[106] For small samples, Haugh proposed the use of the modified S-statistic S^* defined as, $S^* = N^2.\Sigma^{P}_{k=-q} (N-|k|)^{-1} \cdot r^2_{xy}(k)$

significance for causality running in the other direction (feedback). We should also keep in mind that the results we can obtain are subject to the information set. Therefore, any omission of relevant variables can render any test spurious. We then turn to the second univariate test. Evidence obtained from Monte-Carlo studies has proved that the causality tests described below are more powerful than the Pierce and Haugh causality test.

6.3.2 Sims test

Another way of detecting the direction of causality is represented by the Sims causality test. Sims (1972) proposed tests of Fisherian type so as to test the null value of the a_j coefficients appearing in the following regression of $\{X_t\}$ on $\{Y_t\}$, with $j < 0$.

(6.6) $X_t = \Sigma^{p}_{j=-q} a_j.Y_{t-j} + e_t$ with Cov $(e_t;Y_{t-j})=0$ and $E(e_t)=0$

He argues that "X does not cause Y" if and only if a_j equals 0 whenever j is $<$ to 0. The determination whether "Y does not cause X" is carried out by an analogous regression. It seems, however, that autocorrelations of error terms e_t may lead to difficulties in the use of this test.

In the light of the presence of serial correlation in the above regression equation, Sims suggested pre-filtering the X and Y series so as to eliminate the serial correlation[107]. But Sims proposed a common pre-filter, a suggestion which may be difficult to apply in some circumstances.

From the Sims approach, we have three different tests:
1. If the entire set of regressors for past values only or for past and future values for either X_t or Y_t has coefficients significantly different from zero as a group, then there is dependence between X_t and Y_t prices.
2. If the future price values of either X_t or Y_t time series in the regression have coefficients as a group significantly different from zero, then there is unidirectional causality between X_t and Y_t.
3. If the estimated coefficients of the future values for either X_t or Y_t prices, are as large or larger than those of their corresponding past values, then there exists bidirectional causality,

[107] Gupta and Mueller (1982) applied the Hannan efficient estimation procedure.

in other words causality runs from X to Y and vice versa.

6.3.3 The Geweke test (or F test)

An alternative test has been suggested by Geweke (1980, pp 31-47), which uses Ordinary Least Squares regression (OLS) on the stationary price of the series. That is, to test causality between X_t and Y_t ("X_t causes Y_t"), we propose the following specification :

$$(6.7) \quad Y_t = a_o + \Sigma^p_{j=1} (a_j.Y_{t-j}) + e_t$$

$$(6.8) \quad Y_t = b_o + \Sigma^p_{j=1} (b_j.Y_{t-j}) + \Sigma^q_{k=1} (c_k.X_{t-k}) + e'_t$$

where e_t and e'_t are white noise residuals, and a_j, b_j, c_k coefficients parameters of the regressions.

Testing for Granger causality is then equivalent to testing the following null hypothesis, for all j, $c_j = 0$. This is done by calculating the statistic

$$(6.9) \quad F^* = [(SSE_1 - SSE_2)/q] / [(SSE_2)/(N-p-q-1)]$$

where SSE_1 and SSE_2 refer to the sum of squared errors from OLS regressions (6.7) and (6.8), and N the number of observations on Y_t. Under the null hypothesis, F^* is distributed as F with (q;N-p-q-1) degrees of freedom. If F^* is superior to F(q;N-p-q-1), then we reject the hypothesis that "X_t does not cause Y_t".

The use of equations (6.7) and (6.8) requires either the choice of values of p and q large enough to remove substantial autocorrelation in the regression residuals, or the application of generalized least squares. In the case of autocorrelation, the F statistic may be overestimated (Granger and Newbold, 1974). To identify lags or leads, the analyst must rely on "a priori" knowledge or use the mechanical methods of Akaike (1969).

6.3.4 Co-integration

The concept of co-integration has recently been developed by Granger (1986) and Engle and Granger (1987). It emphasises a "long-term" relationship, as opposed to "short-term" Granger causality relationship, which may exist between time series. This relationship takes the form

of a stationary linear combination between the time series which are then said to be co-integrated. Granger (1988) has shown that in the case of co-integrated time series, the usual causality tests can lead to spurious conclusions. For exposition purposes, the description of co-integration takes place below using the case of two series.

It is commonly accepted from Wold's theorem (1974) that a single stationary time series with no deterministic components has an infinite moving average representation which can generally be approximated by an ARMA process (Box-Jenkins, 1970). However, the need for differencing the time series in order to fulfil the assumption of stationarity leads us to the following definition. A series with no deterministic component is said to be integrated of order d, denoted x_t --- I(d), when it shows a stationary, invertible ARMA representation after differencing d times. If we consider x_t, y_t two components of a vector X_t time series which are I(d), their linear combination will generally be I(d). This can be expressed by $z_t = x_t - a.y_t$, with z_t --- I(d). However, it is possible that z_t --- I(d-b) with b>0. We define co-integration between the two components x_t and y_t, denoted (x_t, y_t) -- CI(d,b) if :

. x_t and y_t are I(d)
. there exists a constant α (#0) so that
(6.10) $z_t = x_t - \alpha.y_t$ --- I(d-b)

with b > 0, the constant α is called the co-integrating constant. This definition can be extended to the vector X_t whose components are said to be co-integrated if

. they are all I(d)
. there exists a co-integrating vector α (different from 0) such as $z_t = \alpha'.X_t$ with z_t --- I(d-b) with b>0.

Engle and Granger (1987) argue that the (6.10) relation reflects a "long term" or "equilibrium" relationship between x_t and y_t which can be matched with the economic reality. z_t can be considered as a disequilibrium term which expresses a wandering path of the two series along their equilibrium state. Engle and Granger have developed the study first suggested by Granger (1981) on the relationship between co-integration and Error Correction Models (ECM). If we consider that x_t and y_t are I (1), they argue that, according to the Granger Representation Theorem, these series can be modelled under a general Error Correction Model :

$$(6.11) \quad \blacktriangle x_t = (\delta_1 . z_{t-1}) + (\Sigma_{i=1}^{q} a_i . \blacktriangle x_{t-i}) + (\Sigma_{j=1}^{n} b_j . \blacktriangle y_{t-j}) + d(L)V_{1t}$$

$$\blacktriangle y_t = (\delta_2 . z_{t-1}) + (\Sigma_{i=1}^{r} c_i . \blacktriangle x_{t-i}) + (\Sigma_{j=1}^{s} b_j . \blacktriangle y_{t-j}) + d(L)V_{2t}$$

where $|\delta_1| + |\delta_2| \neq 0$, d(L) is a finite polynomial in L, a lag operator, and V_{1t} and V_{2t} are two white noise processes. This bivariate presentation can be easily extended to the multivariate case.

According to the standard Granger causality definition, this system of error-correction models shows that $\blacktriangle x_t$ or $\blacktriangle y_t$ is caused by z_{t-1} which is in itself a function of x_{t-1} and y_{t-1}. From this, we can assert that if, x_t and y_t are co-integrated, x_t is Granger caused by y_{t-1} or/and y_t is caused by x_{t-1}. This causality expressed in the former system can come either from z_{t-1} if $\delta_1 \neq 0$ or $\delta_2 \neq 0$, or from the existence of lagged variables in these equations. Therefore to converge towards a long-term equilibrium, a Granger causality relationship should exist between two co-integrated variables. Analysis of co-integration seems to be a pre-requisite to any Granger causality study.

In order to test for co-integration, we use the Engle-Granger (1987) methodology which first investigates the integration order of each series and then undertakes unit root tests on residuals of OLS. The co-integration regression, i.e. a linear least squares regression of x_t and y_t, produces a good estimate of α. Three unit root tests are here investigated[108]:

. the Durbin-Watson test (CRDW)
. the Dickey-Fuller test (DF)
. the Augmented Dickey-Fuller test (ADF)

The Durbin-Watson test is similar to the standard test of Durbin-Watson (DW). If the residuals are non-stationary, the DW will approach 0. If the DW is high, then residuals are stationary and there is evidence of co-integration. Critical values for the CRDW test are shown in Engle and Ganger (1987), under the null hypothesis that data have a unit root (non-stationary).

The Dickey-Fuller test (DF) and the Augmented Dickey-Fuller test (ADF) are meant to test

[108] Engle and Granger propose seven test statistics (pp 266). The three tests examined here are recommended for their simplicity and their power properties (pp 269).

the order of integration of a time series. They consist of applying OLS to the following regression:

$$(6.12) \quad {}^{\blacktriangle d}x_t = ({}^{\blacktriangle d-1}x_{t-1}) + (\Sigma_{i=1}^{p} \beta_i \cdot {}^{\blacktriangle d}x_{t-i}) + u_t$$

with ${}^{\blacktriangle d}x_t = (1-L)^d x_t$ and u_t a white noise process $(0;\sigma^2_u)$

DF and ADF tests are tests of Student significance of coefficient α. They test the null hypothesis H_o that the series ${}^{\blacktriangle d}x_t$ has a unit root and is then stationary. Fuller (1976) has shown that under H_o, the t-ratio distribution of α does not follow a standard Student distribution. Critical values are given in Engle and Granger (1987). For DF tests, we use p equal to 1, while for ADF tests, p is taken large enough to take account of ${}^{\blacktriangle d}x_t$ autocorrelations. The ADF test is, according to Engle-Granger (1987), the recommended approach because it is the less sensible to sample size and it has good power properties.

6.3.5 Multivariate approach

The multivariate approach provides another way of assessing the speed and magnitude of dynamic process and transmission of information through the market price mechanism[109]. Together with the univariate approach, it gives a useful indication of the real causal relationship. The estimation of a system of market prices equations can be performed by a Three Stages Least Squares (3SLS) procedure. However, rank conditions are insufficient and make the use of this procedure impossible. Describing our system as a set of single equations might enable the use of OLS. However, OLS is inappropriate here since it assumes independent error terms and that all explanatory variables are exogenous. We choose, as Blank (1987) did, to use Zellner's method based on a Seemingly Unrelated Regressions models (SUR). This method is not limited by the rank conditions since no loss of variables is needed to estimate the system. The main difference between SUR and 3SLS is that the former method assumes that all explanatory variables are exogenous while the latter does not. This introduces a bias if predicted and actual values differ enough to alter the coefficients of the estimated explanatory variables. Nevertheless, we may argue that this bias is a trade-off for the dropping of variables which would have been needed should we use the 3SLS. An autoregressive multivariate model is performed for each market price series. The order

[109] Investigation of the dynamic multipliers values which express the impact of an exogenous shock occurring from the j th variable on the values of the i th variable at later time period can also be undertaken by using the Chow definition (1975).

is arbitrarily fixed at 56 and 12 lags in order to obtain a long- and a short-run estimation of the causal relationship. In the final system, all insignificant variables are removed.

6.4 Empirical Analysis

6.4.1 Data sets

The analysis considers four markets: the UK and French spot markets, the UK forward market and the London wheat futures market. Data are weekly price averages[110] for the spot and forward markets and Friday closing price of the nearby and next to nearby contract for the futures market[111]. We transform the series so as to work on logarithmic price changes by taking first differences of the natural logarithm of each price. Hence, we define

(6.13) $P^{i}_{t} = \ln(P^{i}_{t}) - \ln(P^{i}_{t-1})$ for spot prices, with i=1,2 for the UK and France respectively

$P^{fi}_{t} = \ln(P^{fi}_{t}) - \ln(P^{fi}_{t-1})$ i=1,2 for futures and forward prices, respectively.

French prices are adjusted by the MCA system (cf Chapter 2), i.e. they represent the French spot prices as they are perceived by British exporters to France. The time period covers the 08/1980-06/1988 period.

6.4.2 Modelling procedure and results

A linearly regular zero-mean covariance stationary five-vector stochastic process is postulated ($X = \{X_t; t \text{ in } Z\}$). That means that $E(X_t)$ exists and does not depend on t and, for all integers t and k, Cov (X_t, X_{t+k}) exists and depends only on k. By linearly regular,i.e. purely non-deterministic, we mean that the "best" (in the mean square sense) linear forecast of the infinitely removed future is the mean of the process. Examination of the integration

[110] Daily prices might have given a better picture of the real dynamic adjustment of prices across markets, giving that way a clearer description of the causality paths. This could be appropriate for a liquid commodity such as currency contracts where arbitrage supply is very elastic between markets and where even intra-daily data would be relevant. However, for the EC wheat market, we assume that weekly prices may provide evidence concerning the causality link between markets.

[111] Each futures contract is used until the beginning of the delivery period.

order of the five series takes place by differencing them to achieve stationarity[112].

6.4.2.1 Univariate Approach: the Pierce and Haugh test and the F test

After an examination of the time series plot, the univariate time series models are fitted for each price time series by the procedure developed by Box and Jenkins (1970) and reported in Table 6.1[113]. The Q test results shown in Tables 6.2 and 6.3 and, to a lesser degree, the F test results shown in Table 6.4 suggest that the role of the next to nearby futures price is of major importance, since this price seems to play the role of market leader of the markets system. The influence of the nearby futures price on the next to nearby futures price is null with the Q test and significant but strongly declining after seven weeks with the F test. The F test displays evidence of a strong influence of the nearby futures price on the forward price. The forward price leads the nearby futures price in the short-run, up to three weeks, whatever the test used. The Q test shows that the forward price also influences the UK spot price but not instantaneously. The F test and the Q test provides contradictory evidence about the relationship between the nearby futures price and the forward price. The UK spot price is led by all markets according to the F test and leads, for up to three weeks, the nearby futures price and the forward price. Bilateral tests show that all price series referring to the British market are very much related in the short-run (up to twelve weeks).

The Haugh test in Table 6.3 suggests that the French price, adjusted by the MCA system, leads the complete markets system. Yet, this influence mainly occurs in the short-run: up to three weeks with the nearby futures price, up to seven weeks for the next to nearby futures price and up to twelve weeks for the UK spot and forward prices. These results are supported by the F test in Table 6.4 apart from the relationship between the French spot price and the next to nearby futures price. Note the lack of instantaneous and bilateral dependence between series when the French spot price is involved. As opposed to the Q test findings, the UK spot price does not lead the French spot price while the UK forward price does in the short-run with the F test.

These results are summarized in Figure 6.1 for the Pierce and Haugh test and in Figure 6.2 for the Geweke test.

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[112] It should be noted that the stationarity of the 5 dimensions vector is not theoretically limited to the stationarity of each vector component. Nevertheless, it is generally the case in practice.

[113] For a detailed description of the methodology, refer to Chapter 2.

Table 6.1 SARIMA models of the five stationary price series constituting the wheat markets system over the 08/1980-06/1988 period.

Model 1 : FUT

$$(1-B).(1-B^{52}).Y_t = (1 + 0.62\ B^{52}).(1 + 0.15\ B^{1} - 0.13\ B^{8} + 0.25\ B^{53}).\epsilon_t$$
$$(-10.72) \quad (-2.72) \quad (2.63) \quad (-4.39)$$

R^2 Adj = 0.275
Sum of Squared Resid. = 0.133287
X^2 (4;60) = 38.58

Model 2 : FUTN

$$(1-B).(1-B^{52}).Y_t = (1 + 0.40\ B^{52}).(1 + 0.25\ B^{1} - 0.11\ B^{26} + 0.19\ B^{51}).\epsilon_t$$
$$(-7.20) \quad (-5.01) \quad (2.02) \quad (-3.30)$$

R^2 Adj = 0.174
Sum of Squared Resid. = 0.132136
X^2 (4;60) = 30.63

Model 3 : FORW

$$(1-B).(1-B^{52}).Y_t = (1 + 0.48\ B^{52}).(1 + 0.16\ B^{4} + 0.17\ B^{48} + 0.27\ B^{56}).\epsilon_t$$
$$(-8.22) \quad (-2.87) \quad (-3.05) \quad (-4.54)$$

R^2 Adj = 0.193
Sum of Squared Resid. = 0.191176
X^2 (4;60) = 33.70

Model 4 : SPOT

$$(1-B).(1-B^{52}).Y_t = (1 + 0.19\ B^{1} + 0.29\ B^{51} + 0.19\ B^{54}).\epsilon_t$$
$$(-3.65) \quad (-4.99) \quad (-3.27)$$

R^2 Adj = 0.106
Sum of Squared Resid. = 0.168941
X^2 (3;60) = 36.26

Model 5 : BLE - Time Period : 08/1980 to 06/1988 :

$$(1-B).Y_t = (1 + 0.15\ B^{1} + 0.12\ B^{2} + 0.15\ B^{32} - 0.27\ B^{52}).\epsilon_t$$
$$(-3.02) \quad (-2.47) \quad (-2.74) \quad (5.10)$$

R^2 Adj = 0.099
Sum of Squared Resid. = 0.300083
X^2 (4;60) = 58.28

FUT, FUTN, FORW, SPOT AND BLE denote respectively the stationary series of the nearby futures, the next to nearby futures, the UK forward, the UK spot and the French spot market, prices.

Table 6.2 Pierce and Haugh causality tests (or Q tests)

Q statistic:	RFUT,RFUTN			RFUT,RSPOT		
	lag	lead	Bilat.	lag	lead	Bilat.
lag: 1-3	9.23*	7.33	44.83*	8.42*	21.17*	34.48*
lag: 1-7	9.63	10.33	48.24*	13.27	45.27*	63.44*
lag:1-12	26.77*	14.17	69.21*	15.61	56.47*	76.98*
lag:1-36	50.59*	28.83	107.69*	27.33	70.28*	102.51*
lag:1-52	61.89	46.69	136.85*	55.01	87.68*	147.59*
lag:1-60	71.34	48.14	147.75*	57.69	93.91*	156.50*
Instant. Causality	28.27*			4.90*		

Q statistic:	RSPOT,RFORW			RFUT,RFORW		
	lag	lead	Bilat.	lag	lead	Bilat.
lag: 1-3	12.55*	12.63*	25.58*	8.22*	2.95	101.04*
lag: 1-7	31.64*	13.05	45.08*	12.91	10.75	113.52*
lag:1-12	38.57*	15.12	54.08*	13.81	14.42	118.09*
lag:1-36	52.86*	29.76	83.00	38.20	33.39	161.45*
lag:1-52	68.45	54.03	122.88	47.54	39.96	177.36*
lag:1-60	76.63	56.21	133.23	59.53	47.95	197.34*
Instant. Causality	.39			89.86*		

Q statistic:	RSPOT,RFUTN			RFUTN,RFORW		
	lag	lead	Bilat.	lag	lead	Bilat.
lag: 1-3	13.32*	5.33	25.46*	1.90	10.52*	22.29*
lag: 1-7	16.69*	7.49	31.00*	4.73	13.69	28.29*
lag:1-12	18.00	13.49	38.31*	6.55	31.34*	47.76*
lag:1-36	58.54*	29.99	95.35*	28.18	50.79*	88.84
lag:1-52	76.27*	68.89	151.97*	42.74	60.79	113.39
lag:1-60	79.09*	71.01*	156.92*	43.73	65.33	118.93
Instant. Causality	6.82*			9.87*		

Tabulated values of Q : Q(1) = 3.84 ; Q(3) = 7.81; Q(7) = 14.07 ;
Q(12) = 21.03; Q(15) = 25.00 ; Q(25) = 37.7 ; Q(36) = 50.66 ;
Q(52) = 69.49; Q(60) = 79.1 ; Q(73) = 93.59 ; Q(105) = 129.56 ;
Q(121) = 147.31;
* denotes significant coefficients at 5%.

RFUT, RFUTN, RFORW and RSPOT denote respectively innovation time series of nearby futures, next to nearby futures, forward and UK spot, prices.

Table 6.3 Pierce and Haugh causality tests (or Q tests)

	RBLE, RSPOT			RBLE, RFUT		
Q statistic :	Lag	Lead	Bilat.	Lag	Lead	Bilat.
lag: 1-3	9.59*	4.28	16.28*	2.45	11.06*	14.31*
lag: 1-7	14.75*	14.90*	32.07*	8.77	11.90	21.46
lag:1-12	17.34	22.22*	41.97*	10.88	15.10	26.77
lag:1-36	27.22	36.35	65.99	26.31	32.87	59.97
lag:1-52	44.98	53.27	100.67	59.48	48.97	109.24
lag:1-60	52.44	65.11	119.96	65.08	57.30	123.18
Instantaneous Causality	2.41			0.79		

	RBLE, RFUTN			RBLE, RFORW		
Q statistic :	Lag	Lead	Bilat.	Lag	Lead	Bilat.
lag: 1-3	1.94	12.82*	15.46*	5.56	9.85*	15.74*
lag: 1-7	8.17	12.91+	21.77	6.19	14.31*	20.82
lag:1-12	11.45	13.43	25.57	6.53	19.42+	26.28
lag:1-36	43.35	39.86	83.91	13.58	30.01	43.92
lag:1-52	59.16	69.26+	129.11+	31.27	59.48	91.07
lag:1-60	65.27	83.48	149.45*	45.50	67.55	113.38
Instantaneous Causality	0.69			0.32		

Tabulated values of Q :

Q(1) = 3.84 ; Q(3) = 7.81; Q(7) = 14.07 ; Q(12) = 21.03 ;
Q(15) = 25.00 ; Q(25) = 37.7 ; Q(36) = 50.66 ; Q(52) = 69.49;
Q(60) = 79.1 ; Q(73) = 93.59 ; Q(105) = 129.56 ; Q(121) = 147.31

* and + denote statistical significance at 5% and 10% respectively.

RFUT, RFUTN, RFORW, RSPOT and RBLE denote respectively residual time series of nearby futures, next to nearby futures, forward, UK and French spot, prices.

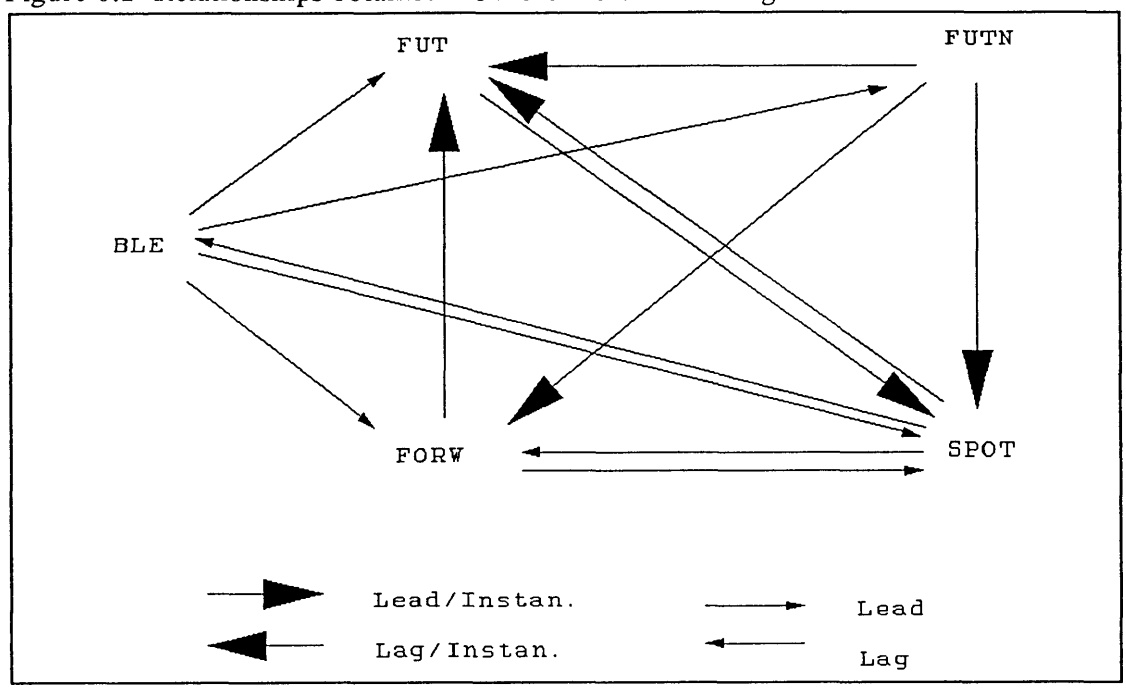
Table 6.4 Geweke causality tests (or F tests)

H_o hypothesis : B "Granger causes" A						
	3 lags		7 lags		12 lags	
A/B	Dir.	Inst.	Dir.	Inst.	Dir.	Inst.
Spot/Fut	9.37**	10.18**	11.97**	13.42**	10.03**	9.76**
Spot/Futn	6.00**	7.63*	3.47**	8.09**	2.72**	5.77*
Spot/Forw	4.97**	1.95	9.07**	6.50*	6.02**	6.13*
Fut/Spot	1.52	10.18**	1.88	13.42**	1.17	9.76**
Fut/Futn	3.18*	51.26**	1.92	49.41**	5.10**	50.70**
Fut/Forw	2.87*	132.55**	1.68	144.98**	0.87	146.37**
Futn/Forw	2.06	7.63**	1.54	8.09**	1.23	5.77*
Futn/Fut	4.42*	51.26**	2.14*	49.41**	1.45	50.70**
Futn/Forw	0.83	16.54**	0.66	18.60**	0.40	20.62**
Forw/Spot	2.24	1.95	1.85	6.50*	1.26	6.13*
Forw/Fut	6.11**	132.55**	6.07**	144.98**	4.66**	146.37**
Forw/Futn	6.57**	16.54**	4.11**	18.60*	6.74**	20.62**
Ble/Fut	0.69	0.32	0.82	0.24	0.46	0.26
Ble/Forw	3.83**	0.62	1.84	0.76	1.17	0.63
Ble/Spot	1.59	0.01	1.55	0.05	0.97	0.02
Ble/Futn	1.55	0.51	1.06	0.95	0.87	0.73
Fut/Ble	7.82**	0.32	3.79**	0.23	2.26**	0.26
Futn/Ble	1.04	0.51	0.74	0.95	0.68	1.02
Forw/Ble	5.18**	0.62	2.53*	0.76	1.76*	0.81
Spot/Ble	1.60	0.02	2.85**	0.05	2.36**	0.11

One-way test (5% / 1%): Tabulated values of F(q;N-p-q-1)
Three lags : F(3;349) = 2.60 / 3.78; Seven lags : F(7;337) = 2.01 / 2.64
Twelve lags: F(12;322) = 1.75 / 2.18
Instantaneous test: Tabulated values of F(1;N-p-q-2) are equal to 3.84 / 6.63 at (5% and 1%).
** and * denote statistical significance at 1% and 5%, respectively.

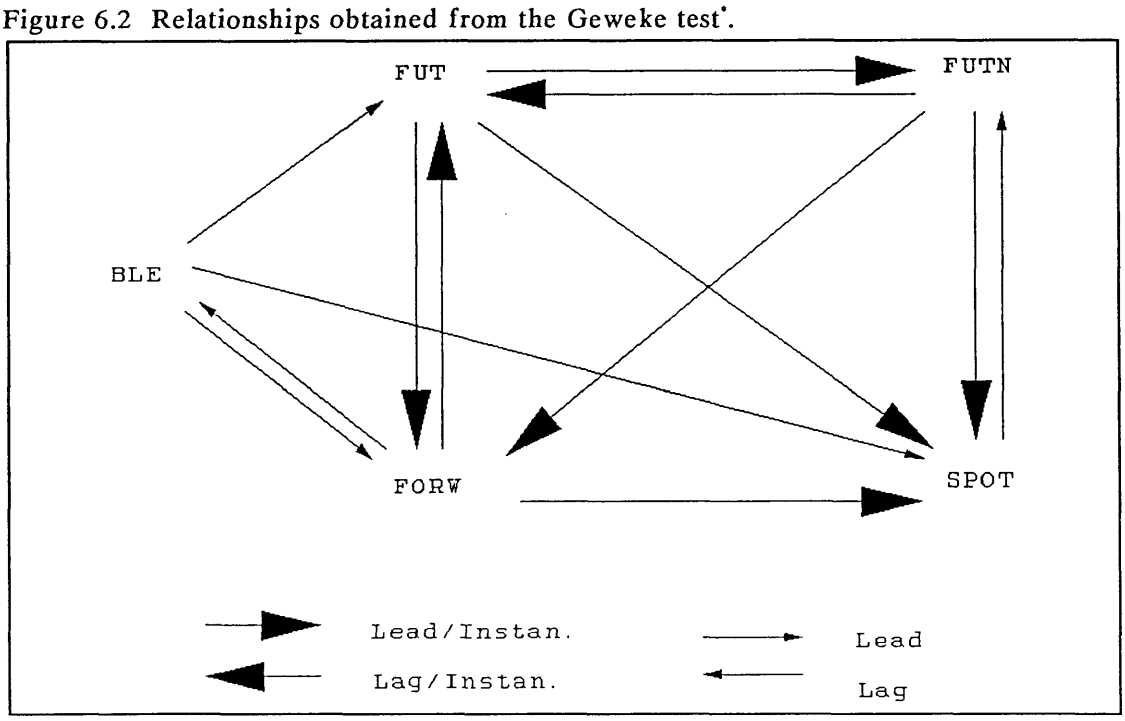
Fut, Futn, Forw, Spot and Ble denote the stationary time series of the nearby futures, the next to nearby futures, the forward, the UK spot and the French spot prices, respectively.

Figure 6.1 Relationships obtained from the Pierce and Haugh test*.



* Ble, Spot, Forw, Fut and Futn denote respectively the French spot price, the UK spot price, the UK forward price, the nearby futures price and the next to nearby futures price.

Figure 6.2 Relationships obtained from the Geweke test*.



* Ble, Spot, Forw, Fut and Futn denote respectively the French spot price, the UK spot price, the UK forward price, the nearby futures price and the next to nearby futures price.

6.4.2.2 Test of co-integration

Co-integration between price series is investigated within a system of two, three and finally four series. If evidence of co-integration is obtained, series fluctuations are modelled by an Error Correcting Model whose long term solution is the co-integration relationship found. We apply the system of equations (6.11), with a large enough backward operator, by removing insignificant lags.

The analysis of co-integration has only involved four market price series. The French spot price has not been used since it does not fit the condition that all series should be of the same differencing order. The French spot price series is of first order and does not show a seasonality of fifty-two weeks. Thus we cannot integrate it in the model assessment. In the following, P0, PF0, PF0N and PFOR denote the spot, nearby futures, next to nearby futures and forward market prices. Critical values obtained from Engle and Granger (1987) are, at the level of significance of 5%, equal to .386, 3.37 and 3.17 for the CRDW test, the DF test and the ADF test respectively.

Table No.6.5 Pairwise analysis[+] of co-integration between price series

Depend. variable	C	PF0	PF0N	PFOR	R^2 Adj	CRDW	DF	ADF
(1) P0	.68 (4.56)	.85 (26.7)			.633	.404*	-6.4*	-3.36*
(2) PF0	1.56 (8.38)		.66 (16.97)		.411	.232	-4.99*	-2.77
(3) PF0N	2.19 (13.45)			.53 (15.56)	.371	.244	-5.06*	-2.68
(4) P0	2.32 (10.02)		.50 (10.31)		.203	.143	-3.66*	-1.80
(5) PF0	.51 (10.11)			.89 (82.03)	.942	.865*	-8.78*	-8.57*
(6) P0	1.12 (7.74)			.76 (24.89)	.601	.392*	-6.54*	-4.29*

[+] t values of Student test are given in parenthesis.
* significant tests for CRDW, DF and ADF respectively to the columns.

From Table 6.5 three significant pairwise co-integration relations, namely (1), (5) and (6), are obtained. These three relations can be summarized in two relations, (1) and (5), as expressed in the system (6.14).

(6.14) $P0 = 0.68 + 0.85\ PF0$

$PF0 = 0.51 + 0.89\ PFOR$

Table 6.6 Analysis[+] of co-integration between price series, three by three.

Depend. variable	C	PF0	PF0N	PFOR	R^2 Adj	CRDW	DF	ADF
(7) P0	.88 (5.25)	.92 (22.21)	-.11 (-2.54)		.638	.439*	-6.79*	-3.53*
(8) P0	1.19 (6.87)		-.03 (-.77)	.78 (20.19)	.605	.401*	-6.65*	-4.35*
(9) P0	.70 (4.52)	.80 (6.03)		.04 (.35)	.632	.401*	-6.42*	-3.32*
(10) PF0	.34 (5.77)		.08 (5.54)	.84 (63.97)	.946	.887*	-9.30*	-11.83

[+] t values of Student test are given in parenthesis.
* significant tests for CRDW, DF and ADF respectively to the columns.

Only relations (7) and (10) show significant co-integration with two dependant variables. Relations (8) and (9) are equivalent to relations (6) and (1) respectively.

Table 6.7 Analysis[+] of co-integration between price series, four by four

Depend. variable	C	P0	PF0	PF0N	PFOR	R^2 Adj	CRD W	DF	ADF
(11) P0	.89 (5.2)		.89 (6.5)	-.10 (-2.5)	.01 (.2)	.63	.43*	-6.7*	-3.5*
(12) PF0	.20 (3.5)	.10 (6.5)		.08 (6.2)	.76 (42.9)	.95	.91*	-9.1*	-11.6*
PF0N (13)	1.85 (10.4)	-.14 (-2.5)	.96 (6.4)		-.21 (-1.5)	.42	.29	-5.5*	-3.1
PFOR (14)	-.23 (-3.3)	0.1 (.2)	1.07 (42.9)	-.02 (-1.5)	.84 (63.9)	.94	.88*	-8.9*	-8.7*

[+] t values of Student test are given in parenthesis.
* significant tests for CRDW, DF and ADF respectively to the columns.

Since the CRDW value is superior to Engle and Granger (1987) critical values (0.386), we reject the non-stationary hypothesis and find stationarity for the relations (11), (12) and (14). However, the correct critical values of the Durbin-Watson test depend much upon the dynamics of the errors and we must keep in mind that our sample (412 data) is much greater

than the one used for the tabulated values of Engle and Granger (1987) (which are based on a Monte-Carlo simulation). The ADF test completes these early findings. Adding large lags such as 9, 13 and up to 52 weeks for relations (14), (13) and (11) respectively, after having removed all non-significant coefficients, in order to improve the fit, gives test statistics over 3.17 for all relations but the (13). This confirms the CRDW test statistics. Note that relations (11) and (14) are equivalent to relations (5) and (7).

There may be more than one co-integrating vector α as argued by Engle and Granger (1987). It is indeed possible to find several equilibrium relations to govern the joint behaviour of price series. In the study, we focus on the relation (12) in Table 6.7 since it is the only relation with all individual α_i (i=1,2,3) significant. PFOR and P0 and PFOR and PF0N show insignificant coefficients in relations (11), (13) and (14) in Table 6.7 which tend to prove that these price series explain similar variations of the PF0 variable when used as independent variables to explain each other. The relation (12) in Table 6.7 which tries to express PF0 relatively to P0, PF0N and PFOR is the only relation where these variables do not "compete", in terms of explaining power, with PF0. From equations (12) and (14) we find that PF0 and PFOR are co-integrated. PFOR mainly explains PF0's variations, relatively to the others. It seems that long-run relationship strongly tightens PF0, PFOR and P0. On the other hand, PF0N does not display the sign of co-integration as found from the pairwise analysis in Table 6.5. However, a long-run equilibrium relationship links it to other market prices development in multiple linear equations, but only to a minor degree: positive with PF0 as dependant variable and negative with P0 as dependant variable in equations (14) and (11) respectively in Table 6.7. The significant tests of co-integration are summarized in Table 6.8.

Table 6.8 Summary of co-integration results

Pairwise Analysis	(1) P0 = 0.68 + 0.85 PF0 (5) PF0 = 0.51 + 0.89 PFOR
3/3 Analysis	(7) P0 = 0.88 + 0.92 PF0 - 0.11 PF0N (10) PF0 = 0.34 + 0.08 PF0N + 0.84 PFOR
4/4 Analysis	(12) PF0 = 0.20 + 0.10 P0 + 0.08 PF0N + 0.76 PFOR

The last step of this co-integration analysis consists in modelling price time series variations by applying an Error-Correcting Model (ECM) which regards as the long-run solution the above co-integration equations in Table 6.7. We apply the ECM as described in the system of equations (6.11) to obtain the interactions between the four variables. The estimation is

carried out using a Seemingly Unrelated Regression model. This technique (see Chapter 3) takes into account the correlation between the error terms of the regressions. Two ECM are computed. The first one considers a medium-term approach since it involves fifty-six weeks, while the second ECM proposes a more short-term approach with only twelve weeks.

Table 6.9 Error Correcting Model for a medium-term approach of fifty-six weeks[+].

$$\begin{aligned}
\Delta SPOT = {} & SPOT\,[-0.34\,L^{1} - 0.21\,L^{3} - 0.11\,L^{4} - 0.17\,L^{5} - 0.13\,L^{6} - 0.09\,L^{11}] \\
& \quad (-6.75) \quad (-4.03) \quad (-2.14) \quad (-3.44) \quad (-2.88) \quad (-2.07) \\
& + FUT\,[0.29L^{1} + 0.24\,L^{2} + 0.21\,L^{3} + 0.26\,L^{4} + 0.21\,L^{5} + 0.27\,L^{6} + 0.12\,L^{9} \\
& \quad (5.13) \quad (4.21) \quad (3.59) \quad (3.55) \quad (3.40) \quad (4.62) \quad (2.15) \\
& + 0.17\,L^{15}] + FUTN\,[-0.32\,L^{15}] + FORW\,[0.25\,L^{4} - 0.11\,L^{55} + 0.21\,L^{56}] \\
& \quad (3.17) \quad (-5.73) \quad (4.07) \quad (-2.46) \quad (4.53) \\
& + INTP0\,[0.04\,L^{1}] \\
& \quad (1.98)
\end{aligned}$$

$Q(60;19) = 38.95$ and S.E. of regression = 0.01909

$$\begin{aligned}
\Delta FUTN = {} & INTPF0N\,[0.01\,L^{1}] + FUTN\,[-0.26\,L^{52}] + FORW[-0.19\,L^{44}] \\
& \quad (0.14) \quad (-4.69) \quad (-4.48) \\
& + SPOT\,[-0.17\,L^{38} + 0.24\,L^{39}] \\
& \quad (-3.92) \quad (5.14)
\end{aligned}$$

$Q(60;4) = 33.84$ and S.E. of regression = 0.019444

$$\begin{aligned}
\Delta FORW = {} & FUT\,[0.38\,L^{1}] + FUTN\,[0.15\,L^{2} + 0.32\,L^{8}] + FORW\,[-0.27\,L^{1} - 0.21\,L^{52} \\
& \quad (6.16) \quad (2.62) \quad (5.68) \quad (-5.21) \quad (-5.61) \\
& - 0.08\,L^{56}] + SPOT\,[0.09\,L^{52}] + INTPFOR\,[-0.11\,L^{1}] \\
& \quad (-2.22) \quad (2.43) \quad (-1.58)
\end{aligned}$$

$Q(60;8) = 36.19$ and S.E. of regression = 0.022396

$$\begin{aligned}
\Delta FUT = {} & FUT\,[0.06\,L^{32} - 0.36\,L^{52} - 0.13\,L^{53}] + FUTN\,[0.10\,L^{2} + 0.26\,L^{8} \\
& \quad (1.98) \quad (-10.74) \quad (-3.74) \quad (2.30) \quad (5.68) \\
& + 0.11\,L^{9}] + FORW\,[-0.07\,L^{47}] + INTPF0\,[-0.09\,L^{1}] \\
& \quad (3.17) \quad (-2.82) \quad (-1.33)
\end{aligned}$$

$Q(60;8) = 42.59$ and S.E. of regression = 0.018727

[+] t values of Student test are given in parenthesis.

Table 6.10 Error Correcting Model for a short-term approach of twelve weeks+

$$\Delta SPOT = SPOT\,[-0.30\,L^{1} - 0.17\,L^{2} - 0.14\,L^{3} - 0.16\,L^{4} - 0.16\,L^{5} - 0.11\,L^{6}$$
$$(-6.17)\quad (-3.38)\quad (-2.92)\quad (-3.23)\quad (-3.32)\quad (-2.34)$$
$$- 0.10\,L^{10}] + FUT\,[0.26\,L^{1} + 0.29\,L^{2} + 0.29\,L^{3} + 0.36\,L^{4} + 0.27\,L^{6}$$
$$(-2.33)\quad (4.86)\quad (5.29)\quad (5.28)\quad (6.44)\quad (5.07)$$
$$+ 0.15\,L^{8}] + FORW\,[0.14\,L^{4}] + FUTN\,[-0.22\,L^{12}] + INTP0\,[0.02\,L^{1}]$$
$$(2.82)\quad (3.04)\quad (-4.14)\quad (1.06)$$

$Q(60;16) = 40.21$ and S.E. of regression = 0.019704

$$\Delta FUTN = INTPF0N\,[0.01\,L^{1}] + FUTN\,[-0.29\,L^{1}] + FUT\,[0.21\,L^{1}]$$
$$(0.23)\quad (-5.65)\quad (3.88)$$

$Q(60;3) = 29.02$ and S.E. of regression = 0.02068

$$\Delta FORW = FORW\,[-0.38\,L^{1} - 0.28\,L^{2} - 0.33\,L^{3} - 0.37\,L^{4} - 0.21\,L^{5} - 0.23\,L^{6}$$
$$(-6.37)\quad (-4.72)\quad (-5.22)\quad (-6.10)\quad (-3.51)\quad (-4.01)$$
$$- 0.18\,L^{7} - 0.13\,L^{8}] + FUTN\,[0.12\,L^{2} + 0.12\,L^{7} + 0.44\,L^{8}]$$
$$(-3.21)\quad (-2.70)\quad (1.97)\quad (2.14)\quad (7.43)$$
$$+ FUT\,[0.47\,L^{1} + 0.30\,L^{2} + 0.37\,L^{3} + 0.31\,L^{4} + 0.31\,L^{5} + 0.25\,L^{6}$$
$$(7.22)\quad (4.38)\quad (5.59)\quad (4.73)\quad (4.76)\quad (4.03)$$
$$+ 0.24\,L^{7}] + INTPFOR\,[0.11\,L^{1}]$$
$$(3.88)\quad (1.26)$$

$Q(60;19) = 26.39$ and S.E. of regression = 0.023228

$$\Delta FUT = FUTN\,[0.13\,L^{2} + 0.31\,L^{8}] + FORW\,[0.13\,L^{3}] + INTPF0\,[-0.31\,L^{1}]$$
$$(2.60)\quad (6.33)\quad (2.86)\quad (-3.95)$$

$Q(60;4) = 40.72$ and S.E. of regression = 0.021261

+ t values of Student test are given in parenthesis.

SPOT, FUT, FUTN and FORW denote the stationary-transformed time series derived from the UK spot price, the nearby futures price, the next to nearby futures price and the UK forward price, respectively. INTP0, INTPF0, INTPF0N and INTPFOR denote the residuals of the co-integration system shown in Table 6.7 for the UK spot price, the nearby futures price, the next to nearby futures price and the UK forward price (equations (11), (12), (13), (14)) respectively.

Regression of the UK spot price in Table 6.9 is the only one to show a significant Error Correction Mechanism for a medium-term horizon. The short-term analysis shows distinct results since the only significant ECM in Table 6.10 is the regression of the nearby futures

price. These two selected systems are the long-term relationship system captured by the ECM. These two equations present different results according to the time span. Yet, they stress interactions existing between on one hand, the nearby futures price, the next to nearby futures price and the forward price and, on another hand, the spot price, the nearby futures price, the next to nearby futures price and the forward price.

6.4.2.3 Multivariate Analysis

The Tables 6.11 and 6.12 below relate results from the multivariate analysis undertaken within a Seemingly Unrelated Regressions system (SUR). The long-run multivariate analysis gives evidence of a very strong relationship between all these markets. Nevertheless, while the UK spot price is related to all other market prices, the next to nearby futures prices and the French spot prices are not linked with the nearby futures prices. It also appears that surprisingly the UK forward and nearby futures prices are not related to the UK spot prices. The short-run multivariate analysis, while confirming these market interactions, offers a somewhat different picture. While the nearby futures price is related with all other market prices, the next to nearby futures price and the French spot price are not linked to each other and to the UK forward price and the UK spot price respectively. The R^2 displayed by their equations is also very low. The UK spot price does not seem to be linked to the French spot price, nor the UK forward price.

6.5 Discussion

The univariate, multivariate and co-integration analysis allows us to draw some conclusions about the informational role of the London wheat futures market and its relationship with other wheat markets. The three British markets, namely the spot, forward and futures markets seem closely linked. The futures market appears to lead the forward and spot markets. This is observed by the Pierce and Haugh test, the F test and the multivariate analysis. Instantaneous relationships and bilateral dependence emphasize the interaction dynamics of the British wheat markets.

The forward price and the nearby futures price are closely related. The Pierce and Haugh test suggests a short-term lead of three weeks for the forward price. While confirming this finding, the short-run multivariate analysis indicates a seven-week lag relationship between the forward and the nearby futures price. From the Q test and the F test, the UK spot price appears to lag other markets in generating price signal. While the F test shows instantaneous

Table 6.11 Multivariate analysis of a wheat markets system for lags up to fifty-six weeks.

$$SPOT = SPOT\,[-0.25\,L^{1} - 0.11L^{3}] + FUT\,[0.29\,L^{1} + 0.16L^{2} + 0.19\,L^{6} + 0.15\,L^{15}]$$
$$(-5.14)\ (-2.38) \qquad (5.18)\ (2.99)\ (3.56)\ (2.86)$$
$$+ FUTN\,[-0.32\,L^{15}] + FORW\,[0.35\,L^{4} - 0.09\,L^{55} + 0.25\,L^{56}]$$
$$(-5.66) \qquad (7.05)\ (-2.08)\ (5.32)$$
$$+ BLE\,[-0.09\,L^{7} + 0.10\,L^{16} - 0.11\,L^{52}]$$
$$(-2.60)\ (2.79)\ (-3.24)$$

R^2 Adj = 0.302 DW = 2.01

$$FUTN = FUTN\,[-0.30\,L^{52}] + FORW\,[-0.16\,L^{44}] + SPOT\,[-0.17\,L^{38} + 0.19\,L^{39}]$$
$$(-5.79) \qquad (-4.10) \qquad (-4.20)\ (4.35)$$
$$+ BLE\,[0.11\,L^{1} + 0.09\,L^{34} + 0.07\,L^{40} - 0.11\,L^{46}$$
$$(3.14)\ (2.84)\ (2.19)\ (-3.32)$$
$$+ 0.11\,L^{47} - 0.13\,L^{53}]$$
$$(3.20)\ (-4.12)$$

R^2 Adj = 0.307 DW = 2.15

$$FORW = FUT\,[0.45\,L^{1}] + FUTN\,[0.08\,L^{2} + 0.38\,L^{8}] + FORW\,[-0.34\,L^{1}$$
$$(7.78) \qquad (2.06)\ (6.54) \qquad (-6.67)$$
$$- 0.23\,L^{52}] + BLE\,[-0.07\,L^{47} + 0.20\,L^{54}]$$
$$(-6.12) \qquad (-2.59)\ (4.76)$$

R^2 Adj = 0.265 DW = 1.87

$$FUT = FUT\,[0.09\,L^{32} - 0.36\,L^{52} - 0.17\,L^{53}] + FUTN\,[0.26\,L^{8}]$$
$$(2.85)\ (-10.50)\ (-5.09) \qquad (5.69)$$
$$+ BLE\,[0.11\,L^{54}] + FORW\,[-0.06\,L^{47}]$$
$$(3.12) \qquad (-2.41)$$

R^2 Adj = 0.252 DW = 1.99

$$BLE = FORW\,[0.18\,L^{49}] + FUTN\,[-0.15\,L^{3} + 0.21\,L^{14} + 0.27\,L^{15}$$
$$(3.01) \qquad (-2.32)\ (2.80)\ (3.49)$$
$$- 0.35\,L^{19} - 0.28\,L^{52}] + BLE\,[-0.13\,L^{24} + 0.13\,L^{45} + 0.21\,L^{52}$$
$$(-4.78)\ (-3.80) \qquad (-2.69)\ (2.59)\ (4.33)$$
$$+ 0.13\,L^{56}]$$
$$(2.47)$$

R^2 Adj = 0.263 DW = 2.13

Table 6.12 Multivariate analysis of a wheat markets system for lags up to twelve weeks.

$$SPOT = SPOT\,[-0.29\,L^{1} - 0.16\,L^{2} - 0.12\,L^{3} - 0.16\,L^{4} - 0.13\,L^{5} - 0.12\,L^{6}]$$
$$(-6.10)\quad (-3.22)\quad (-2.69)\quad (-3.32)\quad (-2.66)\quad (-2.71)$$
$$+ FUT\,[0.23\,L^{1} + 0.26L^{2} + 0.30\,L^{3} + 0.36\,L^{4} + 0.25\,L^{6} + 0.15\,L^{8}$$
$$(4.48)\quad (5.07)\quad (5.65)\quad (6.71)\quad (4.81)\quad (3.01)$$
$$- 0.19\,L^{11}] + FORW\,[0.15\,L^{4}] + FUTN\,[-0.24\,L^{12}]$$
$$(-3.77)\quad (3.19)\quad (-4.64)$$

R^2 Adj = 0.296 DW = 1.95

$$FUTN = FUTN\,[-0.29\,L^{1}] + SPOT\,[0.09\,L^{1}] + FUT\,[0.17\,L^{1}]$$
$$(-5.89)\quad (1.96)\quad (3.11)$$

R^2 Adj = 0.075 DW = 1.95

$$FORW = FUT\,[0.31\,L^{1} + 0.18\,L^{3} + 0.11\,L^{7}] + FORW\,[-0.26\,L^{1} - 0.12\,L^{2} - 0.17\,L^{3}$$
$$(4.80)\quad (3.12)\quad (2.10)\quad (-4.87)\quad (-2.35)\quad (-2.89)$$
$$- 0.12\,L^{4}] + BLE\,[0.14\,L^{2}] + FUTN\,[0.18\,L^{2} + 0.33\,L^{8}]$$
$$(-2.38)\quad (3.25)\quad (3.03)\quad (5.83)$$

R^2 Adj = 0.173 DW = 1.88

$$FUT = FUT\,[-0.11\,L^{1} - 0.18\,L^{2} - 0.09\,L^{9}] + FUTN\,[0.18\,L^{2} + 0.31\,L^{8}]$$
$$(-2.17)\quad (-3.76)\quad (-2.11)\quad (3.61)\quad (6.70)$$
$$+ FORW\,[0.11\,L^{3}] + SPOT\,[0.09\,L^{1}] + BLE\,[0.14\,L^{2} - 0.10\,L^{3}]$$
$$(2.56)\quad (2.11)\quad (4.09)\quad (-3.07)$$

R^2 Adj = 0.186 DW = 1.93

$$BLE = FORW\,[-0.20\,L^{2}] + FUT\,[0.16\,L^{4}] + BLE\,[0.11\,L^{7}]$$
$$(-3.09)\quad (2.19)\quad (1.98)$$

R^2 Adj = 0.037 DW = 2.14

but no unilateral relationship with other British markets, the Q test gives evidence of short-run lead, i.e. three weeks, of the UK spot price over the UK forward and nearby futures prices. The multivariate analysis reinforces these findings by stressing the lag of the spot market in generating information but does not confirm the three-week lead over the UK

forward market. On the contrary, it supports evidence of a one-week lead over the two futures prices.

Despite the theoretically little need for futures trading and its informational role in a regulated market, this analysis shows that the wheat futures market is the market leader in processing and generating new market information. However, the forward market plays a major informational role. Such a finding confirms its importance, with respect to its size and use by producers, merchants, traders and wheat processors.

Examination of co-integration between these three markets suggests that they are closely linked in the long-run and confirms the specificity of the next to nearby futures price in its somewhat independent behaviour. The analysis of co-integration shows the strong link between the spot price, the forward price and the nearby futures price, with a particular emphasis on the relationship between the forward price and the nearby futures price.

The French spot market seems to be isolated from the UK markets. The univariate tests support evidence of a lead of French market prices over its British counterparts. Yet the F test shows a three-week lead of the UK forward market over the French market. The long-run multivariate analysis confirms these findings, while the short-run multivariate analysis indicates no lead over the UK spot price and the next to nearby futures price but a three-week lag over the nearby futures price. The lead of the French spot market may be explained by its dominant position with regard to its production, its export capacity and its political weight in the EC decision-making. Many criticisms of the CAP have indeed pictured the EC wheat regime as tailored to the French market and its needs (Turner and Crabtree, 1982). Because of the domestic supply conditions of the British and the French markets which are currently in overproduction and generally deal with different wheat qualities, these two markets are not closely related. This relationship has been further loosened by the agri-monetary system which, through the MCA system, imperfectly reflects the real price differential between the EC Intervention prices prevailing in each of the two countries. A delay in the price and the exchange rate transmission prevents any price signal on the French market from being instantaneously processed and transmitted to the British market.

6.6 Conclusion

The objectives of the chapter were to test the fourth sub-hypothesis of the thesis which

stipulates that the annual price-fixing and the implementation of institutional prices have affected the informational role of the futures market. Evidence does not support this sub-hypothesis. Empirical findings, obtained by using the Granger causality test and by an investigation of co-integration links, suggest that the wheat futures market operates as the wheat market leader in processing and generating information. Despite the very close relationship between the British futures, forward and spot prices, the next to nearby futures price seems to lead other market prices. The forward price appears to play an informational function similar to that of the nearby futures price. Finally the French spot price seems to evolve somewhat independently of the other markets considered.

Causality may reflect market power expressed as price leadership and may express the competition for and the use of information. If the wheat futures market leads other markets, then information is first processed in this market and is then transmitted to other markets such as the spot or the forward market. The administrative management of EC wheat prices, and particularly the establishment of the intervention system, may have put into question the economic usefulness of a wheat futures market. Empirical findings appear to suggest that the London wheat futures market may have found its *raison d'être* as an efficient information processing instrument.

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CHAPTER 7

Summary, conclusions and implications

7.1 Introduction

This chapter provides a summary of the study emphasizing the major findings and conclusions. Rather than restating the main results from the empirical analysis, it aims at highlighting their significance with regard to the initial hypothesis and sub-hypotheses and at examining their policy implications.

The analysis of futures markets has generally failed to address the issue of the influence of governmental intervention on futures markets performance. This failure may arise from the location of early futures trading development and the free market environment within which futures markets have historically developed. Analysis of interactions between futures markets and agricultural policies has so far focused on their respective performance in stabilizing income.

While some studies have examined the potential for substitution between futures markets and agricultural policies, it has to be accepted that futures markets can only contribute to one of the basic goals of many agricultural policies, namely the control of price risk. Futures markets and agricultural policies differ in two ways in their handling of price risk (Schertz, 1985). First, the use of futures markets by hedgers has proved to be costly while price support schemes of agricultural policies are almost free for these operators. Second, agricultural policies have frequently supported prices above long-run market-clearing levels whereas futures markets in themselves cannot noticeably affect market prices. Futures markets cannot guarantee a certain level of income. Few studies (Gemmill, 1988) have sought to explore the working of futures markets within a particular agricultural policy in order to focus on their compatibility and their complementarity.

This thesis investigates the influence of the CAP on the performance of the London wheat

futures market. The objectives are to examine the influence of the CAP on the three major functions of futures markets as described in Chapter 1, namely the risk-reduction function of the futures market, its price discovery role and the establishment of forward prices. Based on these objectives, the study focuses on the hypothesis that the London wheat futures market performance in fulfilling its three primary functions has been affected by the implementation of the CAP. Analysis of the above general hypothesis is elaborated by examination of several sub-hypotheses.

7.2 Summary of major findings

7.2.1 Sub-hypothesis 1

The first sub-hypothesis claims that not only the CAP has removed most of market price risk from EC wheat markets, but also that it has generated an institutional price risk, thus justifying the existence of a wheat futures market. Examination and test of this sub-hypothesis is related in Chapter 2 where a definition and empirical assessment of risk on the UK and French domestic markets as well as in the case of intra-EC trade between these two countries, takes place.

Empirical results reveal a low level of price risk. This seems likely to be attributable to the CAP, and particularly to the intervention system which originally operated as a price floor and also to the current market situation of oversupply. These findings therefore appear to support the first sub-hypothesis of the thesis. While intervention prices, which are set above long-run market-clearing prices, combined with an overproduction situation may be expected to induce an almost zero level of price risk, a low but significant price risk is in fact found. These results may illustrate the policy uncertainty which has been a common feature of the CAP. They suggest that the difficulty in predicting policy changes has turned price volatility into price risk. Operators on EC wheat markets have to face a low but less foreseeable price variability. The increase in price risk during the 1982/87 period, considered in our study, may be due to institutional factors relative to changes in the EC wheat regime, especially the intervention price system, and to changes in the EC markets situation which is strongly influenced by that particular regime. The relatively high price risk found in the case of intra-EC trade may also reflect the uncertainty surrounding the definition and the application of the agri-monetary system.

This low but institutionally-derived price risk might be expected to have discouraged futures

trading activity since presence of risk is regarded as one of the major prerequisites for futures trading development and since futures markets are not generally designed to cover this specific type of risk.

7.2.2 Sub-hypothesis 2

The second sub-hypothesis deals with the fulfilment by the futures market of its primary role of risk management. It is hypothesised that the EC wheat regime has altered the effectiveness of the London wheat futures market in reducing price and income risk. This sub-hypothesis is examined and tested in Chapters 3 and 4 which focus on the basis performance and on the hedging function, i.e. the optimal hedging ratio determination and the hedging effectiveness.

Chapter 3 considers the basis performance of the wheat futures market and examines whether the CAP, through the EC wheat regime and the agri-monetary system, has affected the performance of the futures market by increasing the basis risk thus reducing its economic usefulness. The empirical analysis shows that the nearby basis risk fluctuated widely and was sometimes above the level of price risk in the UK, particularly in the 1984/85 and 1985/86 seasons. The agri-monetary system appears to have influenced the basis behaviour for foreign operators with the introduction of uncertainty associated with Monetary Compensatory Amounts, hence reducing access to the London futures market. The poor performance of the basis for French domestic operators, and to a lesser degree, for French exporters to the UK may reflect the isolation of national physical markets that the agri-monetary system has contributed to develop. These results may also explain the very low level of Continental futures trading in London.

Empirical findings from the econometric modelling of the basis variations demonstrate that, while the influence of economic and CAP-related factors have changed along with the new conditions prevailing on the British market, the EC wheat regime appears to have significantly influenced the basis behaviour. The seasonal pattern of the basis and the role of some market fundamental variables, such as the stock levels of wheat and barley, appear to have been fundamentally modified. The emergence of some important institutional variables such as the intervention price, the monthly increment and, to a minor degree, the intervention store level of wheat, is largely due to the CAP.

All these results highlight the importance of the CAP as a major determinant of the

development of the basis and in its performance on the London wheat futures market.

The study of the impact of the EC wheat regime on the risk-reduction function is complemented by Chapter 4 where the hedging function of the London wheat futures market was explored. The optimal hedging ratio (OHR) and the hedging effectiveness (HE) of various hedging models for three different types of market operators are here investigated. The great variability in the OHR and HE over time and the high sensitivity to the risk aversion coefficient may reflect the low values of statistical parameters involved in the OHR and HE determination which in turn are derived from the low level of price risk on the spot and futures markets.

The negative sign of the speculative component of the OHR and the HE shows the existence of a risk premium paid by hedgers to speculators who bear the institutional price risk on the futures market. This, combined with production variability which seems to have contributed to negative hedging components for producers, and with low values of the statistical parameters, has favoured the appearance of reverse-hedging situations. The institutional influence, as far as traders' positions on the market are concerned, is highlighted by the changing cash-futures relationship over time and the consequent variability of the OHR and HE values obtained from sampling periods of different length.

Hedging effectiveness, measured by the traditional formula, is low. This may arise from the low level of variance of cash and futures price changes, thus leading to less variance to be explained. A new approach to HE, adopted to match these specific conditions and which takes account of both risk and return opportunities, shows the great sensitivity of HE results to risk aversion and, more generally, to speculative components of HE. Study of the forward contract performance, as an alternative to futures contracts for the marketing of wheat, displays evidence of a greater use of the forward market, relatively to the futures market, by producers and merchants.

Results from the empirical analysis appear to support the hypothesis that the CAP has altered the effectiveness of the London wheat futures market in the fulfilment of its risk-reduction function.

7.2.3 Sub-hypothesis 3

The third sub-hypothesis is tested and the results are reported in Chapter 5. It is concerned

with the price discovery function of the futures market. The pricing performance of the futures market (i.e. the informational efficiency, the forecasting performance and the existence of a risk premium) is hypothesised to have been detrimentally affected by the EC wheat regime and more particularly by the complex set of price policy instruments.

Evidence of deviation from the market efficiency hypothesis is provided by results showing that some futures contracts displayed informational inefficiency, particularly during the 1983 and 1986/88 time periods. The performance of the wheat futures market in fulfilling its forecasting function suggest that this market is a fairly efficient forecasting tool, despite findings of forecasting deficiencies for two futures contracts over the 1980/88 period. When compared to other forecasting methods the London wheat futures market stood up well, although outperformed by the forward market, revealing the futures market's lack of liquidity and volume of trade relative to that of the forward market.

While evidence of the existence of a risk premium is only found during the 1980/88 period for a two-month lag and when the forward price is used as proxy for the expected spot price, further examination fails to generate a deterministic structure for this risk premium. The risk premium paid by hedgers to speculators as a compensation for bearing the risk may arise from the emergence of a institutionally-derived price risk.

As far as the informational efficiency and the forecasting performance are concerned, we would argue that the wheat futures market performs its pricing function efficiently, although it displays some specific deficiencies. But these deficiencies do not seem to be strong enough to support the third sub-hypothesis of the thesis.

7.2.4 Sub-hypothesis 4

The fourth sub-hypothesis considers the informational performance of the futures market which is hypothesised to be affected by the annual price-fixing and the implementation of institutional prices. A system of four wheat markets, i.e. the UK forward market, the UK and French cash markets and the London wheat futures market, is examined in Chapter 6 to test this sub-hypothesis.

Granger causality tests completed by investigation of co-integration links are used in the empirical assessment. Findings reveal that the wheat futures market operates as the wheat market leader in processing and generating information. The next to nearby futures price

appears to lead other market prices, despite the close relationship between the British futures, forward and spot prices. Importance of the forward market in the marketing of wheat is reflected in the informational role of this market whose price seems to play an informational function similar to that of the nearby futures price. When examined within a British wheat markets system, the French spot price exhibits somewhat independent behaviour. Since causality generally reflects market power expressed as price leadership and may express the competition for and the use of information, these empirical findings mean that information is first processed in the wheat futures market and then transmitted to other markets such as the UK spot and forward markets.

Therefore the fourth sub-hypothesis which concerns the impact of the annual price-fixing and of the institutional prices on the informational role of the futures market is not supported.

7.3 Conclusion

From the foregoing, the results support the general hypothesis of the study which is that the CAP, and particularly the EC wheat regime, has altered the performance of the London wheat futures market. Yet support for this hypothesis is not total since the third and fourth sub-hypotheses are rejected. The following conclusions are then drawn:

. Agricultural policies appear to have a significant impact on the performance of futures markets in fulfilling their primary roles.

. The CAP has removed most of spot market price risk while contributing to the emergence of an institutional price risk, arising from the uncertainty surrounding the definition and the working of the EC wheat regime.

. This specific price risk has proved to be difficult to cover on the London wheat futures market. Measurement of the basis risk and identification of variables influencing variations in the basis show that, on average, the London wheat futures market has performed poorly in managing the institutional price risk. Such findings are confirmed by investigation of the hedging function, especially the empirical assessment of the optimal hedging ratio and the hedging effectiveness.

. The London wheat futures market appears to fulfil efficiently its price discovery function

and its role in establishing forward prices. Although evidence of inefficiency exists for some particular futures contracts, they do not appear to last long enough to put into question the performance of the futures markets in fulfilling these two functions.

. The impact of the CAP on the performance of the London wheat futures market has been twofold. By implementing a Common pricing system based on a set of institutional prices and the agri-monetary system and by controlling the EC external trade, the EC wheat regime has distorted the market mechanisms. This administrative management of EC wheat markets has prevented the London wheat futures market from operating effectively. Furthermore, whilst reducing the need for futures trading, this institutional grip on the spot market has deterred some operators, such as speculators, from entering the market, leading thus to a low volume of activity and market liquidity which in turn induce market inefficiencies.

7.4 Implications

At a time when the futures industry is witnessing an important expansion, the influence of institutional factors, such as agricultural policies on futures markets performance has received little attention. The thesis aims to contribute to that knowledge by addressing the issue as to whether the EC wheat regime has affected the performance of the London wheat futures market. From these results, several implications and questions may be raised.

. Trading activity on or reference to the London wheat futures market can only be carried out after a detailed analysis of the wheat spot markets and, in particular, the EC wheat regime. Knowledge of the various instruments of the EC wheat regime is of major importance to any agent involved in wheat futures trading. This may deter speculative activity since no trading is possible without being accustomed with EC regulations whose administrative and political features are perhaps not always characterized by simplicity, rationality and effectiveness.

. The poor performance of the wheat futures market in operating some of its primary functions such as its risk-reduction role may mean that this market has found its *raison d'être* in efficiently exercising other functions. Indeed, although the volume of activity is limited to around 50 % of the British domestic production, such level of trade in an inefficient market would be irrational from market agents without the existence of other potentially efficient uses of the market. Yet it can be argued that this inefficiency only arises at certain points in time (as found in the analysis of the pricing performance), thus

justifying normal trading activity at other times. Nevertheless, this market, as well as other futures markets operating within an institutional framework, appears to have adapted itself to this particular environment. Trading rules adopted by operators may also have to be adjusted by the management.

. If this futures market has specialized in some functions where its operation has become more compatible with the current agricultural policy, we may question whether traditional tools and methods used in the assessment of futures market performance are still relevant or whether new performance criteria should be introduced (such as the new definition of the HE). The suggestion is particularly relevant for the risk-reduction function of this market. Hedging a low but institutionally-derived price risk might need new measurement techniques. The co-existence of the inefficient risk-reduction function and the efficient informational and pricing functions is indeed rather surprising.

. While there is discussion relating to the setting up of a wheat futures market in Paris (Feedstuffs, February 1990), the performance of the London wheat futures market and the influence of the CAP on this performance is important since it may provide evidence as to how a wheat futures market might operate and develop in another EC country. The influence of the CAP on the futures market performance for French domestic operators and for foreign-based traders may be forecast and assessed on the basis of the current situation from the London wheat futures market. As discussed by Marquet (1986), the definition of any specific regulations in the running of futures markets, with regard to features such as the type of operators involved in the market, the time period of trading and the contract design, might constitute a way of responding to potential problems arising from institutional factors.

. Finally, the performance of such futures markets can be improved by tailoring their activity to the characteristics of the prevailing agricultural policy. Gemmill (1988) discusses to what extent futures trading could have a larger role to play under a revised CAP. By simulating different options in agricultural policies changes, he examines the potential contribution of futures markets in the EC as a means for laying-off price risk. A futures market (or option market) adapted to the operating agricultural policy would certainly dramatically improve its performance.

7.5 Potential for further research

Further research might obviously involve a direct extension of the work presented here. The

analysis of each of the primary goals of the wheat futures market can be developed, either by applying new methodology or by enlarging the data sample, either to a greater span or to other agricultural products in the portfolio analysis.

The last issue referred to in the previous section concerning the contribution of futures trading to a revised CAP may be explored since it represents a possible next step for the present study. Indeed the assessment of futures market activity within a variety of agricultural policies should be complemented by the analysis of how such policy changes might influence and affect the performance of the wheat futures market.

The development of new products is also of interest. Some studies (Debatisse et al., 1980, Debatisse, 1984 and Terwitte, 1988) have made suggestions about trading futures contracts suitable for exporters operating on the world market where the international price risk for exporters and the EC budget is great, and on the EC markets where the MCA risk is difficult to cover.

Finally the potential relationship between wheat option contracts and the EC price support program deserves to be investigated. If tailored to the need of farmers, these contracts might to some degree substitute for governmental intervention in its role of controlling price risk.

7.6 Limitations of the results

As argued in 1.7, the lack of direct comparison of the performance of the London wheat futures market with another futures market not subject to a price support regime or with a pre-CAP situation reduces the value of the results obtained in this empirical investigation. Any study of causal links between two economic mechanisms is always faced with this particular problem. The results are very time-specific and space-specific and any study of "what-if" scenarios are impossible. Since no "control" period is available to show what would happen to the futures market performance without the CAP, no direct comparison is possible. It is consequently clear that the value of our results has to be limited.

Regarding the first sub-hypothesis, the causal link between the low measured price risk and the CAP cannot be clearly demonstrated since we can only assume that price risk would have been higher without the CAP. Likewise the institutional component of price risk is difficult to separate (within the total price risk) from the market-generated component of price risk. We can only suggest that the results are consistent with the view that due to the high level

of EC institutional prices, the current overproduction situation and the import/export system, the market-generated component of price risk can be thought of as almost null and that the remaining level of price risk comes from the institutional component.

The effect of futures trading on market price risk can be isolated for there is very minor futures trade from French traders on the London wheat futures market. The price risk found on the French domestic markets is clear of any potential futures market influence on the variance and risk of spot price.

The second sub-hypothesis is the only sub-hypothesis which emphasizes the causal link between the CAP and the futures market performance. Market fundamentals such as the level of stocks on farm of wheat and barley are not significant in explaining the basis variations. The influence of the cost of storage in the determination of the basis is still significant but strongly declining (Table 3.7). The deviation of market price from the intervention price is very much linked to the level of this institutional price, the availability of the monthly increment and of the intervention system. The very existence of such a variable, inconceivable for futures markets operating under free-market conditions, makes it unambiguously derived from the CAP. Its impact, as well as the impact of the wheat intervention store level, emphasizes the influence of the CAP on the behaviour of the basis. The different behaviour of the basis before and after 1981 (when the CAP had full effect on the marketing of wheat in the UK) reinforces these findings.

Analysis of the optimal hedging ratio and the hedging effectiveness gives also clear indication that the results obtained here are different from those found on the American futures markets. In the UK, we observed:

. frequent reverse-hedging positions
. very high level of OHR
. low level of HE when assessed by the traditional approach
. great variability of OHR overtime

OHR and HE results obtained by the traditional approach in American futures markets (Peck, 1975, Brown, 1985, Miller and Kahl, 1987 and 1989, among others) are generally included in the interval [.5;1] which is a smaller interval than those observed here. Results obtained with the new definition of hedging effectiveness, introduced for the specific context of the London wheat futures market, are obviously not comparable to existing HE

measures.

Sub-hypotheses 3 and 4 are rejected since the few deviations from the hypothesised efficiency were inconclusive.

Conclusions from the body of the thesis should only be drawn with caution and in a broad perspective. As in most empirical work, a clear-cut assertion as to whether the CAP has affected the performance of the London wheat futures market is impossible to make unequivocably. While it is not possible to conclusively accept the general hypothesis of the thesis, much evidence in its support has been advanced. The contribution of this thesis to the study of futures markets may be regarded as being threefold:

1) the work provides us with one of the first comprehensive studies of the performance of the London wheat futures market
2) very few studies have so far examined the impact of agricultural policies on futures market performance and none of them has investigated the impact of the Common Agricultural Policy in the method outlined here.
3) finally some analytical methodologies in this work concerning the assessment of futures market performance are either new to the futures market literature (such as the proposed definition of HE) or new to the study of agricultural commodity futures markets (such as the risk premium analysis in 5.4.2.2).

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APPENDICES

Appendix 1-A

1-A.1 The pricing system of the EC wheat regime

The target price is fixed every year by the Council of Agricultural Ministers. This price constitutes the pivot upon which other institutional prices are based. The price of grain in Duisburg, in West Germany - area of greatest deficit in the Community - is intended to be related to the target price. It then should be higher than the intervention price by the transport cost from the area of greatest surplus to the area of greatest deficit, plus a market element. Being the arbitrary element between the intervention, threshold and target price, this market element is used by the Ministers to modify the relative competitive positions of EC and third countries grains. This market element is meant to reflect the difference between the market price and the intervention price in the area of greatest surplus in the Community. Over the last seasons the gap between these two institutional prices have been widened by the Commission to increase protection of the EC market from third countries.

The threshold price, fixed each season by the Commission, is the Community minimum import price for third country grain. This protective barrier is such that the cost of buying grain on the world market and importing it in the EC is at least as high as the threshold price. Its determination is made on the basis that when third country grain arrives at Rotterdam and is transported to Duisburg, its cost amounts to a little above the target price. The difference between the target and threshold prices is made of the transport cost between Rotterdam and Duisburg and a market element representing transhipment cost and trading margin.

The intervention price is fixed every year by the Council of Agricultural Ministers for common wheat. In order to avoid situations where overproduction can drive market prices to levels incompatible with the CAP objectives, support is provided by the intervention system. Subject to certain quality and minimum quantity standards, intervention agencies are obliged to buy grain offered to them. The intervention price is related to market conditions in Ormes in France, the area of greatest surplus in the Community.

In addition to this price, a **reference price** was fixed in the past, from 1976 to 1986, for bread-making wheat in the framework of a pricing policy that came to be known as the **silo system**. The difference between the reference price and the intervention price constituted a premium or a return for the production of better quality wheat needed in the Community.

However, the reference price was not operated as a conventional intervention price and the level of the premium of the reference price had been steadily lowered in the following years. Owing to financial difficulties and heavy sales into intervention, the 1986/87 price fixing has set a single intervention price for common wheat, with stricter quality requirements. Feed grains intervention price was fixed at 5 % below the common wheat price.

Monthly increments are gradually used to raise common support prices (target, threshold and intervention) as the year progresses. Their size is dependant on considerations relative to the storage cost and the assurance of a regular flow of supplies on the market throughout the year. During the two last months of the season, intervention and reference prices come back to their August level in order to prevent early-harvested crop being sold at a high price but the target and threshold prices still benefit from one further increment.

The Council of Agricultural Ministers decides every year (the price fixing generally takes place in March) on the support prices for grain for the following season by adopting two related decisions:

. the level at which the EC grain market should be supported
. the level at which the third-country grain can be imported into the EC.

These decisions are determined by political and financial factors such as the state of the EC budget, lobbying groups and institutional pressure (especially the USA) and the markets for grain and other products. While the common cereals regime came into force in 1967, the first seasons from 1967/68 to 1973/74 have witnessed modest price increases. The 1974/75 to 1976/77 seasons showed more substantial increases before returning to smaller increases up to the 1980/81 season. The three following seasons were characterized by price rises but also by increased pressure on the EC budget. The 1983/84 seasons were marked by a small increase, then more recently a price freeze and eventually price reductions.

1-A.2 The external trade system

The Commission operates its cereal export policy by considering the Community supply situation, the willingness to avoid price fluctuations on the Community markets, the world market situation and the areas where export opportunities can be found. Pressure from the USA has also played a significant role in Commission's decisions in recent years.
The EC wheat regime tries to prevent the entry into the Community of lower priced produce from third countries. Import levies, based on the threshold price are used to regulate imports

of cereals. The levy is calculated as the difference between the threshold price and the lowest currently available cif price at a Community port (generally Rotterdam). Since, for most of the time, world prices are below those prevailing on Community markets, grain, which cannot be sold on domestic markets and which has to be exported, benefits from an **export refund** to compensate for the price gap. In exceptional circumstances, when world prices are above Community prices, export levies may be imposed. Refunds are fixed by the Cereals Management Committee every week in accordance with the following criteria:

. cereal prices in the Community.
. the most favourable quotations recorded on the market of importing third countries.
. the marketing costs and transport charges within the country from the Community markets to the ports for these exports.

Exports refunds can vary according to the country of destination since third countries are divided among eight zones.

1-A.3 Specific arrangements relative to the agri-monetary system

There is a number of specific arrangements which may undermine the application of the MCA system (Fulton, 1988).

1. the franchise or neutral margin : it is a fixed and arbitrary deduction operated on the gross MCA percentage. They are of 1 and 1.5 % for positive and negative MCAs respectively.

2. the non-cumulative rule which states that if the net MCA (after franchise deduction) is less than or equal to ± 0.5 %, and greater than ± 0.5 % but less than or equal to 1 %, the MCA is merely taken to be null or equal to ± 1 % respectively.

3. the minimum change rule : the MCA should move by a minimum of 1 % since it was previously set. Otherwise it remains unchanged.

4. The MCA fixation delay can also be prejudicial to the good functioning of the MCA's system. MCA's calculation is realized on the Wednesday of week t, based on exchange rate of the previous 7 days (average exchange rate over a Wednesday-Tuesday period) and applied on the following Monday of the week t+1. This delay represents nearly two weeks which, in the case of volatile exchange rate, can lead to currency losses or gains. The

competitive position of a country in turn may be changed.

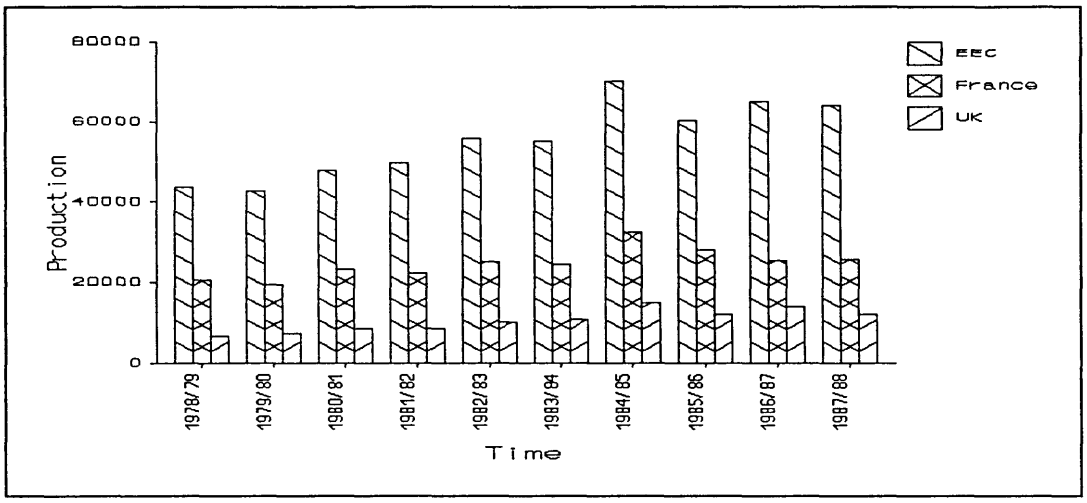
5. MCA calculation basis. The MCA calculation is currently based on 92.5 % of the July intervention price. Such arrangement comes from the market situation which permanently keeps a market prices below the intervention price. Then, a MCA calculated on the full intervention price would produce a MCA levy or refund which over-compensated for the price disparity resulting from the gap between the green currency and the prevailing exchange rate of the currency. By choosing to base the value of the MCA on these lower prices, it is hoped that much of this over-compensation may be eliminated although some degree of over-compensation may still persist. Nevertheless, if market prices were higher than the assumed levels used in the MCA calculation, than the MCA may well under-compensate the intra-Community trader.

The calculation of the MCA is also based on the July intervention price (before the August price) instead of the prevailing intervention price and despite the rise in both market and intervention prices which takes place during the marketing season. For a negative MCA country, the MCA export levy progressively under-compensate the price gap existing between its domestic market and other member states' domestic market. Thus, it improves that country's competitiveness as the season goes on. The argument is reversed for a positive MCA country where the strength of its currency is less and less compensated.

6. There may also be fluctuations of the market exchange rate around the central rate, used for the calculation of the MCA for the so-called fixed-currency countries. For example, France is a member of the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) and its currency is allowed to fluctuate within a narrow range of ± 2.25% around its bilateral central rate with the other inner-group currencies of the ERM. These fluctuations however are not taken into account in the calculation of the French MCA's at the beginning of each marketing year.

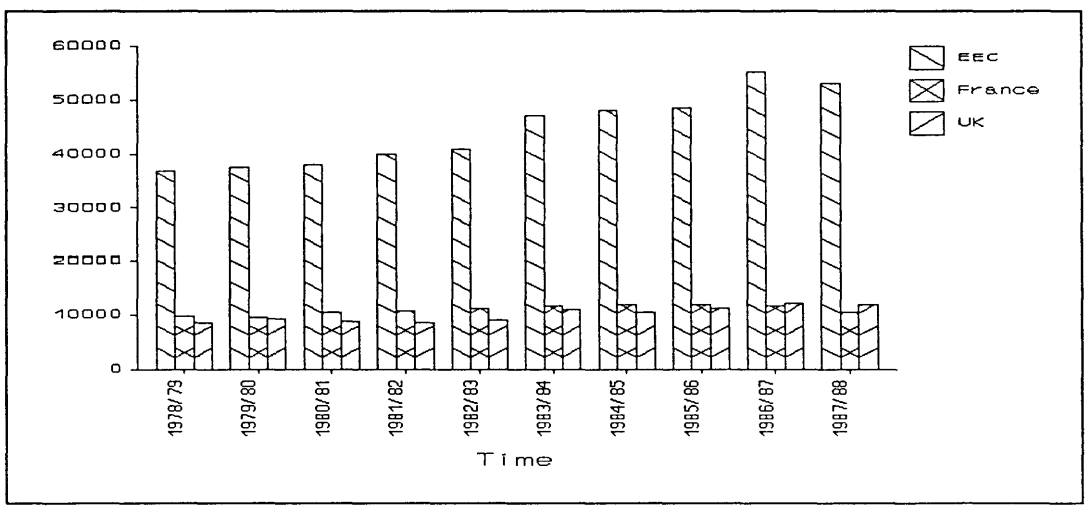
Appendix 1-B Figures related to the EC wheat market

Fig 1-B.1 Soft wheat total production in the EC-10, France and the UK, in '000 tonnes from 1978/79 to 1988/89



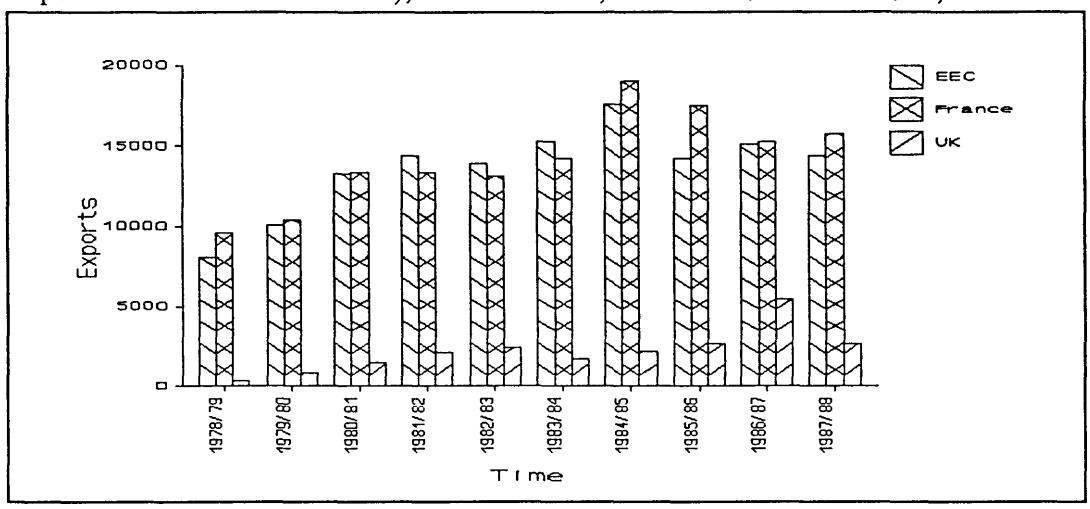
Source: EUROSTAT

Fig 1-B.2 Soft wheat total utilisation in the EC-10, France and the UK, in '000 tonnes from 1978/79 to 1988/89



Source: EUROSTAT

Figure 1-B.3 Soft wheat export from the EC-10, France and the UK (including intra-EC export for France and the UK), in '000 tonnes, from 1978/79 to 1988/89,



Source: EUROSTAT

2-A.1 Price risk results in the UK and France

2-A.1.1 Annual average of monthly short-term price risk calculated from weekly data for the UK and French domestic markets.

UK : Intra-Marketing Year	Forecast Error				Price Risk	
	4 Lags	8 Lags	12 Lags	1-12 Lags	UK	UK/France
1982/83	-.0040	-.0129	-.0168	-.0118	.0159	.7769
1983/84	-.0012	.0064	.0221	.0129	.0203	1.0544
1984/85	-.0107	-.0139	-.0123	-.0101	.0174	.8231
1985/86	-.0034	-.0042	-.0086	-.0015	.0106	.3938
1986/87	-.0025	-.0014	.0001	.0068	.0209	.6308
Overall (1982/87)	-.0044	-.0053	-.0030	-.0007	.0165	.7262

France : Intra-Marketing Year	Forecast Error				Price Risk
	4 Lags	8 Lags	12 Lags	1-12 Lags	
1982/83	.0006	-.0022	-.0026	-.0051	.0207
1983/84	.0123	.0159	.0207	.0095	.0199
1984/85	.0057	.0064	-.0003	-.0056	.0231
1985/86	.0023	.0010	-.0026	-.0103	.0256
1986/87	-.0086	-.0091	-.0093	-.0174	.0328
Overall (1982/87)	.0024	.0024	.0012	-.0056	.0244

Inter-Marketing Year : Forecast Error					Price Risk	
	4 Lags	8 Lags	12 Lags	1-12 Lags	UK	UK/ France
UK :	.0028	-.0124	-.0247	-.0217	.0289	.8128
France :	.0069	-.0064	-.0093	.0066	.0421	

Overall 1982/87 (intra- and inter marketing year)

UK :	-.0038	-.0063	-.0076	-.0054	.0193	.7454
France :	.0028	.0012	-.0010	-.0028	.0286	

2-A.1.2 Annual average of monthly short-term price risk calculated from weekly data for exports from France to the UK:

Intra-Marketing Year :	Forecast Error				Price Risk
	4 Lags	8 Lags	12 Lags	1-12 Lags	
1983/84	.0152	.0241	.0429	.0196	.0294
1984/85	.0012	.0056	.0107	.0112	.0207
1985/86	.0071	.0194	.0372	.0071	.0307
1986/87	-.0063	-.0179	-.0241	-.0076	.0382
Overall	.0042	.0075	.0161	.0076	.0297

Inter-Marketing Year :	Forecast Error				Price Risk
	4 Lags	8 Lags	12 Lags	1-12 Lags	
	-.1083	-.0971	-.0958	-.0544	.0541

Overall 1982/87 (intra- and inter marketing year)

	-.0046	-.0071	-.0067	-.0069	.0355

2-A.1.3 Annual price risk calculated from weekly data for the UK market, the French domestic market and the export between these two countries.

Marketing Year:	1982/83	1983/84	1984/85	1985/86	1986/87
Price Risk :					
UK	.0223	.0449	.0341	.0194	.0365
France	.0241	.0339	.0273	.0627	.0434
French Export		.0588	.0430	.0916	.0518
Average Forecast Error :					
UK	-.0187	.0145	.0173	-.0566	.0898
France	.0395	.0068	-.0642	-.0812	-.1772
French Export		-.0759	-.0629	-.0863	-.0022

2-A.2 SARIMA models for assessment of price risk on the UK, French domestic and French export markets[114]

2-A.2.1 Models for french domestic markets

. Model No.1 : From 1978.08 to 1982.07

$$(1-B).(1-B^{52}).(1 + 0.569B^{1} + 0.211B^{2}).Y_t = (1 + 0.739B^{52}).(1 + 0.263B^{37}).\epsilon_t$$
$$(-8.28) \quad (-2.61) \qquad (-7.39) \qquad (-2.86)$$

R^2 adj. = 0.453
Sum of Squared Resid= 17,147.10
$X^2(4;60)$ = 30.02

. Model No.2 : From 1978.08 to 1982.08

$$(1-B).(1-B^{52}).(1 + 0.520B^{1} + 0.148B^{2}).Y_t = (1 + 0.763B^{52}).(1 + 0.156B^{5} + 0.281B^{37}).\epsilon_t$$
$$(-7.52) \quad (-2.14) \qquad (-7.68) \qquad (-2.17) \quad (-3.02)$$

R^2 adj. = 0.457
Sum of Squared Resid= 18,279.45
$X^2(5;60)$ = 38.50

. Model No.3 : From 1978.08 to 1982.11

$$(1-B).(1-B^{52}).(1 + 0.442B^{1}).Y_t = (1 + 0.738B^{52}).(1 + 0.170B^{5} + 0.219B^{37}).\epsilon_t$$
$$(-7.76) \qquad (-7.68) \qquad (-2.51) \quad (-2.53)$$

R^2 adj. = 0.459
Sum of Squared Resid= 20,029.96
$X^2(4;60)$ = 31.55

. Model No.4 : From 1978.08 to 1983.02

$$(1-B).(1-B^{52}).(1 + 0.431B^{1}).Y_t = (1 + 0.765B^{52}).(1 + 0.213B^{37}).\epsilon_t$$
$$(-7.63) \qquad (-8.01) \qquad (-2.29)$$

R^2 adj. = 0.442
Sum of Squared Resid= 25,564.87
$X^2(3;60)$ = 43.01

[114] Description of the models : they are all of the form SARIMA $(p,d,q;P,D,Q)_s$. We can notice that in all models we find $d = D = 1$, $s = 52$, $P = 0$ and $Q = 1$. Figures in brackets denote the t-statistic values. Chi-squared value at the 5 % significance level with 56, 57 and 58 degrees of freedom is about 79.1.

. Model No.5 : From 1978.08 to 1983.03

$$(1-B).(1-B^{52}).(1 + 0.429B^{1}).Y_t = (1 + 0.781B^{52}).(1 + 0.158B^{26}).\epsilon_t$$
$$(-7.77) \qquad (-8.58) \qquad (-2.29)$$

R^2 adj. = 0.451
Sum of Squared Resid= 24,990.40
$X^2(3;60)$ = 33.96

. Model No.6 : From 1978.08 to 1983.06

$$(1-B).(1-B^{52}).(1 + 0.559B^{1} + 0.185B^{2}).Y_t = (1 + 0.784B^{52}).(1 + 0.330B^{26}).\epsilon_t$$
$$(-9.50) \quad (-3.13) \qquad (-8.02) \qquad (-4.40)$$

R^2 adj. = 0.471
Sum of Squared Resid= 34,485.23
$X^2(4;60)$ = 45.84

. Model No.7 : From 1978.08 to 1983.07

$$(1-B).(1-B^{52}).(1 + 0.511B^{1} + 0.194B^{2} - 0.151B^{17}).Y_t = (1 + 0.749B^{52}).(1 + 0.215B^{2} + 0.148B^{11} + 0.321B^{26}).\epsilon_t$$
$$(-8.93) \quad (-3.88) \quad (2.36) \qquad (-8.16) \qquad (-2.93) \quad (-2.19) \qquad (-4.26)$$

R^2 adj. = 0.550
Sum of Squared Resid= 34,404.97
$X^2(7;60)$ = 49.75

. Model No.8 : From 1978.08 to 1983.09

$$(1-B).(1-B^{52}).(1 + 0.517B^{1} + 0.201B^{4}).Y_t = (1 + 0.767B^{52}).(1 + 0.212B^{2} + 0.152B^{11} - 0.149B^{17} + 0.276B^{26}).\epsilon_t$$
$$(-9.97) \quad (-4.40) \qquad (-9.20) \qquad (-3.19) \quad (-2.55) \quad (2.36) \qquad (-3.96)$$

R^2 adj. = 0.577
Sum of Squared Resid= 35,474.43
$X^2(7;60)$ = 53.74

. Model No.9 : From 1978.08 to 1984.07

$$(1-B).(1-B^{52}).(1 + 0.395B^{1} + 0.144B^{4}).Y_t = (1 + 0.787B^{52}).(1 + 0.193B^{2} - 0.196B^{17} + 0.226B^{26} + 0.171B^{37}).\epsilon_t$$
$$(-8.37) \quad (-3.35) \qquad (-10.58) \qquad (-3.19) \quad (3.41) \quad (-3.83) \qquad (-2.90)$$

R^2 adj. = 0.571
Sum of Squared Resid= 54,846.46
$X^2(7;60)$ = 42.66

. Model No.10 : From 1978.08 to 1984.07

$$(1-B).(1-B^{52}).(1+0.410B^{1}).Y_t = (1+0.724B^{52}).(1+0.295B^{2}-0.154B^{17}+0.169B^{26}+0.161B^{37}).\epsilon_t$$
$$(-8.39) \quad (-9.57) \quad (-5.04) \quad (2.66) \quad (-2.78) \quad (-2.61)$$

R^2 adj. = 0.524
Sum of Squared Resid= 65,217.34
$X^2(6;60)$ = 55.79

. Model No.11 : From 1978.08 to 1985.07

$$(1-B).(1-B^{52}).(1+0.383B^{1}+0.088B^{6}+0.172B^{16}).Y_t = (1+0.748B^{52}).(1+0.302B^{2}+0.168B^{37}+0.153B^{44}).\epsilon_t$$
$$(-8.58) \quad (-2.08) \quad (-3.90) \quad (-11.26) \quad (-5.75) \quad (-3.22) \quad (-2.95)$$

R^2 adj. = 0.508
Sum of Squared Resid= 78,479.73
$X^2(7;60)$ = 66.03

. Model No.12 : From 1978.08 to 1985.08

$$(1-B).(1-B^{52}).(1+0.395B^{1}+0.088B^{6}+0.171B^{16}).Y_t = (1+0.792B^{52}).(1+0.308B^{2}+0.114B^{26}+0.174B^{37}+0.171B^{44}).\epsilon_t$$
$$(-8.93) \quad (-2.13) \quad (-3.91) \quad (-13.08) \quad (-5.81) \quad (-2.22) \quad (-3.31) \quad (-3.28)$$

R^2 adj. = 0.518
Sum of Squared Resid= 77,920.34
$X^2(8;60)$ = 53.04

. Model No.13 : From 1978.08 to 1985.12

$$(1-B).(1-B^{52}).(1+0.399B^{1}+0.097B^{6}+0.159B^{16}).Y_t = (1+0.810B^{52}).(1+0.297B^{2}+0.141B^{37}+0.172B^{44}).\epsilon_t$$
$$(-9.16) \quad (-2.38) \quad (-3.82) \quad (-13.56) \quad (-5.84) \quad (-2.81) \quad (-3.40)$$

R^2 adj. = 0.504
Sum of Squared Resid= 83,607.75
$X^2(7;60)$ = 56.52

. Model No.14 : From 1978.08 to 1986.02

$$(1-B).(1-B^{52}).(1+0.400B^{1}+0.088B^{6}+0.138B^{16}).Y_t = (1+0.789B^{52}).(1+0.296B^{2}-0.116B^{24}+0.144B^{37}+0.161B^{44}).\epsilon_t$$
$$(-9.34) \quad (-2.19) \quad (-3.37) \quad (-13.18) \quad (-5.80) \quad (2.44) \quad (-2.87) \quad (-3.20)$$

R^2 adj. = 0.508
Sum of Squared Resid= 84,868.84
$X^2(8;60)$ = 56.02

. Model No.15 : From 1978.08 to 1986.08

$$(1-B).(1-B^{52}).(1 + 0.247B^{1} + 0.133B^{6} + 0.167B^{16}).Y_t = (1 + 0.729B^{52}).(1 + 0.146B^{2} + 0.124B^{44}).\epsilon_t$$
$$(-5.52)\quad (-2.92)\quad (-3.92)\qquad\qquad (-11.01)\qquad (-2.96)\quad (-2.28)$$

R^2 adj. = 0.381
Sum of Squared Resid= 137,482.90
$X^2(6;60)$ = 37.17

. Model No.16 : From 1978.08 to 1986.09

$$(1-B).(1-B^{52}).(1 + 0.264B^{1} + 0.114B^{6} + 0.157B^{16}).Y_t = (1 + 0.734B^{52}).(1 + 0.218B^{2} + 0.176B^{3}$$
$$(-5.83)\quad (-2.59)\quad (-3.28)\qquad\qquad (-11.07)\qquad (-4.40)\quad (-3.69)$$
$$+ 0.137B^{4} + 0.135B^{44}).\epsilon_t$$
$$(-2.43)\quad (-2.87)$$

R^2 adj. = 0.387
Sum of Squared Resid= 139,818.50
$X^2(8;60)$ = 29.57

2-A.2.2. Models for the UK

. Model No.1 : From 1979.08 to 1982.08

$$(1-B).(1-B^{52}).Y_t = (1 + 0.293B^{1} + 0.147B^{10}).(1 + 0.691B^{52}).\epsilon_t$$
$$(-4.30)\quad (-2.17)\qquad\qquad (-8.16)$$

R^2 adj. = 0.409
Sum of Squared Resid= 721.25
$X^2(3;60)$ = 33.76

. Model No.2 : From 1979.08 to 1982.09

$$(1-B).(1-B^{52}).Y_t = (1 + 0.233B^{1} + 0.142B^{8} - 0.272B^{45}).(1 + 0.746B^{52}).\epsilon_t$$
$$(-3.38)\quad (-2.14)\quad (3.8)\qquad\qquad (-8.9)$$

R^2 adj. = 0.405
Sum of Squared Resid= 737.24
$X^2(4;60)$ = 28.32

. Model No.3 : From 1979.08 to 1983.01

$$(1-B).(1-B^{52}).Y_t = (1 + 0.233B^{1} - 0.247B^{45} + 0.214B^{46}).(1 + 0.724B^{52}).\epsilon_t$$
$$(-3.66) \quad (3.69) \quad (-3.22) \quad (-9.35)$$

R^2 adj. = 0.436
Sum of Squared Resid= 712.18
$X^2(4;60)$ = 22.12

. Model No.4 : From 1979.08 to 1983.10

$$(1-B).(1-B^{52}).Y_t = (1 + 0.346B^{1} + 0.156B^{46}).(1 + 0.716B^{52}).\epsilon_t$$
$$(-5.92) \quad (-2.55) \quad (-10.09)$$

R^2 adj. = 0.392
Sum of Squared Resid= 910.57
$X^2(3;60)$ = 35.65

. Model No.5 : From 1979.08 to 1984.07

$$(1-B).(1-B^{52}).Y_t = (1 + 0.361B^{1} - 0.122B^{45} + 0.209B^{46}).(1 + 0.751B^{52}).\epsilon_t$$
$$(-6.89) \quad (2.24) \quad (-3.81) \quad (-11.61)$$

R^2 adj. = 0.431
Sum of Squared Resid= 974.03
$X^2(4;60)$ = 39.19

. Model No.6 : From 1979.08 to 1985.07

$$(1-B).(1-B^{52}).Y_t = (1 + 0.33B^{1}).(1 + 0.856B^{52}).\epsilon_t$$
$$(-7.76) \quad (-15.38)$$

R^2 adj. = 0.472
Sum of Squared Resid= 1074.11
$X^2(2;60)$ = 69.05

. Model No.7 : From 1979.08 to 1985.08

$$(1-B).(1-B^{52}).Y_t = (1 + 0.359B^{1} + 0.109B^{46}).(1 + 0.698B^{52}).\epsilon_t$$
$$(-7.21) \quad (-2.14) \quad (-10.89)$$

R^2 adj. = 0.33
Sum of Squared Resid= 1484.73
$X^2(3;60)$ = 43.94

. Model No.8 : From 1979.08 to 1986.06

$$(1-B).(1-B^{52}).Y_t = (1 + 0.354B^{1} - 0.135B^{41}).(1 + 0.691B^{52}).\epsilon_t$$
$$(-7.70) \quad (2.96) \quad (-12.09)$$

R^2 adj. = 0.328
Sum of Squared Resid= 1622.12
$X^2(3;60)$ = 53.71

. Model No.9 : From 1979.08 to 1986.07

$$(1-B).(1-B^{52}).Y_t = (1 + 0.333B^{1} - 0.123B^{41} + 0.116B^{46}).(1 + 0.703B^{52}).\epsilon_t$$
$$(-7.27) \quad (2.69) \quad (-2.48) \quad (-12.25)$$

R^2 adj. = 0.345
Sum of Squared Resid= 1624.53
$X^2(4;60)$ = 49.80

2-A.2.3 Models for French export market

. Model No.1 : 08/1980 to 07/1983

$$(1-B).(1-B^{52}).(1 + 0.334B^{1} + 0.205B^{2}).Y_t = (1 + 0.757B^{52}).(1 - 0.307B^{7}).\epsilon_t$$
$$(-4.58) \quad (-2.80) \quad (-8.52) \quad (4.01)$$

R^2 adj = 0.509
SSR = 70,902.59
X^2 (60;4) = 32.33

. Model No.2 : 08/1980 to 02/1984

$$(1-B).(1-B^{52}).Y_t = (1 + 0.693B^{52}).(1 + 0.169B^{1} - 0.217B^{7}).\epsilon_t$$
$$(-8.19) \quad (-2.41) \quad (3.20)$$

R^2 adj = 0.418
SSR = 99,643.48
X^2 (60;3) = 44.65

. Model No.3 : 08/1980 to 08/1984

$$(1-B).(1-B^{52}).Y_t = (1 + 0.747B^{52}).(1 + 0.276B^{1} + 0.135B^{2}).\epsilon_t$$
$$(-9.22) \quad (-4.23) \quad (-2.51)$$

R^2 adj = 0.380
SSR =149,307.30
X^2 (60;3) = 30.93

2-A.3 SARIMA models used in the portfolio risk estimation in the UK and in France[115]

2-A.3.1 Models for the UK

2-A.3.1.1 Eggs

Model No.1 : From 1978.01 to 1984.07

$$(1-B).(1-B^{12}).Y_t = (1 - 0.385B^5 + 0.476B^{16}).(1 + 0.623B^{12}).\epsilon_t$$
$$(2.29) \quad (-2.98) \quad (-3.45)$$

R^2 adj. = 0.407
Sum of Squared Resid= 110.85
$X^2(3;32)$ = 15.83

Model No.2 : From 1978.01 to 1985.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.448B^{16}).(1 + 0.698B^{12}).\epsilon_t$$
$$(-3.60) \quad (-4.983)$$

R^2 adj. = 0.495
Sum of Squared Resid= 125.77
$X^2(2;32)$ = 23.34

Model No.3 : From 1978.01 to 1986.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.362B^{16}).(1 + 0.737B^{12}).\epsilon_t$$
$$(-3.21) \quad (-5.49)$$

R^2 adj. = 0.432
Sum of Squared Resid= 161.65
$X^2(2;32)$ = 16.69

[115] Figures in brackets denote the t-statistic values. Chi-squared value at the 5 % significance level with 28, 29 and 30 degrees of freedom is 41.3, 42.5 and 43.7.

2-A.3.1.2 Pigmeat

Model No.1 : From 1978.01 to 1984.07

$$(1-B).(1-B^{12}).(1 - 0.263B^{2} + 0.233B^{3}).Y_t = (1 + 0.281B^{6}).(1 + 0.799B^{12}).\epsilon_t$$
$$(2.78) \quad (-2.41) \qquad\qquad (-2.58) \qquad (-5.48)$$

R^2 adj. = 0.468
Sum of Squared Resid= 162.21
$X^2(4;32)$ = 20.40

Model No.2 : From 1978.01 to 1985.07

$$(1-B).(1-B^{12}).(1 - 0.315B^{2} + 0.222B^{3}).Y_t = (1 + 0.217B^{6}).(1 + 0.799B^{12}).\epsilon_t$$
$$(3.63) \quad (-2.55) \qquad\qquad (-2.22) \qquad (-6.05)$$

R^2 adj. = 0.515
Sum of Squared Resid= 221.41
$X^2(4;32)$ = 21.90

Model No.3 : From 1978.01 to 1986.07

$$(1-B).(1-B^{12}).(1 - 0.324B^{2}).Y_t = (1 - 0.383B^{19} + 0.243B^{21}).(1 + 0.831B^{12}).\epsilon_t$$
$$(4.01) \qquad\qquad (3.87) \quad (-2.42) \qquad (-7.64)$$

R^2 adj. = 0.553
Sum of Squared Resid= 221.98
$X^2(4;32)$ = 30.21

2-A.3.1.3 Beefmeat

Model No.1 : From 1978.01 to 1984.07

$$(1-B).(1-B^{12}).(1 + 0.254B^{5}).Y_t = (1 + 0.89B^{12}).\epsilon_t$$
$$(-3.38) \qquad\qquad (-7.95)$$

R^2 adj. = 0.593
Sum of Squared Resid= 104.95
$X^2(2;32)$ = 11.54

Model No.2 : From 1978.01 to 1985.07

$$(1-B).(1-B^{12}).(1 + 0.246B^{5}).Y_t = (1 + 0.306B^{14}).(1 + 0.638B^{12}).\epsilon_t$$
$$(-2.74) \qquad\qquad (-2.68) \qquad (-4.71)$$

R^2 adj. = 0.396
Sum of Squared Resid= 218.71
$X^2(3;32)$ = 19.31

Model No.3 : From 1978.01 to 1986.07

$$(1-B).(1-B^{12}).(1 + 0.152B^{4} + 0.160B^{5}).Y_t = (1 + 0.872B^{12}).\epsilon_t$$
$$(-2.05) \quad (-2.17) \qquad (-8.26)$$

R^2 adj. = 0.501
Sum of Squared Resid= 201.65
$X^2(3;32)$ = 19.62

2-A.3.1.4 Wheat

Model No.1 : From 1978.08 to 1984.07

$$(1-B).(1-B^{12}).(1 + 0.389B^{2}).Y_t = (1 - 0.185B^{1}).(1 + 0.878B^{12}).\epsilon_t$$
$$(-4.91) \qquad (2.20) \qquad (-7.29)$$

R^2 adj. = 0.664
Sum of Squared Resid= 191.81
$X^2(3;32)$ = 16.30

Model No.2 : From 1978.08 to 1985.07

$$(1-B).(1-B^{12}).(1 + 0.414B^{2}).Y_t = (1 - 0.306B^{1}).(1 + 0.870B^{12}).\epsilon_t$$
$$(-4.92) \qquad (2.45) \qquad (-7.36)$$

R^2 adj. = 0.592
Sum of Squared Resid= 294.15
$X^2(3;32)$ = 19.89

Model No.3 : From 1978.08 to 1986.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.203B^{2}).(1 + 0.872B^{12}).\epsilon_t$$
$$(-2.54) \qquad (-7.32)$$

R^2 adj. = 0.549
Sum of Squared Resid= 447.15
$X^2(2;32)$ = 13.97

2-A.3.1.5 Barley

Model No.1 : From 1978.08 to 1984.07

$$(1-B).(1-B^{12}).Y_t = (1 - 0.349B^{9} + 0.302B^{13}).(1 + 0.514B^{12}).\epsilon_t$$
$$(2.55) \quad (-2.05) \qquad (-3.46)$$

R^2 adj. = 0.275
Sum of Squared Resid= 344.03
$X^2(3;32)$ = 15.09

Model No.2 : From 1978.08 to 1985.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.766B^{12}).\epsilon_t \quad (-6.89)$$

R^2 adj. = 0.408
Sum of Squared Resid= 339.53
$X^2(1;32)$ = 25.53

Model No.3 : From 1978.08 to 1986.07

$$(1-B).(1-B^{12}).(1 + 0.290B^{1}).(1 + 0.504B^{12}).Y_t = \epsilon_t \quad (-2.48) \quad (-5.71)$$

R^2 adj. = 0.306
Sum of Squared Resid= 316.55
$X^2(2;32)$ = 17.81

2-A.3.2 Models for France

2-A.3.2.1 Wheat

Model No.1 : From 1978.08 to 1984.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.528B^{8} + 0.337B^{13}).(1 + 0.479B^{12}).\epsilon_t \quad (-3.55) \quad (-2.16) \quad (-2.81)$$

R^2 adj. = 0.271
Sum of Squared Resid= 14080.90
$X^2(3;32)$ = 15.75

Model No.2 : From 1978.08 to 1985.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.423B^{1}).(1 + 0.795B^{12}).\epsilon_t \quad (-3.54) \quad (-5.07)$$

R^2 adj. = 0.442
Sum of Squared Resid= 36247.85
$X^2(2;32)$ = 15.38

Model No.3 : From 1978.08 to 1986.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.345B^{1}).(1 + 0.885B^{12}).\epsilon_t$$
$$(-3.97) \qquad (-7.75)$$

R^2 adj. = 0.591
Sum of Squared Resid= 44732.74
$X^2(2;32)$ = 21.59

2-A.3.2.2 Barley

Model No.1 : From 1978.08 to 1984.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.236B^{2}).(1 + 0.777B^{12}).\epsilon_t$$
$$(-2.25) \qquad (-5.32)$$

R^2 adj. = 0.328
Sum of Squared Resid= 19335.65
$X^2(2;32)$ = 15.43

Model No.2 : From 1978.08 to 1985.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.856B^{12}).\epsilon_t$$
$$(-7.31)$$

R^2 adj. = 0.439
Sum of Squared Resid= 20317.44
$X^2(1;32)$ = 15.65

Model No.3 : From 1978.08 to 1986.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.829B^{12}).\epsilon_t$$
$$(-6.21)$$

R^2 adj. = 0.338
Sum of Squared Resid= 42968.04
$X^2(1;32)$ = 18.32

2-A.3.2.3 Eggs

Model No.1 : From 1978.01 to 1984.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.860B^{12}).\epsilon_t$$
$$(-6.33)$$

R^2 adj. = 0.525
Sum of Squared Resid= 159.34
$X^2(1;32)$ = 18.06

Model No.2 : From 1978.01 to 1985.07

$$(1-B).(1-B^{12}).Y_t = (1 - 0.222B^{6}).(1 + 0.712B^{12}).\epsilon_t$$
$$(2.23) \qquad (-5.45)$$

R^2 adj. = 0.433
Sum of Squared Resid= 223.92
$X^2(2;32)$ = 17.26

Model No.3 : From 1978.01 to 1986.07

$$(1-B).(1-B^{12}).Y_t = (1 - 0.188B^{6}).(1 + 0.742B^{12}).\epsilon_t$$
$$(2.12) \qquad (-6.11)$$

R^2 adj. = 0.443
Sum of Squared Resid= 262.21
$X^2(2;32)$ = 18.36

2-A.3.2.4 Beefmeat

Model No.1 : From 1978.01 to 1984.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.246B^{3} - 0.297B^{7}).(1 + 0.776B^{12}).\epsilon_t$$
$$(-2.46) \quad (2.96) \qquad (-6.34)$$

R^2 adj. = 0.445
Sum of Squared Resid= 4.63
$X^2(3;32)$ = 13.76

Model No.2 : From 1978.01 to 1985.07

$$(1-B).(1-B^{12}).Y_t = (1 + 0.847B^{12}).\epsilon_t$$
$$(-6.84)$$

R^2 adj. = 0.467
Sum of Squared Resid= 7.40
$X^2(1;32)$ = 23.46

Model No.3 : From 1978.01 to 1986.07

$$(1-B).(1-B^{12}).(1 - 0.239B^{1}).Y_t = (1 + 0.180B^{9}).(1 + 0.929B^{12}).\epsilon_t$$
$$(3.05) \qquad (-2.34) \qquad (-8.93)$$

R^2 adj. = 0.486
Sum of Squared Resid= 8.18
$X^2(3;32)$ = 18.44

2-A.3.2.5 Pigmeat

Model No.1 : From 1978.01 to 1984.07

$$(1-B).(1-B^{12}).Y_t = (1 - 0.264B^{1} - 0.366B^{2}).(1 + 0.663B^{12}).\epsilon_t$$
$$(2.32) \quad (3.28) \qquad (-5.26)$$

R^2 adj. = 0.402
Sum of Squared Resid= 2.75
$X^2(3;32)$ = 18.75

Model No.2 : From 1978.01 to 1985.07

$$(1-B).(1-B^{12}).Y_t = (1 - 0.210B^{1} - 0.289B^{2}).(1 + 0.751B^{12}).\epsilon_t$$
$$(2.03) \quad (2.88) \qquad (-6.45)$$

R^2 adj. = 0.377
Sum of Squared Resid= 3.32
$X^2(3;32)$ = 18.91

Model No.3 : From 1978.01 to 1986.07

$$(1-B).(1-B^{12}).Y_t = (1 - 0.241B^{1} - 0.235B^{2}).(1 + 0.713B^{12}).\epsilon_t$$
$$(2.66) \quad (2.63) \qquad (-6.70)$$

R^2 adj. = 0.360
Sum of Squared Resid= 3.73
$X^2(3;32)$ = 18.68

2-A.4 Commodity portfolio price risk

	Individual Risk per Product					
UK: Product	84/85	85/86	86/87	84/85	85/86	86/87
	Product Price Risk in Absolute Value			Product Price Risk Scaled by the Portfolio Risk		
Wheat	.0243	.0271	.0343	1.572	.696	1.058
Barley	.0275	.0123	.0421	1.775	.316	1.299
Egg	.0443	.1816	.1248	2.862	4.650	3.8481
Pigmeat	.0334	.0172	.0564	2.161	.442	1.739
Beefmeat	.0236	.0181	.0167	1.523	.464	.515
Total Portfolio Price Risk	.0155	.0391	.0324			
Sum of individual commodity Variance (A)	.0009	.0069	.0044			
Total Portfolio Variance (B)	.0002	.0015	.0011			
Ratio (B/A)	.2403	.2209	.2391			

France : Product	84/85	85/86	86/87	84/85	85/86	86/87
	Product Price Risk in Absolute Value			Product Price Risk Scaled by the Portfolio Risk		
Wheat	.0427	.0502	.0497	2.131	1.424	1.666
Barley	.0331	.0391	.0460	1.656	1.109	1.544
Egg	.0634	.1176	.0182	3.167	3.338	.612
Pigmeat	.0267	.0440	.1168	1.335	1.249	3.912
Beefmeat	.0337	.0193	.0317	1.682	.549	1.064
Total Portfolio Price Risk	.0200	.0352	.0298			
Sum of individual commodity Variance (A)	.0017	.0040	.0039			
Total Portfolio Variance (B)	.0004	.0012	.0008			
Ratio (B/A)	.2280	.3073	.2275			

2-A.5 Price variability assessed by the coefficient of variation

Year	Wheat		Barley		Potato	
	France	UK	France	UK	France	UK
1981	02.77	02.86	04.96	03.37	44.49	31.78
1982	01.10	06.90	05.22	04.20	10.71	07.20
1983	05.50	03.50	06.70	04.69	33.35	18.27
1984	04.42	01.30	03.38	05.42	31.08	18.16
1985	05.29	06.73	06.36	06.18	39.82	41.23
1986	01.37	02.33	02.76	04.90	33.13	10.47
1987	N/A	N/A	N/A	N/A	N/A	N/A
Average	03.40	03.93	04.89	04.77	32.09	21.18

Year	Pigmeat		Egg		Tomato		Onion	
	France / UK		France / UK		France / UK		France / UK	
1981	07.45	03.41	07.44	07.05	45.73	61.54	17.81	13.85
1982	04.63	05.13	14.92	21.85	48.89	53.59	04.55	26.27
1983	03.30	03.98	17.93	15.63	34.52	49.08	26.27	41.72
1984	05.00	03.75	09.40	17.39	46.89	49.27	20.11	18.24
1985	02.24	04.13	08.00	07.94	66.19	61.81	30.73	23.57
1986	03.15	02.56	08.35	15.80	63.00	47.72	12.72	30.54
1987	N/A	02.97	N/A	N/A	57.05	42.64	N/A	N/A
Average	04.21	03.70	11.00	14.27	60.37	52.23	18.69	25.69

	Beef		Poultry		Apple		Wine
	France	UK	France	UK	France	UK	France
1981	03.31	03.87	07.52	01.55	33.04	15.37	04.92
1982	02.05	03.59	08.61	03.50	23.78	20.20	01.40
1983	03.08	03.84	08.43	03.57	12.39	12.28	05.07
1984	03.40	01.30	07.63	02.90	21.55	16.66	02.44
1985	03.30	03.08	08.10	04.76	08.30	14.56	02.76
1986	03.66	04.40	08.60	03.51	19.51	19.97	01.13
1987	01.58	02.88	20.76	02.20	N/A	N/A	04.53
Average	02.86	03.28	09.33	03.14	19.76	16.50	03.12

2-A.6 Data sources

Weekly data sources are as follows :

The Service de Nouvelles de Marche (SNM) in France and the Home-Grown Cereals Authority in the UK. French internal prices are weighted average prices of different qualities of soft wheat from nine major areas in FF/100 Kg, from 01/1978 to 05/1988. UK prices correspond to the HGCA weekly average ex-farm spot prices of feedwheat, in £/tonne, from 08/1978 to 07/1987. As far as exports from France to the UK are concerned, HGCA weekly average ex-farm spot prices of bread-making wheat, in £/tonne, from 08/1978 to 07/1987 are used. Values of MCA for France and the UK are extracted from the weekly bulletin of Agra-Europe as well as the exchange rate between the £ and the FFr.

Analysis of portfolio price risk involves monthly data.

. wheat and barley : HGCA monthly average ex-farm spot prices of feedwheat, in £/tonne, from 08/1978 to 07/1987 are used for the UK while the HGCA monthly average soft wheat prices in Rouen are used for France. Barley sources and data reference are similar.
. eggs : The main source is the Commission of the European Communities.
France : Paris-Rungis market : monthly wholesale selling price, free-at-market, quality A4, price in FFr/100 eggs, from 01.1978 to 04.1988.
United Kingdom : National monthly average of wholesale buying price for "Standard " quality eggs (57,4 g), price in £/dozen, from 1978.01 to 04/1987.
. pigmeat : Source : Commission of the European Communities. France : Monthly weighted average of the following group of quotation centres : Rennes, Angers, Caen, Lille, Paris, Lyon, Metz, Toulouse. The quality is Class II, with price in FFr/100 Kg of Slaughtered Weight, from 01.1978 to 07.1988.
United-Kingdom : Monthly weighted average of the quotation centre of Bletchley for the following group of regions : Scotland, Northern Ireland, Wales and Western England, Northern England, Eastern England. Quality is Class II, with price in £/100 kg of Slaughtered Weight, from 01.1978 to 05.1988.
. beefmeat : Source : Commission of the European Communities. The monthly prices used in our survey refer to the national average of market prices of Adult Bovine Animals on fifteen representative markets in France and fourty-one in the United kingdom, from 01.1978 to 01.1988. These prices are expressed in Ecu/100 Kg of Live weight (net weight on the hoof).

Table 3-A.1. Nearby basis risk results in the UK and in France

UK : Intra-Marketing Year	Forecast Error 4 Lags	Forecast Error 8 Lags	Forecast Error 12 Lags	Basis Risk 1-12 Lags	Basis Risk	Basis Risk/ Price Risk
1983/84	.0029	.0029	.0008	.0009	.0148	.3699
1984/85	-.0163	-.0156	-.0069	-.0058	.0219	1.1771
1985/86	-.0018	-.0030	-.0038	.0017	.0136	1.2019
1986/87	.0057	.0125	.0030	.0057	.0137	.3102
Overall	-.0025	-.0007	-.0017	-.0013	.0161	.5191

France 1: Intra-Marketing Year :	Forecast Error 4 Lags	Forecast Error 8 Lags	Forecast Error 12 Lags	Basis Risk 1-12 Lags	Basis Risk	Basis Risk/ Price Risk
1983/84	.0199	.0359	.0459	.0291	.0248	1.2553
1984/85	-.0062	-.0021	.0058	.0078	.0253	1.1835
1985/86	.0068	.0199	.0384	.0319	.0271	1.1226
1986/87	.0041	-.0104	-.0258	-.0042	.0369	1.0980
Overall	.0061	.0106	.0155	.0158	.0286	1.1659

France 2: Intra-Marketing Year :	Forecast Error 4 Lags	Forecast Error 8 Lags	Forecast Error 12 Lags	Basis Risk 1-12 Lags	Basis Risk	Basis Risk/ Price Risk
1983/84	.0103	.0186	.0176	.0126	.0285	1.0175
1984/85	-.0030	-.0072	-.0105	-.0095	.0211	1.0564
1985/86	-.0122	-.0126	-.0178	.0007	.0334	1.1829
1986/87	.0023	.0028	-.0030	-.0080	.0226	.6715
Overall	-.0009	.0007	-.0031	-.0011	.0263	.9769

Inter-Marketing Year :	Forecast Error 4 Lags	Forecast Error 8 Lags	Forecast Error 12 Lags	Basis Risk 1-12 Lags	Basis Risk	Basis Risk/ Price Risk
UK :	.0270	.0147	.0122	.0007	.0407	.8056
France 1:	.0156	.0037	.0083	.0144	.0390	.9956
France 2:	.0804	.0592	.0676	.0481	.0454	.9675

Overall 1983/87 (intra- and inter marketing year)

UK :	-.0002	-.0001	.0011	-.0012	.0215	1.6798
France 1:	.0069	.0096	.0141	.0154	.0311	1.1258
France 2:	.0054	.0089	.0114	.0105	.0308	.9747

France 1 and France 2 refer to French domestic operators and exporters to the UK respectively.

3-A.2 Basis risk models[116]

3-A.2.1 Models of UK nearby basis risk

Model No.1 : 08/1980 to 07/1983

$$(1-B).(1-B^{52}).(1 + 0.110B^{2} + 0.309B^{4}).Y_t = (1 - 0.891B^{52}).(1 + 0.247B^{3} - 0.181B^{5}).\epsilon_t$$
$$\qquad\qquad (-2.01) \quad (-5.14) \qquad\qquad (16.12) \qquad (-3.72) \quad (3.55)$$

R^2 adj = 0.748
SSR = 207.34
X^2 (60;5) = 39.32

Model No.2 : 08/1980 to 08/1983

$$(1-B).(1-B^{52}).(1 + 0.290B^{4}).Y_t = (1 - 0.941B^{52}).(1 + 0.247B^{3}).\epsilon_t$$
$$\qquad\qquad (-6.02) \qquad\qquad (19.65) \qquad (-3.37)$$

R^2 adj = 0.785
SSR = 181.91
X^2 (60;3) = 43.90

Model No.3 : 08/1980 to 10/1983

$$(1-B).(1-B^{52}).(1 + 0.487B^{1} + 0.389B^{2}).Y_t = (1 + 0.488B^{3} + 0.404B^{4} - 0.205B^{7}).\epsilon_t$$
$$\qquad\qquad (-5.49) \quad (-3.89) \qquad\qquad (-4.43) \quad (-4.01) \quad (2.11)$$

R^2 adj = 0.293
SSR = 604.97
X^2 (60;5) = 27.77

Model No.4 : 08/1980 to 07/1984

$$(1-B).(1-B^{52}).(1 + 0.449B^{1} + 0.335B^{2}).Y_t = (1 + 0.395B^{3} + 0.425B^{4} + 0.176B^{6}).\epsilon_t$$
$$\qquad\qquad (-5.90) \quad (-4.01) \qquad\qquad (-4.23) \quad (-4.94) \quad (-2.01)$$

R^2 adj = 0.309
SSR = 726.24
X^2 (60;5) = 36.52

[116] All the models are of the form SARIMA $(p,d,q;P,D,Q)_s$. Note that in most of models we find $d = D = 1$, $s = 52$, $p = P = 0$ and $Q = 1$. Figures in brackets denote the t-statistic values and SSR refers to the sum of squared residuals. Chi-Squared value at the 5% significance level with 56, 57 and 58 degrees of freedom is approximately 79.1.

Model No.5 : 08/1980 to 08/1985

$$(1-B).(1-B^{52}).(1 + 0.344B^{1}).Y_t = (1 + 0.227B^{3} + 0.458B^{4} + 0.313B^{6}).\epsilon_t$$
$$(-5.77) \qquad (-3.20) \quad (-6.23) \quad (-4.24)$$

R^2 adj = 0.307
SSR = 1,231.91
X^2 (60;4) = 54.59

Model No.6 : 08/1980 to 11/1984

$$(1-B).(1-B^{52}).(1 + 0.370B^{1} + 0.133B^{2}).Y_t = (1 + 0.279B^{3} + 0.395B^{4} + 0.280B^{6}).\epsilon_t$$
$$(-6.09) \quad (-2.05) \qquad (-3.82) \quad (-5.67) \quad (-3.92)$$

R^2 adj = 0.311
SSR = 1,240.65
X^2 (60;5) = 40.17

3-A.2.2 Models of France 1 nearby basis risk

Model No.1 : 08/1980 to 07/1983

$$(1-B).(1-B^{52}).(1 - 0.547B^{1} + 0.187B^{2}).Y_t = (1 + 0.970B^{52}).\epsilon_t$$
$$(9.98) \quad (-3.94) \qquad (-19.63)$$

R^2 adj = 0.798
SSR = 32,204.89
X^2 (60;3) = 40.78

Model No.2 : 08/1980 to 09/1983

$$(1-B).(1-B^{52}).Y_t = (1 + 0.757B^{52}).(1 + 0.174B^{4} + 0.404B^{22}).\epsilon_t$$
$$(-7.65) \qquad (-2.22) \quad (-2.04)$$

R^2 adj = 0.367
SSR =104,390.20
X^2 (60;3) = 44.58

Model No.3 : 08/1980 to 02/1984

$$(1-B).(1-B^{52}).Y_t = (1 + 0.673B^{52}).(1 + 0.180B^{4} + 0.166B^{5} + 0.147B^{28}).\epsilon_t$$
$$(-7.35) \qquad (-2.45) \quad (-2.27) \quad (-2.14)$$

R^2 adj = 0.353
SSR =111,998.70
X^2 (60;4) = 42.35

Model No.4 : 08/1980 to 04/1984

$$(1-B).(1-B^{52}).(1 + 0.189B^{4} + 0.161B^{5}).Y_t = (1 + 0.676B^{52}).(1 + 0.140B^{4}).e_t$$
$$(-2.74) \quad (-2.34) \qquad (-7.31) \qquad (-2.05)$$

R^2 adj = 0.353
SSR =110,072.00
X^2 (60;4) = 35.27

Model No.5 : 08/1980 to 07/1984

$$(1-B).(1-B^{52}).Y_t = (1 + 0.627B^{52}).(1 + 0.171B^{4} + 0.179B^{5} + 0.186B^{41}).e_t$$
$$(-7.47) \qquad (-2.38) \quad (-2.49) \quad (-2.59)$$

R^2 adj = 0.273
SSR =145,404.50
X^2 (60;4) = 38.78

Model No.6 : 08/1980 to 12/1984

$$(1-B).(1-B^{52}).(1 + 0.306B^{4} + 0.168B^{20}).Y_t = (1 + 0.895B^{52}).e_t$$
$$(-6.16) \quad (-3.49) \qquad (-15.45)$$

R^2 adj = 0.625
SSR = 71,017.86
X^2 (60;3) = 37.54

Model No.7 : 08/1980 to 07/1985

$$(1-B).(1-B^{52}).(1 + 0.107B^{1} + 0.189B^{4} + 0.241B^{5}).Y_t = (1 + 0.811B^{52}).e_t$$
$$(-2.01) \quad (-3.53) \quad (-4.36) \qquad (-11.68)$$

R^2 adj = 0.429
SSR =133,480.90
X^2 (60;4) = 62.77

Model No.8 : 08/1980 to 07/1986

$$(1-B).(1-B^{52}).(1 + 0.192B^{4} + 0.224B^{20}).Y_t = (1 + 0.815B^{52}).e_t$$
$$(-4.08) \quad (-4.76) \qquad (-13.71)$$

R^2 adj = 0.440
SSR =149,203.20
X^2 (60;3) = 61.71

Model No.9 : 08/1980 to 04/1987

$$(1-B).(1-B^{52}).Y_t = (1 + 0.784B^{52}).(1 + 0.191B^{4} + 0.172B^{5}).\epsilon_t$$
$$(-13.39) \quad (-3.99) \quad (-3.61)$$

R^2 adj = 0.379
SSR =200,382.20
X^2 (60;3) = 60.95

3-A.2.3 Models of France 2 nearby basis risk

Model No.1 : 08/1980 to 07/1983

$$(1-B).(1-B^{52}).Y_t = (1 + 0.594B^{52}).(1 - 0.224B^{5} - 0.263B^{31}).\epsilon_t$$
$$(-5.14) \quad (2.57) \quad (3.05)$$

R^2 adj = 0.344
SSR =114,492.20
X^2 (60;3) = 32.45

Model No.2 : 08/1980 to 07/1984

$$(1-B).(1-B^{52}).Y_t = (1 + 0.612B^{52}).(1 - 0.184B^{5} - 0.143B^{31} + 0.173B^{48}).\epsilon_t$$
$$(-7.05) \quad (2.56) \quad (2.02) \quad (-2.42)$$

R^2 adj = 0.280
SSR =147,676.20
X^2 (60;4) = 39.65

Model No.3 : 08/1980 to 07/1985

$$(1-B).(1-B^{52}).Y_t = (1 + 0.638B^{52}).(1 + 0.127B^{4} - 0.186B^{5} + 0.172B^{22} + 0.138B^{48}).\epsilon_t$$
$$(-9.24) \quad (-2.06) \quad (2.94) \quad (-2.84) \quad (-2.31)$$

R^2 adj = 0.336
SSR =166,176.30
X^2 (60;5) = 50.01

Model No.4 : 08/1980 to 11/1986

$$(1-B).(1-B^{52}).Y_t = (1 + 0.584B^{52}).(1 + 0.133B^{1} + 0.179B^{4} + 0.220B^{22} + 0.220B^{48}).\epsilon_t$$
$$(-9.14) \quad (-2.36) \quad (-3.27) \quad (-3.94) \quad (-3.87)$$

R^2 adj = 0.281
SSR =219,094.20
X^2 (60;5) = 45.20

3-A.2.4 Models used for the next to nearby basis

3-A.2.4.1 UK basis risk

Model No.1 : 08/1980 to 07/1983

$$(1-B).(1-B^{52}).(1 + 0.425B^{1}).Y_t = (1 + 0.252B^{5}).\epsilon_t$$
$$(-4.36) \qquad (-2.34)$$

R^2 adj = 0.189
SSR = 488.81
X^2 (60;2) = 25.51

Model No.2 : 08/1980 to 07/1985

$$(1-B).(1-B^{52}).(1 + 0.358B^{1}).Y_t = (1 + 0.221B^{4} + 0.170B^{5} + 0.217B^{32}).\epsilon_t$$
$$(-5.21) \qquad (-2.88) \quad (-2.16) \quad (-2.69)$$

R^2 adj = 0.171
SSR = 906.19
X^2 (60;4) = 22.45

Model No.3 : 08/1980 to 07/1986

$$(1-B).(1-B^{52}).(1 + 0.438B^{1}).Y_t = (1 + 0.183B^{4} + 0.171B^{5} + 0.146B^{6} + 0.199B^{32} - 0.199B^{41}).\epsilon_t$$
$$(-7.60) \qquad (-2.76) \quad (-2.56) \quad (-2.20) \quad (-2.67) \quad (40.20)$$

R^2 adj = 0.250
SSR = 1,440.26
X^2 (60;6) = 26.27

3-A.2.4.2 France 1 basis risk

Model No.1 : 08/1980 to 07/1983

$$(1-B).(1-B52).Y_t = (1 + 0.849B^{52}).(1 - 0.216B^{5} + 0.204B^{5}).\epsilon_t$$
$$(-11.54) \qquad (3.08) \quad (-3.07)$$

R^2 adj = 0.612
SSR = 51,583.43
X^2 (60;3) = 29.31

Model No.2 : 08/1980 to 07/1984

$$(1-B).(1-B^{52}).Y_t = (1 + 0.876B^{52}).(1 + 0.225B^{1} + 0.232B^{5} - 0.151B^{6}).\epsilon_t$$
$$(-12.21) \quad (-4.17) \quad (-4.30) \quad (2.71)$$

R^2 adj = 0.605
SSR = 65,767.64
X^2 (60;4) = 31.15

Model No.3 : 08/1980 to 07/1985

$$(1-B).(1-B^{52}).(1 + 0.226B^{1} + 0.233B^{5}).Y_t = (1 + 0.784B^{52}).\epsilon_t$$
$$(-10.75) \quad (-4.45) \quad (-10.75)$$

R^2 adj = 0.434
SSR =109,313.70
X^2 (60;3) = 32.56

Model No.4 : 08/1980 to 07/1986

$$(1-B).(1-B^{52}).(1 + 0.275B^{1} + 0.173B^{5}).Y_t = (1 + 0.662B^{52}).(1 + 0.147B^{20} - 0.228B^{46}).\epsilon_t$$
$$(-5.42) \quad (-3.44) \quad (-9.61) \quad (-2.05) \quad (3.80)$$

R^2 adj = 0.349
SSR =165,433.20
X^2 (60;5) = 25.99

3-A.2.4.3 France 2 basis risk

Model No.1 : 08/1980 to 07/1983

$$(1-B).(1-B^{52}).(1 + 0.176B^{1}).Y_t = (1 + 0.777B^{52}).(1 + 0.164B^{5} + 0.227B^{17}).\epsilon_t$$
$$(-2.29) \quad (-7.52) \quad (-2.15) \quad (-2.95)$$

R^2 adj = 0.411
SSR = 81,134.92
X^2 (60;4) = 41.77

Model No.2 : 08/1980 to 07/1984

$$(1-B).(1-B^{52}).(1 + 0.154B^{1}).Y_t = (1 + 0.711B^{52}).(1 + 0.175B^{17} + 0.134B^{47}).\epsilon_t$$
$$(-2.65) \quad (-9.79) \quad (-3.05) \quad (-2.32)$$

R^2 adj = 0.335
SSR = 13,113.60
X^2 (60;4) = 48.71

3-A.2.5 Models used for the November Basis

3-A.2.5.1 UK basis risk

Model No.1 : 08/1980 to 07/1983

$$(1-B).(1-B^{52}).(1 + 0.439B^{1}).Y_t = (1 + 0.832B^{41}).\epsilon_t$$
$$(-9.23) \qquad (-6.08)$$

R^2 adj = 0.521
SSR = 225.78
X^2 (60;4) = 22.90

Model No.2 : 08/1980 to 07/1985

$$(1-B).(1-B^{52}).(1 + 0.244B^{1}).Y_t = (1 + 0.173B^{17} + 0.332B^{48}).\epsilon_t$$
$$(-3.39) \qquad (-3.74) \quad (-2.06)$$

R^2 adj = 0.122
SSR = 812.38
X^2 (60;4) = 35.81

Model No.3 : 08/1980 to 07/1986

$$(1-B).(1-B^{52}).(1 + 0.347B^{1} + 0.192B^{4}).Y_t = (1 + 0.207B^{5}).\epsilon_t$$
$$(-3.45) \quad (-2.88) \qquad (-2.36)$$

R^2 adj = 0.119
SSR = 1,174.38
X^2 (60;4) = 35.43

3-A.2.5.2 France 1 basis risk

Model No.1 : 08/1980 to 07/1983

$$(1-B).(1-B^{52}).(1 - 0.218B^{2}).Y_t = (1 + 0.873B^{52}).(1 + 0.270B^{5} - 0.210B^{6}).\epsilon_t$$
$$(3.13) \qquad (-11.22) \qquad (-3.60) \quad (2.80)$$

R^2 adj = 0.543
SSR = 50,539.41
X^2 (60;4) = 30.66

Model No.2 : 08/1980 to 07/1984

$$(1-B).(1-B^{52}).(1 + 0.225B^{1}).Y_t = (1 + 0.813B^{52}).(1 + 0.261B^{5} - 0.279B^{6}).\epsilon_t$$
$$(-3.69) \qquad (-10.06) \qquad (-3.95) \qquad (4.23)$$

R^2 adj = 0.453
SSR = 86,662.45
X^2 (60;4) = 34.88

3-A.2.5.3 France 2 basis risk

Model No.1 : 08/1980 to 07/1983

$$(1-B).(1-B^{52}).Y_t = (1 + 0.823B^{52}).(1 + 0.225B1^{7} + 0.161B^{45}).\epsilon_t$$
$$(-6.94) \qquad (-2.88) \qquad (-1.99)$$

R^2 adj = 0.362
SSR = 83,368.59
X^2 (60;4) = 33.17

Appendix 4-A Results of empirical analysis of the Optimal Hedging Ratio

Table A-4.1 Hedging ratio from 1983/84 to 1987/88, producer's hedge from June/September, determinants independent from the risk aversion coefficient.

Hedging ratio	1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]					
T	10.137	11.001	9.888	10.321	4.385
B	-1.690	2.025	-2.858	-15.893	-8.311
C	4.409	.001	4.469	15.399	6.351
D	-2.797	-.001	-3.007	-10.703	-4.220
W	1.189	-1.440	2.139	12.231	7.154
Minimum-risk ratio[2] Portfolio I[3]					
$x^f/E(y)$	5.216	4.010	2.767	-.839	-1.391
$x^F/E(y)$	-3.084	-2.852	-1.491	2.598	2.082
Minimum-risk ratio Portfolio II					
$x^f/E(y)$	.834	.000	.776	2.537	1.027
$x^F/E(y)$	.225	-.259	.371	2.015	1.158

[1] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $T=(1/(1-Cor^2(R^f;R^F)))$; $B=(Cor^2(R^f;R^F).Cov(R^F;R^c)/Cov(R^f;R^F))$; $C=(-Cov(R^f;R^c)/Var(R^f))$; $D=(Cor^2(R^f;R^F).Cov(R^f;R^c)/Cov(R^f;R^F))$; $W=(-Cov(R^F;R^c)/Var(R^F))$.
Equations (4.9) and (4.10) can be rewritten as
$x^{f*}=(1/T).(G+F+B+C)$ and $x^{F*}=(1/T).(H+I+D+W)$.

[2] It refers to the minimization of the income variance and is equal to $[(T.(B+C))/E(y)]$ and $[T.(D+E)/E(y)]$ for futures and forward contracts respectively when these contracts are used together and to $[-Cov(R^f;R^c)/(Var(R^f).E(y))]$ and $[-Cov(R^c;R^F)/(Var(R^F).E(y))]$ when these contracts are used separately.

[3] Strategies I and II refer to the use of the futures and forward contracts together and separately respectively.

Table A-4.2 Optimal hedging ratio from 1983/84 to 1987/88, producer's hedge from June/September, determinants dependent from the risk aversion coefficient, value for A = -.1 (simulation for other values of A are not shown below since they are directly proportional to the present values).

Hedging ratio	1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]					
F	.056	-.050	-.072	-.103	.382
G	-.425	-.229	-.256	-.253	-1.291
H	.269	.148	.172	.176	.857
I	-.039	.036	.054	.079	-.329

[1] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $G = (-E(R^f)/(2.A.Var(R^f)))$; $F = (E(R^F).Cor^2(R^f;R^F)/2.A.Cov(R^f;R^F))$ for futures contracts; $I = (-E(R^F)/(2.A.Var(R^F)))$; $H = (E(R^f).Cor^2(R^f;R^F)/2.A.Cov(R^f;R^F))$ for forward contracts.

Table A-4.3 Optimal hedging ratio from 1983/84 to 1987/88, producer's hedge from June/September.

Hedging ratio		1983/84	1984/85	1985/86	1986/87	1987/88
Optimal hedging ratio Portfolio I[1]						
A = -1000	$x^{f*}/E(y)$	5.216	4.010	2.767	-.839	-1.391
	$x^{F*}/E(y)$	-3.084	-2.852	-1.490	2.598	2.082
	x^{f*}/x^{F*}	-1.691	-1.405	-1.856	-.323	-.668
A = - 1	$x^{f*}/E(y)$	5.145	3.954	2.711	-.900	-1.456
	$x^{F*}/E(y)$	-3.040	-2.816	-1.451	2.642	2.120
	x^{f*}/x^{F*}	-1.692	-1.404	-1.867	-.341	-.686
A = -.1	$x^{f*}/E(y)$	4.507	3.455	2.202	-1.446	-2.036
	$x^{F*}/E(y)$	-2.642	-2.487	-1.100	3.033	2.457
	x^{f*}/x^{F*}	-1.706	-1.389	-2.001	-.476	-.828
A = -.001	$x^{f*}/E(y)$	-65.646	-51.422	-53.773	-61.510	-65.874
	$x^{F*}/E(y)$	41.128	33.642	37.493	46.075	39.601
	x^{f*}/x^{F*}	-1.596	-1.528	-1.434	-1.334	-1.663
Optimal hedging ratio Portfolio II						
A = -1000	$x^{f*}/E(y)$	.834	.000	.776	2.537	1.027
	$x^{F*}/E(y)$	.225	-.259	.371	2.015	1.158
A = -1	$x^{f*}/E(y)$	.826	-.004	.771	2.533	1.007
	$x^{F*}/E(y)$	.224	-.258	.372	2.016	1.152
A = -.1	$x^{f*}/E(y)$	.753	-.041	.731	2.495	.819
	$x^{F*}/E(y)$	.217	-.252	.381	2.028	1.104
A = -.001	$x^{f*}/E(y)$	-7.216	-4.128	-3.684	-1.638	-19.869
	$x^{F*}/E(y)$	-.521	.388	1.312	3.325	-4.172

[1] Strategies I and II refer to the use of the futures and forward contracts together and separately respectively.

Table A-4.4 Optimal hedging ratio from 1983/84 to 1987/88, producer's hedge from December/March, determinants independent from the risk aversion coefficient.

Hedging ratio	1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]					
T	9.099	2.872	2.936	2.673	9.539
B	-1.816	-.198	-.229	-.160	-.733
C	2.460	2.116	1.921	1.810	1.126
D	-2.338	-1.887	-1.733	-1.605	-1.173
W	1.981	.271	.314	.227	.854
Minimum-risk[2] ratio Portfolio I[3]					
x^f/y	5.863	5.511	4.968	4.412	3.742
x^F/y	-3.711	-4.643	-4.168	-3.685	-3.045
Minimum-risk ratio Portfolio II					
x^f/y	2.460	2.116	1.921	1.810	1.126
x^F/y	1.981	.271	.314	.227	.854

[1] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $T=(1/(1-Cor^2(R^f;R^F)))$; $B=(Cor^2(R^f;R^F).Cov(R^F;R^c)/Cov(R^f;R^F))$; $C=(-Cov(R^f;R^c)/Var(R^f))$; $D=(Cor^2(R^f;R^F).Cov(R^f;R^c)/Cov(R^f;R^F))$; $W=(-Cov(R^F;R^c)/Var(R^F))$.
Equations (4.9) and (4.10) can be rewritten as $x^{f*}=(1/T).(G+F+B+C)$ and $x^{F*}=(1/T).(H+I+D+W)$. The stored quantity y is set at 1.

[2] It refers to the minimization of the income variance and is equal to $[(T.(B+C))/y]$ and $[T.(D+E)/y]$ for futures and forward contracts respectively when these contracts are used together and to $[-Cov(R^f;R^c)/(Var(R^f).y)]$ and $[-Cov(R^c;R^F)/(Var(R^F).y)]$ when these contracts are used separately.

[3] Strategies I and II refer to the use of the futures and forward contracts together and separately respectively.

Table A-4.5 Optimal hedging ratio from 1983/84 to 1987/88, producer's hedge from December/March, determinants dependent from the risk aversion coefficient, value for A is -.1 (simulation for other values of A are not shown below since they are directly proportional to the present values).

Hedging ratio	1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]					
F	.074	.572	.520	.500	.031
G	-.019	-.555	-.498	-.598	-.123
H	.018	.495	.449	.531	.128
I	-.081	-.782	-.712	-.708	-.036

[1] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $G = (-E(R^f)/(2.A.Var(R^f)))$; $F = (E(R^F).Cor^2(R^f;R^F)/2.A.Cov(R^f;R^F))$ for futures contract; $I = (-E(R^F)/(2.A.Var(R^F)))$; $H = (E(R^f).Cor^2(R^f;R^F)/2.A.Cov(R^f;R^F))$ for forward contracts.

Table A-4.6 Optimal hedging ratio from 1983/84 to 1987/88, producer's hedge from December/March.

Hedging ratio		1983/84	1984/85	1985/86	1986/87	1987/88
Optimal hedging ratio Portfolio[1]						
A = -1000	x^{f*}/y	5.863	5.511	4.968	4.412	3.741
	x^{F*}/y	-3.711	-4.643	-4.168	-3.685	-3.045
	x^{f*}/x^{F*}	-1.579	-1.186	-1.192	-1.197	-1.228
A = - 1	x^{f*}/y	5.914	5.515	4.974	4.386	3.653
	x^{F*}/y	-3.769	-4.726	-4.245	-3.733	-2.956
	x^{f*}/x^{F*}	-1.569	-1.166	-1.171	-1.174	-1.235
A = -.1	x^{f*}/y	6.371	5.559	5.033	4.150	2.858
	x^{F*}/y	-4.286	-5.470	-4.939	-4.161	-2.161
	x^{f*}/x^{F*}	-1.486	-1.016	-1.019	-.997	-1.322
A = -.001	x^{f*}/y	56.618	10.417	11.528	-21.807	-84.588
	x^{F*}/y	-61.161	-87.304	-81.291	-51.311	85.398
	x^{f*}/x^{F*}	-.925	-.119	-.141	.425	-.990
Optimal hedging ratio Portfolio II						
A = -1000	x^{f*}/y	2.460	2.116	1.921	1.810	1.126
	x^{F*}/y	1.981	.271	.314	.226	.854
A = -1	x^{f*}/y	2.458	2.061	1.871	1.750	1.113
	x^{F*}/y	1.972	.193	.243	.156	.851
A = -.1	x^{f*}/y	2.441	1.561	1.423	1.212	1.002
	x^{F*}/y	1.898	-.511	-.397	-.481	.818
A = -.001	x^{f*}/y	.540	-53.391	-47.891	-58.032	-11.233
	x^{F*}/y	-6.197	-78.012	-70.890	-70.647	-2.755

[1] Strategies I and II refer to the use of the futures and forward contracts together and separately respectively. The stored quantity y is set at 1.

Table A-4.7 Optimal hedging ratio from 1983/84 to 1987/88, merchant's hedge from December/March, determinants independent from the risk aversion coefficient.

Hedging ratio	1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]					
T	9.099	2.872	2.936	2.673	9.539
B	-.983	-.858	-.849	-.815	-.847
C	1.033	1.030	1.007	.983	.903
D	-1.003	-.918	-.908	-.871	-.941
W	1.072	1.174	1.162	1.155	.986
Minimum-risk[2] ratio Portfolio I[3]					
x^f/y	.457	.493	.461	.446	.529
x^F/y	.627	.733	.745	.759	.435
Minimum-risk ratio Portfolio II					
x^f/y	1.033	1.030	1.007	.983	.903
x^F/y	1.072	1.174	1.162	1.155	.986

[1] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $T=(1/(1-Cor^2(R^f;R^F)))$; $B=(Cor^2(R^f;R^F).Cov(R^F;R^c)/Cov(R^f;R^F))$; $C=(-Cov(R^f;R^c)/Var(R^f))$; $D=(Cor^2(R^f;R^F).Cov(R^f;R^c)/Cov(R^f;R^F))$; $W=(-Cov(R^F;R^c)/Var(R^F))$.
The equations (4.9) and (4.10) can be rewritten as $x^{f*}=(1/T).(G+F+B+C)$ and $x^{F*}=(1/T).(H+I+D+W)$. The stored quantity y is set at 1.

[2] It refers to the minimization of the income variance and is equal to $[(T.(B+C))/y]$ and $[T.(D+E)/y]$ for futures and forward contracts respectively when these contracts are used together and to $[-Cov(R^f;R^c)/(Var(R^f).y)]$ and $[-Cov(R^c;R^F)/(Var(R^F).y)]$ when these contracts are used separately.

[3] Strategies I and II refer to the use of the futures and forward contracts together and separately respectively.

Determinants of the optimal hedging ratio which are dependent on the risk aversion coefficient are not shown below since similar to those of the producer's hedge with the same time period.

Table A-4.8 Optimal hedging ratio from 1983/84 to 1987/88, merchant's hedge from December/March.

Hedging ratio		1983/84	1984/85	1985/86	1986/87	1987/88
Optimal hedging ratio Portfolio[1] I						
A = -1000	x^f/y	.457	.493	.461	.446	.528
	x^{F*}/y	.627	.733	.745	.759	.435
	x^f/x^{F*}	.729	.673	.619	.587	1.214
A = - 1	x^f/y	.508	.498	.468	.420	.440
	x^{F*}/y	.570	.651	.668	.712	.523
	x^f/x^{F*}	.892	.765	.700	.590	.841
A = -.1	x^f/y	.965	.542	.527	.184	-.354
	x^{F*}/y	.053	-.092	-.025	.283	1.319
	x^f/x^{F*}	18.137	-5.847	-20.892	.651	-.268
A = -.001	x^f/y	51.212	5.401	7.022	-25.773	-87.801
	x^{F*}/y	-56.822	-81.926	-76.376	-46.865	88.878
	x^f/x^{F*}	-.901	-.065	-.091	.549	-.987
Optimal hedging ratio Portfolio II						
A = -1000	x^f/y	1.033	1.030	1.007	.982	.903
	x^{F*}/y	1.072	1.174	1.162	1.155	.986
A = -1	x^f/y	1.031	.974	.957	.923	.891
	x^{F*}/y	1.064	1.095	1.091	1.084	.983
A = -.1	x^f/y	1.014	.475	.509	.384	.779
	x^{F*}/y	.990	.391	.451	.447	.951
A = -.001	x^f/y	-.886	-54.477	-48.806	-58.861	-11.456
	x^{F*}/y	-7.105	-77.109	-70.041	-69.719	-2.623

[1] Strategies I and II refer to the use of the futures and forward contracts together and separately respectively. The stored quantity is set at 1.

Table A-4.9 Optimal hedging ratio from 1983/84 to 1987/88, producer's hedge from October/March, S assessed for an A value of -.1 (simulation for other values of A are not shown below since they are directly proportional to the present values).

Hedging ratio		1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]						
S		.030	-.265	-.322	-.445	-.163
B		1.794	1.234	1.128	.983	1.044
Minimum-risk ratio[2] x^f/y		1.794	1.234	1.128	.983	1.044
Optimal hedging ratio x^f/y						
Risk Aversion	A=-1000	1.794	1.234	1.127	.983	1.044
	A=-1	1.797	1.208	1.095	.939	1.028
	A=-.1	1.824	.969	.805	.538	.881
	A=-.001	4.800	-25.328	-31.094	-43.576	-15.335

[1] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $S = (-E(R^f)/(2.A.Var(R^f)))$; $B = (-Cov(R^f;R^c)/Var(R^f))$. The stored quantity y is set at 1.
[2] It refers to the minimization of the income variance and is equal to $[-Cov(R^f;R^c)/(Var(R^f).y)]$.

Table A-4.10 Optimal hedging ratio from 1983/84 to 1987/88, merchant's hedge from October/March, S assessed for an A value of -.1 (simulation for other values of A are not shown below since they are directly proportional to the present values).

Hedging ratio		1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]						
S		.030	-.265	-.322	-.445	-.163
B		.862	1.023	1.027	1.011	.946
Minimum-risk ratio[2] x^f/y		.862	1.023	1.027	1.011	.946
Optimal hedging ratio x^{f*}/y						
Risk Aversion	A=-1000	.862	1.023	1.027	1.011	.946
	A=-1	.865	.997	.995	.967	.931
	A=-.1	.892	.758	.705	.566	.783
	A=-.001	3.868	-25.539	-31.195	-43.548	-15.432

[1] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $S = (-E(R^f)/(2.A.Var(R^f)))$; $B = (-Cov(R^f;R^c)/Var(R^f))$. The stored quantity is set at 1.
[2] It refers to the minimization of the income variance and is equal to $[-Cov(R^f;R^F)/(Var(R^f).y)]$.

Table A-4.11 Optimal hedging ratio from 1983/84 to 1987/88, producer's hedge from June/November, S assessed for an A value of -.1 (simulation for other values of A are not shown below since they are directly proportional to the present values).

Hedging ratio		1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]						
S		-.128	.080	-.031	-.044	-.933
B		-.686	2.433	7.185	16.089	3.364
Minimum-risk ratio[2] $x^f/E(y)$		-.129	.437	1.248	2.651	.544
Optimal hedging ratio $x^{f*}/E(y)$						
Risk Aversion	A=-1000	-.129	.437	1.248	2.651	.544
	A=-1	-.132	.439	1.247	2.650	.529
	A=-.1	-.154	.452	1.242	2.643	.393
	A=-.001	-2.571	1.878	.695	1.919	-14.564

[1] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $S = (-E(R^f)/(2.A.Var(R^f)))$; $B = (-Cov(R^f;R^c)/Var(R^f))$.
[2] It refers to the minimization of the income variance and is equal to $[-Cov(R^f;R^F)/(Var(R^f).E(y))]$.

Table A-4.12 Optimal hedging ratio from 1983/84 to 1987/88, producer's hedge from February/November, S assessed for an A value of -.1 (simulation for other values of A are not shown below since they are directly proportional to the present values).

Hedging ratio		1983/84	1984/85	1985/86	1986/87	1987/88
Determinants[1]						
S		-.125	-.069	-.091	-.033	-.981
B		-.153	-2.461	1.125	10.185	-2.564
Minimum-risk ratio[2] $x^r/E(y)$		-.029	-.442	.195	1.678	-.415
Optimal hedging ratio $x^r/E(y)$						
Risk Aversion	A=-1000	-.029	-.442	.195	1.678	-.415
	A=-1	-.031	-.444	.193	1.677	-.431
	A=-.1	-.052	-.455	.179	1.672	-.574
	A=-.001	-2.410	-1.692	-1.380	1.134	-16.310

[1] The ratio determinants correspond to formula elements in (4.9) and (4.10) with $S = (-E(R^f)/(2.A.Var(R^f)))$; $B = (-Cov(R^f;R^c)/Var(R^f))$.
[2] It refers to the minimization of the income variance and is equal to $[-Cov(R^f;R^F)/(Var(R^f).E(y))]$.

Table A-4.13 Optimal hedging ratio for a one-week hedge, from 1981/82 to 1987/88, with various sampling periods and for simultaneously determined cash and futures positions.

Simultaneously determined positions	Nearby futures contract			Next to nearby futures contract		
	All data	52 data	104 data	All data	52 data	104 data
1981/82	-.736	-.511		.451	1.279+	
1982/83	-1.072	-2.317	-4.911+	-.231	-6.070	-2.138
1983/84	-3.298	-21.949+	-8.067	-1.006	-7.903	-6.534
1984/85	-26.061	1.765+	6.123	-1.109	-13.607	-.289+
1985/86	-72.753+	-6.562+	2.538	-5.025	24.643	2.273+
1986/87	-13.646	-2.641	-3.124+	-6.358	-5.811	-61.519
1987/88	-37.593+	7.019	-34.592	-16.545	10.499	-19.038

+ denotes coefficients not significantly different from 1 at the 5% level.

Table A-4.14 Optimal hedging ratio for a one-week hedge, from 1981/82 to 1987/88, with various sampling periods and for a given cash position.

Given Cash position[1]		Nearby futures contract			Next to nearby futures contract		
		All data[2]	52 data	104 data	All data	52 data	104 data
1981/82	A=-1000	-.289	-.267		-.260	-.340	
	A=-1	-.307	-.276		-.237	-.339	
	A=-.1	-.476	-.366		-.035	-.333	
	A=-.001	-18.98	-10.240		22.224	.377	
1982/83	A=-1000	.040	.438	.118	-.124	.373	-.041
	A=-1	.004	.385	.081	-.131	.253	-.077
	A=-.1	-.313	-.097	-.256	-.198	-.832	-.403
	A=-.001	-35.34	-53.232	-37.328	-7.525	-120.31	-36.24
1983/84	A=-1000	.076	.117	.265	-.071	.035	.175
	A=-1	.036	.074	.214	-.084	.011	.114
	A=-.1	-.321	-.317	-.241	-.206	-.207	-.434
	A=-.001	-39.716	-43.352	-50.421	-13.556	-24.280	-60.856
1984/85	A=-1000	.195	.557	.318	.057	.806	.315
	A=-1	.164	.552	.295	.054	.856	.324
	A=-.1	-.112	.513	.083	.026	1.304	.404
	A=-.001	-30.605	-3.77[+]	-23.240	-3.015	50.601	9.188
1985/86	A=-1000	.217	.305	.419	.102	.631	.698
	A=-1	.191	.293	.411	.089	.513	.687
	A=-.1	-.048	.182	.344	-.020	-.541	.590
	A=-.001	-26.428	-12.011	-7.056	-12.132	-116.615	-10.178
1986/87	A=-1000	.147	-.274	.051	.019	-.548	-.125
	A=-1	.118	-.316	.025	.000	-.622	-.210
	A=-.1	-.139	-.689	-.199	-.177	-1.289	-.977
	A=-.001	-28.569	-41.786	-24.967	-19.687	-74.719	-85.308
1987/88	A=-1000	.191	.466	.116	.081	.591	.004
	A=-1	.160	.418	.076	.058	.523	-.055
	A=-.1	-.113	-.012	-.293	-.144	-.087	-.593
	A=-.001	-30.321	-47.391	-41.076	-22.388	-64.248	-59.805

Table A-4.14 (cont.)

[1] The cash position is set at 1; [+] denotes coefficients not significantly different from 1 at the 5% level.
[2] This sample is made of all prices available, with a minimum sample of 52 data at the beginning in 1981/82.

Table A-4.15 Optimal hedging ratio for a two-month hedge, from 1981/82 to 1987/88, with various sampling periods and for simultaneously determined cash and futures positions.

Simultaneously determined positions	Nearby futures contract			Next to nearby futures contract		
	All data	12 data	18 data	All data	12 data	18 data
1981/82	.301			-.457		
1982/83	.201	.177		14.522[+]	-7.483[+]	
1983/84	.099	-.036	.056	-1.063	-3.851[+]	-1.555
1984/85	-.101	1.491[+]	-.106	-7.735[+]	-.561	.426[+]
1985/86	.236	.683[+]	.573[+]	2.971[+]	.172[+]	-.892[+]
1986/87	.239	.551	.493	-14.214[+]	2.241[+]	10.510[+]
1987/88	.355	.526	.555	-24.744[+]	6.946	-271.431[+]

[+] denotes the coefficients not significantly different from 1 at the 5% level.

Table A-4.16 Optimal hedging ratio for a two-month hedge, from 1981/82 to 1987/88, with various sampling periods and for a given cash position.

Given Cash position[1]		Nearby futures contract			Next to nearby futures contract		
		All data[2]	12 data	18 data	All data	12 data	18 data
1981/82	A=-1000	.498			.514		
	A=-1	.478			.472		
	A=-.1	.302			.094		
	A=-.001	-19.046			-41.432		
1982/83	A=-1000	.566	.563		.623	.615	
	A=-1	.534	.531		.564	.558	
	A=-.1	.242	.251		.024	.047	
	A=-.001	-31.811	-30.618		-59.312	-56.112	
1983/84	A=-1000	.588	.616	.584	.605	.632	.598
	A=-1	.562	.589	.559	.565	.594	.561
	A=-.1	.328	.352	.337	.199	.256	.217
	A=-.001	-25.408	-25.797	-24.138	-40.050	-36.953	-37.507
1984/85	A=-1000	.652	.705	.689	.654	.665	.684
	A=-1	.634	.699	.673	.625	.654	.660
	A=-.1	.476	.649	.531	.369	.556	.442
	A=-.001	-16.903	-4.907[+]	-15.092	-27.848	-10.196	-23.571
1985/86	A=-1000	.655	.757	.694	.673	.807	.694
	A=-1	.639	.758	.686	.634	.776	.667
	A=-.1	.491	.767	.616	.290	.489	.418
	A=-.001	-15.706	1.751[+]	-7.106[+]	-37.618	-31.039	-26.966
1986/87	A=-1000	.654	.682	.716	.685	.874	.786
	A=-1	.638	.672	.711	.640	.758	.736
	A=-.1	.496	.588	.671	.238	-.287	.284
	A=-.001	-15.214	-8.726	-3.855[+]	-44.037	-115.335	-49.475
1987/88	A=-1000	.641	.625	.645	.691	.759	.777
	A=-1	.628	.616	.639	.654	.703	.719
	A=-.1	.514	.536	.586	.316	.191	.195
	A=-.001	-12.050	-8.238[+]	-5.252[+]	-36.822	-56.165	-57.489

Table A-4.16 (cont.)

[1] The cash position is set at 1; [+] denotes the coefficients not significantly different from 1 at the 5% level.
[2] This sample is made of all prices available, with a minimum sample of 6 data at the beginning in 1981/82.

Table A-4.17 Optimal hedging ratio for a two-week hedge, from 1981/82 to 1987/88, with various sampling periods and for simultaneously determined cash and futures positions.

Simultaneously determined positions	Nearby futures contract			Next to nearby futures contract		
	All data	26 data	52 data	All data	26 data	52 data
1981/82	.385	.857[+]		-1.104	-1.394	
1982/83	.350	-.993[+]	-1.089	-2.141	-3.542	-3.872
1983/84	-.061	-68.217[+]	-6.426	-5.311	-1.991[+]	-5.735
1984/85	.942[+]	-16.007[+]	5.610	-12.282	-27.053[+]	-.334[+]
1985/86	2.035	2.601[+]	-2.144[+]	-44.289	32.129	1.520[+]
1986/87	-.177	-2.611	19.912[+]	-17.491	-5.489	-4.668[+]
1987/88	-1.407	9.296	3.131[+]	-1.407[+]	7.614	-25.802

[+] denotes the coefficients not significantly different from 1 at the 5% level.

Table A-4.18 Optimal hedging ratio for a two-week hedge, from 1981/82 to 1987/88, with various sampling periods and for a given cash position.

Given Cash position[1]		Nearby futures contract			Next to nearby futures contract		
		All data[2]	26 data	52 data	All data	26 data	52 data
1981/82	A=-1000	-.082	-.062		-.121	-.094	
	A=-1	-.063	-.049		-.169	-.142	
	A=-.1	.102	.067		-.597	-.572	
	A=-.001	18.426	12.923		-47.675	-47.946	
1982/83	A=-1000	.004	.593	.131	.059	.370	.155
	A=-1	.012	.541	.120	-.006	.270	.083
	A=-.1	.085	.071	.026	-.597	-.624	-.565
	A=-.001	8.118	-51.664	-10.288[+]	-65.600	-99.094	-71.999
1983/84	A=-1000	-.031	-.252	.125	-.037	-.310	.015
	A=-1	-.031	-.294	.076	-.086	-.326	-.033
	A=-.1	-.028	-.669	-.369	-.526	-.470	-.477
	A=-.001	.260[+]	-41.921	-49.445	-48.966	-16.293[+]	-49.356
1984/85	A=-1000	.071	1.143	.284	.195	1.563	.238
	A=-1	.072	1.158	.267	.164	1.621	.247
	A=-.1	.088	1.287	.112	-.120	2.144	.331
	A=-.001	1.867[+]	15.508[+]	-16.913	-31.436	59.612	9.498
1985/86	A=-1000	.096	.309	.654	.224	.472	.946[+]
	A=-1	.098	.319	.664	.187	.393	.939[+]
	A=-.1	.118	.407	.753	-.148	-.312	.874
	A=-.001	2.309	10.108[+]	10.535	-37.054	-77.989	-6.345[+]
1986/87	A=-1000	.069	-.176	.068	.118	-.453	-.086
	A=-1	.068	-.206	.057	.078	-.512	-.148
	A=-.1	.058	-.478	-.043	-.279	-1.040	-.704
	A=-.001	-.953	-30.381	-11.168	-39.682	-59.077	-61.888
1987/88	A=-1000	.096	.375	.099	.188	.668	.082
	A=-1	.094	.252	.074	.148	.598	.032
	A=-.1	.068	.113	-.148	-.212	-.023	-.412
	A=-.001	-2.715	-15.812	-24.650	-39.897	-68.475	-49.341

Table 4-A.18 (Cont.)

[1] The cash position is set at 1; [+] denotes the coefficients not significantly different from 1 at the 5% level.
[2] This sample is made of all prices available, with a minimum sample of 26 data at the beginning in 1981/82.

Appendix 4-B: Results of empirical analysis of Hedging Effectiveness

Table B-4.1 Hedging effectiveness assessed with the new formula, from 1983/84 to 1987/88, producer's hedge from 15/06 to 15/09.

Hedging Effectiveness		1983/84	1984/85	1985/86	1986/87	1987/88
Portfolio I[1]						
A = -1000	HE*[2]	-.061	-.038	-.036	-.364	-.091
	Naive H.[3]	.074	.169	.091	-.339	-.033
	Min. H.[4]	-.061	-.038	-.036	-.364	-.091
A = - 1	HE*	-.061	-.038	-.036	-.377	-.096
	Naive H.	.075	.172	.094	-.351	-.033
	Min. H.	-.060	-.038	-.036	-.377	-.096
A = -.1	HE*	-.054	-.034	-.034	-.545	-.195
	Naive H.	.094	.205	.122	-.493	-.028
	Min. H.	-.054	-.034	-.034	-.545	-.194
A = -.001	HE*	.581	.360	.464	.605	.681
	Naive H.	-.031	-.018	-.012	.005	-.039
	Min. H.	-.096	-.059	-.045	.042	.014
Portfolio II[5] / x^f						
A = -1000	HE*	-.015	.000	-.021	-.306	-.034
	Naive H.	-.014	.023	-.019	-.193	-.034
	Min. H.	-.015	.000	-.021	-.306	-.034
A = -1	HE*	-.015	.000	-.021	-.315	-.034
	Naive H.	-.014	.024	-.019	-.199	-.034
	Min. H.	-.015	.000	-.021	-.315	-.034
A = -.1	HE*	-.014	.000	-.024	-.432	-.041
	Naive H.	-.013	.031	-.021	-.276	-.041
	Min. H.	-.014	.000	-.024	-.432	-.041
A = -.001	HE*	.071	.025	.021	.004	.263
	Naive H.	-.021	-.013	-.013	-.006	-.027
	Min. H.	-.017	.000	-.009	-.023	-.027

Table B-4.1 (Cont.)

Portfolio II[6] / x^F						
A = -1000	HE*	-.002	-.003	-.009	-.361	-.076
	Naive H.	.044	.137	.027	-.294	-.074
	Min. H.	-.002	-.003	-.009	-.361	-.076
A = -1	HE*	-.002	-.003	-.009	-.373	-.079
	Naive H.	.045	.139	.027	-.304	-.077
	Min. H.	-.002	-.003	-.009	-.373	-.079
A = -.1	HE*	-.002	-.004	-.013	-.533	-.139
	Naive H.	.054	.163	.033	-.433	-.137
	Min. H.	-.002	-.003	-.013	-.533	-.139
A = -.001	HE*	.001	.000	.005	.032	.020
	Naive H.	-.008	-.002	.005	.018	-.011
	Min. H.	-.001	-.001	.002	.027	-.013

[1] Portfolios I and II refer to the use of the futures and forward contracts together and separately respectively; $E(U(R^e))$ is negative but for cases where A=-.001.
[2] This HE* denotes the HE for an hedge portfolio involving x^f* and x^F*.
[3] Naive H. relates the naive strategy with an hedge level of $(x^f;x^F) = (1,1)$.
[4] Min. H. refers to the HE of an hedging strategy where $(x^f;x^F)$ is from a minimum-risk strategy. [5] Portfolio with only futures contracts. [6] Portfolio with only forward contracts.

Table B-4.2 Hedging effectiveness from 1983/84 to 1987/88, producer's hedge from 15/06 to 15/09, with the traditional formula.

Hedging Effectiveness	1983/84	1984/85	1985/86	1986/87	1987/88
Portfolio I[a]					
x^f and x^F	.058	.032	.036	.356	.091
$(x^f;x^F) = (1;1)^b$	.013	-.123	-.041	.277	-.013
Portfolio II					
x^f	.015	.000	.021	.306	.034
x^F	-.015	.000	-.001	.337	.075
$x^f = 1$	.051	-.007	.034	.167	.028
$x^F = 1$	.014	-.060	.001	.223	.051

[a] Portfolios I and II refer to the use of the futures and forward contracts together and separately respectively. x^f and x^F are set at the risk-minimizing hedging level.
[b] The case where $(x^f;x^F)$ is equal to (1,1) refers to a naive hedging strategy.

Table B-4.3 Hedging effectiveness assessed with the new formula, from 1983/84 to 1987/88, producer's hedge from 15/12 to 15/03.

Hedging Effectiveness		1983/84	1984/85	1985/86	1986/87	1987/88
Portfolio I[1]						
A = -1000	HE*[2]	-.719	-.632	-.777	-.805	-.719
	Naive H.[3]	-.469	-.083	-.098	-.085	-.041
	Min. H.[4]	-.719	-.632	-.777	-.805	-.719
A = - 1	HE*	-.848	-.867	-1.365	-1.664	-4.628
	Naive H.	-.548	-.094	-.139	-.124	-.203
	Min. H.	-.848	-.867	-1.364	-1.663	-4.626
A = -.1	HE*	1.580	.378	.242	.172	.065
	Naive H.	.942	-.034	-.029	-.040	-.008
	Min. H.	1.573	.361	.231	.161	.061
A = -.001	HE*	.254	1.100	.876	.873	.309
	Naive H.	-.009	-.052	-.045	-.048	-.125
	Min. H.	.027	-.001	-.001	-.022	-.029
Portfolio II[5] / x^f						
A = -1000	HE*	-.582	-.266	-.338	-.360	-.441
	Naive H.	-.377	-.192	-.260	-.288	-.435
	Min. H.	-.582	-.266	-.338	-.360	-.441
A = -1	HE*	-.682	-.347	-.564	-.706	-2.876
	Naive H.	-.442	-.255	-.441	-.506	-2.846
	Min. H.	-.682	-.346	-.563	-.706	-2.876
A = -.1	HE*	1.197	.084	.056	.038	.046
	Naive H.	.779	.073	.051	.036	.046
	Min. H.	1.197	.073	.049	.028	.045
A = -.001	HE*	.000	.624	.488	.708	.051
	Naive H.	.000	-.023	-.021	-.024	-.009
	Min. H.	-.002	-.050	-.039	-.044	-.011
A = -.001	HE*	.023	1.092	.866	.836	.002
	Naive H.	-.008	-.028	-.024	-.023	-.002
	Min. H.	-.017	-.007	-.007	-.005	-.001

Table B-4.3 (Cont.)

Portfolio II[6] / x^F						
A = -1000	HE*	-.356	-.003	-.007	-.004	-.203
	Naive H.	-.268	.022	.027	.047	-.203
	Min. H.	-.356	-.003	-.007	-.004	-.209
A = -1	HE*	-.414	-.002	-.007	-.004	-1.383
	Naive H.	-.313	.041	.671	.126	-1.341
	Min. H.	-.414	-.002	-.007	-.003	-1.383
A = -.1	HE*	.684	.007	.003	.004	.025
	Naive H.	.531	-.057	-.040	-.041	.024
	Min. H.	.682	-.009	-.007	-.005	.025
A = -.001	HE*	.023	1.092	.866	.836	.002
	Naive H.	-.008	-.028	-.024	-.023	-.002
	Min. H.	-.017	-.007	-.007	-.005	-.001

[1] Portfolios I and II refer to the use of the futures and forward contracts together and separately respectively; $E(U(R^c))$ is negative but for cases where A=-.1 and A=-.001.
[2] This HE* denotes the HE for an hedge portfolio involving x^{f*} and x^{F*}.
[3] Naive H. relates the naive strategy with an hedge level of $(x^f;x^F) = (1,1)$.
[4] Min. H. refers to the HE of an hedging strategy where $(x^f;x^F)$ is from a minimum-risk strategy. [5] Portfolio with only futures contracts. [6] Portfolio with only forward contracts.

Table B-4.4 Hedging effectiveness from 1983/84 to 1987/88, producer's hedge from 15/12 to 15/03, with the traditional formula.

Hedging Effectiveness	1983/84	1984/85	1985/86	1986/87	1987/88
Portfolio I[a]					
x^f/y and x^F/y	.719	.632	.777	.805	.719
$(x^f;x^F) = (1;1)^b$	.469	.083	.098	.085	.041
Portfolio II					
x^f	.582	.266	.338	.360	.441
x^F	.356	.003	.007	.004	.209
$x^f = 1$	.377	.192	.260	.288	.435
$x^F = 1$	.268	-.022	-.027	-.047	.203

[a] portfolios I and II refer to the use of the futures and forward contracts together and separately respectively. x^f and x^F are set at the risk-minimizing hedging level.
[b] The case where $(x^f;x^F)$ is equal to (1,1) refers to a naive hedging strategy.

Table B-4.5 Hedging effectiveness assessed with the new formula, from 1983/84 to 1987/88, merchant's hedge from 15/12 to 15/03.

Hedging Effectiveness		1983/84	1984/85	1985/86	1986/87	1987/88
Portfolio I[1]						
A = -1000	HE*[2]	-.988	-.989	-.972	-.972	-.947
	Naive H.[3]	-.279	-.573	-.521	-.511	.124
	Min. H.[4]	-.988	-.989	-.972	-.972	-.947
A = - 1	HE*	-.978	-.943	-.937	-.936	-.941
	Naive H.	-.262	-.408	-.371	-.341	.161
	Min. H.	-.977	-.938	-.933	-.932	-.941
A = -.1	HE*	-.911	-.741	-.911	-.981	-.974
	Naive H.	-.107	5.495	5.357	9.866	.534
	Min. H.	-.881	.894	.537	1.449	-.868
A = -.001	HE*	-177.75	53.809	44.138	41.864	89.073
	Naive H.	10.040	-2.629	-2.371	-2.357	-3.369
	Min. H.	5.475	-1.628	-1.447	-1.403	-1.624
Portfolio II[5] / x^f						
A = -1000	HE*	-.952	-.864	-.844	-.825	-.928
	Naive H.	-.951	-.864	-.844	-.825	-.918
	Min. H.	-.952	-.864	-.844	-.825	-.928
A = -1	HE*	-.947	-.836	-.826	-.795	-.914
	Naive H.	-.947	-.836	-.824	-.791	-.901
	Min. H.	-.947	-.834	-.824	-.792	-.913
A = -.1	HE*	-.911	-.733	-.911	-.845	-.781
	Naive H.	-.911	.162	-.063	1.318	-.718
	Min. H.	-.911	.268	-.038	1.201	-.761
A = -.001	HE*	-.416	32.709	26.341	35.216	14.367
	Naive H.	1.467	-1.211	-1.091	-1.206	-2.617
	Min. H.	1.535	-1.248	-1.098	-1.186	-2.354
A = -.001	HE*	-25.234	53.697	43.952	39.338	.621
	Naive H.	7.602	-1.401	-1.264	-1.136	-.563
	Min. H.	8.191	-1.647	-1.471	-1.315	-.555

Table B-4.5 (Cont.)

Portfolio II[6] / x^F						
A = -1000	HE*	-.968	-.921	-.912	-.908	-.914
	Naive H.	-.963	-.900	-.894	-.892	-.914
	Min. H.	-.968	-.921	-.912	-.908	-.914
A = -1	HE*	-.952	-.867	-.871	-.875	-.917
	Naive H.	-.949	-.860	-.864	-.869	-.917
	Min. H.	-.952	-.862	-.866	-.871	-.917
A = -.1	HE*	-.821	-.408	-.578	-.909	-.957
	Naive H.	-.820	.578	.281	.481	-.955
	Min. H.	-.814	1.225	.865	1.375	-.956
A = -.001	HE*	-25.234	53.697	43.952	39.338	.621
	Naive H.	7.602	-1.401	-1.264	-1.136	-.563
	Min. H.	8.191	-1.647	-1.471	-1.315	-.555

[1] Portfolios I and II refer to the use of the futures and forward contracts together and separately respectively; E(U(R^c)) is negative but for cases where A=-.001 from 1984/85 onwards.
[2] This HE* denotes the HE for an hedge portfolio involving x^f* and x^{F*}.
[3] Naive H. relates the naive strategy with an hedge level of $(x^f;x^F) = (1,1)$.
[4] Min. H. refers to the HE of an hedging strategy where $(x^f;x^F)$ is from a minimum-risk strategy. [5] Portfolio with only futures contracts. [6] Portfolio with only forward contracts.

Table B-4.6 Hedging effectiveness from 1983/84 to 1987/88, merchant's hedge from 15/12 to 15/03, with the traditional formula.

Hedging Effectiveness	1983/84	1984/85	1985/86	1986/87	1987/88
Portfolio I[a]					
x^f and x^F	.988	.989	.972	.972	.947
$(x^f;x^F) = (1;1)^b$	.279	.573	.521	.511	-.124
Portfolio II					
x^f	.952	.864	.844	.825	.928
x^F	.968	.921	.912	.908	.914
$x^f = 1$	.951	.864	.844	.825	.918
$x^F = 1$	.963	.901	.894	.892	.914

[a] Portfolios I and II refer to the use of the futures and forward contracts together and separately respectively. x^f and x^F are set at the risk-minimizing hedging level.
[b] The case where $(x^f;x^F)$ is equal to (1,1) refers to a naive hedging strategy.

Table B-4.7 Hedging effectiveness, from 1983/84 to 1987/88, merchant's hedge from 15/10 to 15/03.

Hedging Effectiveness		1983/84	1984/85	1985/86	1986/87	1987/88
New Formula						
A = -1000	HE*[1]	-.938	-.932	-.933	-.921	-.938
	Naive H.[2]	-.914	-.932	-.932	-.921	-.935
	Min. H.[3]	-.938	-.932	-.933	-.921	-.938
A = - 1	HE*	-.933	-.909	-.910	-.892	-.918
	Naive H.	-.911	-.909	-.910	-.891	-.913
	Min. H.	-.933	-.909	-.909	-.891	-.918
A = -.1	HE*	-.893	-.634	-.594	-.331	-.714
	Naive H.	-.881	-.632	-.591	-.275	-.683
	Min. H.	-.893	-.617	-.566	-.253	-.707
A = -.001	HE*	-1.412	22.017	22.871	30.699	20.268
	Naive H.	-.635	-1.757	-1.489	-1.426	-2.711
	Min. H.	-.559	-1.801	-1.531	-1.443	-2.563
Traditional Formula						
HE[4]		.938	.932	.932	.921	.938
Naive H.		.914	.932	.932	.921	.935

[1] HE* refers to an optimal hedging level. $E(U(R^c))$ is always negative but in the case where A=-.001 from 1984/85 onwards.
[2] Naive H. relates the naive strategy with an hedge level of $x^f = 1$.
[3] Min. H. refers to the hedge level of x^f of a minimum-risk strategy.
[4] HE is from a risk-minimizing hedging strategy.

Table B-4.8 Hedging effectiveness, from 1983/84 to 1987/88, producer's hedge from 15/06 to 15/11.

Hedging Effectiveness		1983/84	1984/85	1985/86	1986/87	1987/88
New Formula						
A = -1000	HE*[1]	-.001	-.004	-.052	-.338	-.012
	Naive H.[2]	.032	.002	-.050	-.207	-.003
	Min. H.[3]	.000	-.004	-.052	-.338	-.012
A = - 1	HE*	-.001	-.004	-.053	-.348	-.012
	Naive H.	.033	.002	-.051	-.213	-.002
	Min. H.	-.001	-.004	-.053	-.348	-.012
A = -.1	HE*	-.001	-.005	-.067	-.481	-.012
	Naive H.	.041	.002	-.064	-.294	.019
	Min. H.	-.001	-.005	-.067	-.480	-.011
A = -.001	HE*	.001	.005	.001	.006	.177
	Naive H.	-.009	.003	.000	.005	-.025
	Min. H.	.001	.002	.000	.005	-.013
Traditional Formula						
HE[4]		.000	.004	.052	.338	.012
Naive H.		-.014	.000	.052	.176	.001

[1] HE* refers to an optimal hedging level. $E(U(R^c))$ is always negative but in the case where A=-.001.
[2] Naive H. relates the naive strategy with an hedge level of $x^f = 1$.
[3] Min. H. refers to the hedge level of x^f of a minimum-risk strategy.
[4] HE is from a risk-minimizing strategy.

Table B-4.9 Hedging effectiveness, from 1983/84 to 1987/88, producer's hedge from 15/10 to 15/03.

Hedging Effectiveness		1983/84	1984/85	1985/86	1986/87	1987/88
New Formula						
A = -1000	HE*[1]	-.486	-.162	-.199	-.171	-.428
	Naive H.[2]	-.391	-.156	-.197	-.171	-.427
	Min. H.[3]	-.486	-.162	-.199	-.171	-.428
A = - 1	HE*	-.580	-.217	-.336	-.333	-3.546
	Naive H.	-.466	-.211	-.333	-.331	-3.544
	Min. H.	-.580	-.217	-.335	-.332	-3.545
A = -.1	HE*	.843	.053	.029	.011	.038
	Naive H.	.671	.053	.028	.003	.038
	Min. H.	.843	.049	.025	.003	.037
A = -.001	HE*	.021	.239	.345	.636	.104
	Naive H.	.008	-.019	-.022	-.029	-.014
	Min. H.	.013	-.023	-.025	-.029	-.014
Traditional Formula						
HE[4]		.486	.162	.199	.171	.427
Naive H.		.390	.156	.196	.171	.427

[1] HE* refers to the optimal hedging level. $E(U(R^c))$ is always negative but in the case where A=-.1 and A=-.001.
[2] Naive H. relates the naive strategy with an hedge level of $x^f = 1$.
[3] Min. H. refers to the hedge level of x^f of a minimum-risk strategy.
[4] HE is from a risk-minimizing strategy.

Table B-4.10 Hedging effectiveness, from 1983/84 to 1987/88, producer's hedge from 15/02 to 15/11.

Hedging Effectiveness		1983/84	1984/85	1985/86	1986/87	1987/88
New Formula						
A = -1000	HE*[1]	.000	-.011	-.003	-.253	-.008
	Naive H.[2]	.061	.109	.051	-.212	.092
	Min. H.[3]	.000	-.011	-.003	-.253	-.008
A = - 1	HE*	.000	-.011	-.003	-.261	-.009
	Naive H.	.062	.111	.052	-.218	.099
	Min. H.	.000	-.011	-.003	-.261	-.009
A = -.1	HE*	.000	-.014	-.003	-.359	-.032
	Naive H.	.076	.131	.069	-.301	.228
	Min. H.	.000	-.014	-.003	-.359	-.032
A = -.001	HE*	.021	.011	.007	.004	.263
	Naive H.	-.021	-.016	-.014	.004	-.033
	Min. H.	.001	.005	-.002	.003	.013
Traditional Formula						
HE*		.000	.011	.003	.253	.008
Naive H.		-.015	-.077	-.013	.173	-.094

[1] HE* refers to the optimal hedging level. $E(U(R^c))$ is always negative but in the case where A=-.001.
[2] Naive H. relates the naive strategy with an hedge level of $x^f = 1$.
[3] Min. H. refers to the hedge level of x^f of a minimum-risk strategy.
[4] HE is from a risk-minimizing strategy.

Table B-4.11 Hedging effectiveness for a one-week hedge, from 1981/82 to 1987/88, with various sampling periods and for simultaneously determined positions.

Simultaneously determined positions [1]		Nearby futures contract			Next to nearby futures contract		
		New HE*[2]	Trad. Naive H.[3]	Trad. HE*	New HE*	Trad. Naive H.	Trad. HE*
1981/82	A=-1000	.000	-.789	-.094	.000	-1.251	-.508
	A=-1	-.002			.000		
	A=-.1	-.556			-.126		
	A=-.001	30.84			3.457		
1982/83	A=-1000	.000	-.379	-.628	.000	-.591	-.117
	A=-1	-.002			.000		
	A=-.1	.740			.026		
	A=-.001	31.38			2.019		
1983/84	A=-1000	.000	-.247	-4.716	.000	-.329	-.308
	A=-1	-.002			.000		
	A=-.1	-.259			-.011		
	A=-.001	64.94			2.680		
1984/85	A=-1000	.000	-.107	-522.11	.000	-.137	-.251
	A=-1	.000			.000		
	A=-.1	-.071			.000		
	A=-.001	122.9			.205		
1985/86	A=-1000	.000	-.101	-25714	.000	-.109	-5.395
	A=-1	-.001			.000		
	A=-.1	-.053			-.002		
	A=-.001	121.5			.705		
1986/87	A=-1000	.000	-.135	-58.2	.000	-.138	-6.374
	A=-1	-.001			.000		
	A=-.1	-.067			-.006		
	A=-.001	122.9			10.584		

Table B-4.11 (Cont.)

1987/88	A=-1000	.000	-10.021	-46.2	.000	-.110	-38.31
	A=-1	-.001			.000		
	A=-.1	-.074			-.007		
	A=-.001	64.53			32.012		

[1] The sample is made of all prices available, with a minimum sample of 52 data at the beginning in 1981/82; $E(U(R^c))$ is always negative but for the cases where A=-.001.
[2] Results obtained with the formula (4.44).
[3] The traditional definition of hedging effectiveness is here assessed with x^{f*} and x^{F*}. The HE is set at: $HE = 1 - [Var(x^{f*}R^f+x^{F*}R^F)/Var(x^{F*}R^F)]$. In the case of naive hedge, $(x^{f*};x^{F*})$ is equal to (1;1).

Table B-4.12 Hedging effectiveness for a two-week hedge, from 1981/82 to 1987/88, with various sampling periods and for simultaneously determined positions.

Simultaneously determined positions [1]		Nearby futures contract			Next to nearby futures contract		
		New HE*[2]	Trad. Naive H.[3]	Trad. HE*	New HE *	Trad. Naive H.	Trad. HE
1981/82	A=-1000	.000	-3.521	-.766	.000	-.719	-.660
	A=-1	-.001			-.002		
	A=-.1	-1.032			-1.843		
	A=-.001	7.889			19.094		
1982/83	A=-1000	.000	-1.294	-.349	.000	-.285	-1.662
	A=-1	.000			-.001		
	A=-.1	-.046			-1.258		
	A=-.001	3.288			21.750		
1983/84	A=-1000	.000	-.675	-.025	.000	-.245	-3.522
	A=-1	.000			-.001		
	A=-.1	-.001			-.081		
	A=-.001	.153			21.828		
1984/85	A=-1000	.000	-.281	-2.295	.000	-.077	-64.031
	A=-1	.000			.000		
	A=-.1	.000			-.013		
	A=-.001	-1.115			12.350		
1985/86	A=-1000	.000	-.242	-2.768	.000	-.065	-749.3
	A=-1	.000			.000		
	A=-.1	.000			-.017		
	A=-.001	.172			30.641		
1986/87	A=-1000	.000	-.265	-.065	.000	-.098	-53.207
	A=-1	.000			.000		
	A=-.1	.000			-.022		
	A=-.001	.114			42.127		

Table B-4.12 (Cont.)

1987/88	A=-1000	.000	-.233	-1.373	.000	-.081	-1293.69
	A=-1	.000			.000		
	A=-.1	.000			-.022		
	A=-.001	1.58			102.992		

[1] The sample is made of all prices available, with a minimum sample of 26 data at the beginning in 1981/82; $E(U(R^c))$ is always negative but for the cases where A=-.001.
[2] Results obtained with the formula (4.44).
[3] The traditional definition of hedging effectiveness is here assessed with x^{f^*} and x^{F^*}. The HE is set at: $HE = 1 - [Var(x^{f^*}R^f + x^{F^*}R^F)/Var(x^{F^*}R^F)]$. In the case of naive hedge, $(x^{f^*};x^{F^*})$ is equal to (1;1).

Table B-4.13 Hedging effectiveness for a two-month hedge, from 1981/82 to 1987/88, with various sampling periods and for simultaneously determined positions.

Simultaneously determined positions [1]		Nearby futures contract			Next to nearby futures contract		
		New HE*[2]	Trad. Naive H.[3]	Trad. HE*	New HE*	Trad. Naive H.	Trad. HE
1981/82	A=-1000	.000	-.241	.804	.000	-.183	-.287
	A=-1	-.005			-.001		
	A=-.1	.036			.008		
	A=-.001	25.851			5.619		
1982/83	A=-1000	.000	.260	.645	.000	.479	-1131.8
	A=-1	-.002			-.003		
	A=-.1	.543			2.350		
	A=-.001	12.732			22.365		
1983/84	A=-1000	.000	-.249	.502	.000	-.397	-3.237
	A=-1	.000			-.001		
	A=-.1	.045			-.499		
	A=-.001	1.108			8.966		
1984/85	A=-1000	.000	.221	-.058	.000	.006	-266.3
	A=-1	.000			-.001		
	A=-.1	-.028			-.116		
	A=-.001	2.405			10.226		
1985/86	A=-1000	.000	.480	.494	.000	.350	-77.586
	A=-1	.000			-.001		
	A=-.1	-.034			-.316		
	A=-.001	2.382			20.705		
1986/87	A=-1000	.000	.427	.501	.000	.358	-666.38
	A=-1	.000			-.002		
	A=-.1	-.047			-.462		
	A=-.001	3.088			29.518		

Table B-4.13 (Cont.)

1987/88	A=-1000	.000	.039	.643	.000	.252	-1742.34
	A=-1	.000			-.001		
	A=-.1	-.082			-.437		
	A=-.001	7.297			20.917		

[1] The sample is made of all prices available, with a minimum sample of 6 data at the beginning in 1981/82; $E(U(R^e))$ is always negative but for the cases where A=-.001 and in 1981/82 and 1982/83 for A=-.1.

[2] Results obtained with the formula (4.44).

[3] The traditional definition of hedging effectiveness is here assessed with x^{f^*} and x^{F^*}. The HE is set at: $HE = 1 - [Var(x^{f^*}R^f + x^{F^*}R^F)/Var(x^{F^*}R^F)]$. In the case of naive hedge, $(x^{f^*};x^{F^*})$ is equal to (1,1).

Table B-4.14 Hedging effectiveness of a one-week hedge, from 1981/82 to 1987/88, with a given cash position.

Hedging Effectiveness		81/82	82/83	83/84	84/85	85/86	86/87	87/88
New Approach [1]								
Nearby contract								
A = -1000	HE*[2]	-.045	-.002	-.002	-.007	-.009	-.005	-.006
	Naive H.[3]	.789	.379	.247	.107	.102	.135	.109
	Min. H.[4]	-.045	-.002	-.002	-.007	-.009	-.005	-.006
A = -1	HE*	-.056	-.001	-.001	-.005	-.007	-.003	-.004
	Naive H.	.887	.442	.279	.119	.112	.147	.125
	Min. H.	-.055	.000	.000	-.005	-.006	-.002	-.003
A = -.1	HE*	-.412	-.139	-.045	-.002	.000	-.004	-.011
	Naive H.	3.071	-1.664	.705	.233	.211	.264	.266
	Min. H.	-.379	-.132	.023	.015	.013	.013	.022
A = -.001	HE*	3.267	8.840	16.92	30.97	30.668	31.053	185.44
	Naive H.	-.269	-.449	-.836	-1.806	-2.401	-2.239	-8.489
	Min. H.	.082	-.023	-.069	-.352	-.502	-.317	-1.534
Next to Nearby contract								
A = -1000	HE*	-.056	-.008	-.001	-.001	-.001	.000	.000
	Naive H.	1.250	.591	.329	.137	.109	.138	.115
	Min. H.	-.056	-.008	-.001	-.001	-.001	.000	.000
A = -1	HE*	-.051	-.009	-.002	.000	-.001	.000	.000
	Naive H.	1.331	.645	.348	.139	.113	.144	.123
	Min. H.	-.051	-.009	-.002	.000	-.001	.000	.000
A = -.1	HE*	.004	-.025	-.021	.000	.000	-.005	-.009
	Naive H.	2.334	1.113	.597	.159	.153	.209	.204
	Min. H.	.286	.011	-.011	.000	.002	.001	.005
A = -.001	HE*	6.837	1.859	2.355	.231	4.827	10.636	81.137
	Naive H.	.498	-.068	-.283	-.121	-.813	-1.136	-4.889
	Min. H.	-.141	-.005	.021	-.004	-.071	-.017	-.292

Table 4-B.14 (Cont.)

Traditional HE[5]							
Nearby	.045	.002	.002	.007	.009	.004	.006
Next to Nearby	.058	.008	.001	.001	.002	.000	.000

[1] The sample is made of all data available, with a minimum of 52 at the beginning in 1981/82. $E(U(R^c))$ is always negative apart from the cases where A=-.001.
[2] This HE^* denotes the HE for an hedge portfolio involving x^{f*} and x^{s*} and corresponds to equation (4.33).
[3] The naive strategy refers to the case where $(x^f;x^c)$ is set at (1,1); HE is then equivalent to $HE = [E(R^f) + (A.Var(R^f)) + (2.A.Cov(R^f;R^c))]/[E(U(R^c))]$.
[4] Min. H. refers to the hedge level of $(x^f;x^s)$ of a minimum-risk strategy. Then HE is set equal to $HE = [((-Cov(R^f;R^c).E(R^f)) - (A.Cov^2(R^f;R^c)))/Var(R^f)]/[E(U(R^c))]$.
[5] Results from the naive strategy are not displayed here since there are equivalent to those shown in the case of simultaneously determined positions. The traditional approach of HE refers to the risk-minimizing strategy whose HE can be described as
$HE = Cov^2(R^f;R^c)/(Var(R^f).Var(R^c))$.

Table B-4.15 Hedging effectiveness of a two-week hedge, from 1981/82 to 1987/88, with a given cash position.

Hedging Effectiveness		81/82	82/83	83/84	84/85	85/86	86/87	87/88
New Approach [1]								
Nearby contract								
A = -1000	HE*[2]	-.022	-.002	-.001	-.002	-.003	-.002	-.003
	Naive H.[3]	.616	.004	.042	.045	.056	.043	.058
	Min. H.[4]	-.022	-.002	-.001	-.002	-.003	-.002	-.003
A = - 1	HE*	-.015	-.002	-.001	-.002	-.003	-.002	-.003
	Naive H.	.561	.021	.042	.046	.058	.042	.056
	Min. H.	.107	.003	-.001	-.002	-.004	-.001	-.002
A = -.1	HE*	-.418	-.062	-.001	-.003	-.005	-.001	-.002
	Naive H.	-6.841	-1.424	.053	.062	.074	.039	.043
	Min. H.	-19.87	-.073	.002	.008	.010	.001	.005
A = -.001	HE*	11.655	3.514	.162	1.177	.110	.132	1.498
	Naive H.	1.238	.456	.013	-.293	-.145	-.076	-.521
	Min. H.	-1.456	-.137	-.009	-.163	.091	-.035	-.237
Next to Nearby contract								
A = -1000	HE*	-.012	-.007	-.001	-.005	-.006	-.002	-.005
	Naive H.	.719	.285	.245	.077	.065	.098	.081
	Min. H.	-.011	-.007	-.001	-.005	-.006	-.002	-.004
A = - 1	HE*	-.019	-.005	-.003	-.003	-.004	-.001	-.003
	Naive H.	-.868	.355	.275	.086	.074	.109	.091
	Min. H.	-.027	.003	-.003	-.001	-.002	.001	.000
A = -.1	HE*	-2.516	-.926	-.093	-.002	-.003	-.011	-.007
	Naive H.	-17.5	6.121	.667	.171	.164	.217	.191
	Min. H.	-2.661	1.639	-.035	.034	.039	.027	.041
A = -.001	HE*	15.492	23.412	21.298	12.991	31.104	42.475	100.75
	Naive H.	-.604	-.717	-.841	-.818	-1.612	-2.197	-5.277
	Min. H.	.186	-.080	.071	-.321	-.742	-.533	-2.210

Table 4-B.15 (Cont.)

Traditional HE[5]							
Nearby	.022	.003	.001	.002	.003	.002	.003
Next to Nearby	.012	.007	.001	.005	.006	.002	.005

[1] The sample is made of all data available, with a minimum of 26 at the beginning in 1981/82. $E(U(R^c))$ is always negative apart from cases where A=-.001 and A=-.1 for 1981/82.

[2] This HE* denotes the HE for an hedge portfolio involving x^{f*} and x^{s*} and corresponds to equation (4.33).

[3] The naive strategy refers to the case where $(x^f;x^c)$ is set at (1,1); HE is then equivalent to $HE = [E(R^f)+(A.Var(R^f)) + (2.A.Cov(R^f;R^c))]/[E(U(R^c))]$.

[4] Min. H. refers to the hedge level of $(x^f;x^s)$ of a minimum-risk strategy. Then HE is set equal to $HE = [((-Cov(R^f;R^c).E(R^f))-(A.Cov^2(R^f;R^c)))/Var(R^f)]/[E(U(R^c))]$.

[5] Results from the naive strategy are not displayed here since there are equivalent to those shown in the case of simultaneously determined positions. The traditional approach of HE refers to the risk-minimizing strategy whose HE can be described as
$HE = Cov^2(R^f;R^c)/(Var(R^f).Var(R^c))$.

Table B-4.16 Hedging effectiveness of a two-month hedge, from 1981/82 to 1987/88, with a given cash position.

Hedging Effectiveness		81/82	82/83	83/84	84/85	85/86	86/87	87/88
New Approach [1]								
Nearby contract								
A = -1000	HE*[2]	-.624	-.647	-.581	-.555	-.573	-.581	-.608
	Naive H.[3]	.012	-.233	-.296	-.397	-.414	-.417	-.417
	Min. H.[4]	-.624	-.647	-.581	-.555	-.573	-.581	-.608
A = - 1	HE*	-.664	-.675	-.588	-.555	-.581	-.588	-.621
	Naive H.	.132	-.114	-.231	-.372	-.395	-.399	-.402
	Min. H.	-.663	-.672	-.587	-.555	-.580	-.588	-.619
A = -.1	HE*	-.854	.863	-.899	-.663	-.883	-.867	-1.001
	Naive H.	-1.584	-3.567	2.210	.136	.156	.040	.142
	Min. H.	-.859	-.051	-.397	-.567	-.763	-.773	-.893
A = -.001	HE*	7.219	14.996	11.396	7.396	5.461	5.324	3.908
	Naive H.	-.791	-.881	-.907	-.853	-.699	-.701	-.624
	Min. H.	-.389	-.506	-.531	-.551	-.453	-.454	-.392
Next to Nearby contract								
A = -1000	HE*	-.536	-.616	-.507	-.486	-.470	-.446	-.495
	Naive H.	-.051	-.352	-.288	-.350	-.357	-.352	-.397
	Min. H.	-.536	-.616	-.507	-.486	-.470	-.446	-.495
A = - 1	HE*	-.522	-.593	-.489	-.470	-.445	-.415	-.471
	Naive H.	.139	-.184	-.195	-.301	-.296	-.284	-.339
	Min. H.	-.517	-.586	-.487	-.469	-.444	-.413	-.469
A = -.1	HE*	-.336	.048	-.346	-.342	-.238	-.142	-.253
	Naive H.	-1.107	-5.884	3.244	.674	1.321	1.307	1.339
	Min. H.	-.391	-2.502	.573	-.132	.212	.359	.291
A = -.001	HE*	26.515	38.938	23.167	16.748	24.661	30.738	24.286
	Naive H.	-1.315	-1.318	-1.155	-1.218	-1.330	-1.405	-1.342
	Min. H.	-.671	-.825	-.698	-.793	-.895	-.959	-.924

Table 4-B.16 (Cont.)

Traditional HE[5]							
Nearby	.624	.647	.581	.555	.573	.581	.608
Next to Nearby	.536	.616	.507	.486	.470	.446	.495

[1] The sample is made of all data available, with a minimum of 6 at the beginning in 1981/82. $E(U(R^c))$ is always negative apart from cases where A=-.001 and A=-.1 for 1981/82 and 1982/83.

[2] This HE^* denotes the HE for an hedge portfolio involving x^{f*} and x^{s*} and corresponds to equation (4.33).

[3] The naive strategy refers to the case where $(x^f;x^c)$ is set at (1,1); HE is then equivalent to $HE = [E(R^f) + (A.Var(R^f)) + (2.A.Cov(R^f;R^c))]/[E(U(R^c))]$.

[4] Min. H. refers to the hedge level of $(x^f;x^s)$ of a minimum-risk strategy. Then HE is set equal to $HE = [((-Cov(R^f;R^c).E(R^f)) - (A.Cov^2(R^f;R^c)))/Var(R^f)]/[E(U(R^c))]$.

[5] Results from the naive strategy are not displayed here since there are equivalent to those shown in the case of simultaneously determined positions. The traditional approach of HE refers to the risk-minimizing strategy whose HE can be described as $HE = Cov^2(R^f;R^c)/(Var(R^f).Var(R^c))$.

Table 5-A.1.1 Results of weak form test of informational efficiency, Q test of the July contract, over 24 lags from 1981 to 1988.

Year	1981	1982	1983	1984	1985	1986	1987	1988
N	233	235	237	236	233	238	218	276
Lags: 1 - 6	14.66*	5.21	17.66	4.57	13.52	22.91*	30.82*	13.15*
Lags: 1 - 12	18.42	10.20	21.22*	8.21	31.87*	26.28*	34.73*	24.60*
Lags: 1 - 18	19.62	28.70	41.36*	16.23	39.11*	30.75*	39.54*	34.03*
Lags: 1 - 24	20.97	34.99	44.00*	22.19	41.67*	39.01*	41.75*	37.44*

Table values of Q at 5%, are 12.59, 21.03, 28.87 and 36.42 for the 6, 12, 18 and 24 lags respectively.
* Q values significant at 5 %; N denotes the number of observations.

Table 5-A.1.2 Results of weak form test of informational efficiency, Q test of the September contract, over 24 lags from 1981 to 1987.

Year	1981	1982	1983	1984	1985	1986	1987
N	248	241	231	247	250	246	246
Lags : 1 - 6	19.10*	12.36	16.48*	26.40*	18.85*	12.64*	15.22*
Lags : 1 - 12	27.25*	15.87	53.31*	35.46*	30.36*	18.16	18.37
Lags : 1 - 18	31.54*	22.39	61.88*	40.22*	34.39*	26.10	23.41
Lags : 1 - 24	34.48	24.63	72.13*	40.84*	38.27*	26.46	30.04

Table values of Q at 5%, are 12.59, 21.03, 28.87 and 36.42 for the 6, 12, 18 and 24 lags respectively.
* Q values significant at 5 %; N denotes the number of observations.

Table 5-A.1.3 Results of weak form test of informational efficiency, Q test of the November contract, over 24 lags from 1981 to 1987.

Year	1981	1982	1983	1984	1985	1986	1987
N	246	246	249	249	259	243	291
Lags : 1 - 6	12.52	5.43	11.49	14.63*	8.44	19.62*	14.61*
Lags : 1 - 12	23.07*	13.33	22.90*	19.99	19.45	31.40*	17.72
Lags : 1 - 18	30.24*	19.55	35.46*	24.78	25.19	38.09*	22.66
Lags : 1 - 24	41.63*	23.62	48.43*	27.05	27.97	39.08*	35.77

Table values of Q at 5%, are 12.59, 21.03, 28.87 and 36.42 for the 6, 12, 18 and 24 lags respectively.
* Q values significant at 5 %; N denotes the number of observations.

Table 5-A.1.4 Results of weak form test of informational efficiency, Q test of the January contract, over 24 lags from 1982 to 1988.

Year	1982	1983	1984	1985	1986	1987	1988
N	245	247	249	246	262	247	288
Lags : 1 - 6	16.33*	7.56	8.01	6.64	5.65	18.98*	13.95
Lags : 1 - 12	24.68*	15.55	15.95	14.56	14.33	23.98*	21.06
Lags : 1 - 18	33.24*	19.55	19.38	15.50	19.69	28.13	26.11
Lags : 1 - 24	49.25*	26.58	25.26	18.66	22.66	31.71	43.00*

Table values of Q at 5%, are 12.59, 21.03, 28.87 and 36.42 for the 6, 12, 18 and 24 lags respectively.
* Q values significant at 5 %; N denotes the number of observations.

Table 5-A.1.5 Results of weak form test of informational efficiency, Q test of the March contract, over 24 lags from 1982 to 1988.

Year	1982	1983	1984	1985	1986	1987	1988
N	246	244	248	243	261	249	289
Lags : 1 - 6	8.65	6.91	16.73*	12.67	11.53	12.59	1.70
Lags : 1 - 12	13.97	18.34	30.65*	15.75	13.17	20.59	6.81
Lags : 1 - 18	26.25	30.83*	39.19*	20.12	16.56	25.48	21.95
Lags : 1 - 24	34.47	35.06*	50.75*	23.34	19.30	27.84	31.43

Table values of Q at 5%, are 12.59, 21.03, 28.87 and 36.42 for the 6, 12, 18 and 24 lags respectively.
* Q values significant at 5 %; N denotes the number of observations.

Table 5-A.1.6 Results of weak form test of informational efficiency, Q test of the May contract, over 24 lags from 1982 to 1988.

Year	1982	1983	1984	1985	1986	1987	1988
N	247	247	249	246	273	248	287
Lags : 1 - 6	8.97	1.98	4.57	2.49	9.25	5.84	14.36
Lags : 1 - 12	10.10	4.72	7.32	5.73	11.17	12.12	25.08
Lags : 1 - 18	15.26	13.23	16.64	15.08	13.78	14.59	34.45
Lags : 1 - 24	26.64	18.01	20.21	21.60	15.32	18.18	52.63*

Table values of Q at 5%, are 12.59, 21.03, 28.87 and 36.42 for the 6, 12, 18 and 24 lags respectively.
* Q values significant at 5 %; N denotes the number of observations.

Table 5-A.1.7 Results from Run test (or Z test) for futures contracts from 1982 to 1987.

Contract Month		R	N_1	N_2	T	SD(R)	E(R)	Z
Jan	1982	109	113	132	245	7.70	120.76	-1.46
Jan	1983	110	123	124	247	7.78	122.50	-1.54
Jan	1984	115	118	131	249	7.79	123.16	-.98
Jan	1985	124	111	135	246	7.69	120.83	.48
Jan	1986	132	134	128	262	8.01	129.93	.32
Jan	1987	95	117	130	247	7.76	122.16	-3.44*
Jan	1988	119	131	157	288	8.34	141.83	-2.68*
Mar	1982	104	117	129	246	7.74	121.71	-2.22*
Mar	1983	99	138	106	244	7.59	118.90	-2.56*
Mar	1984	122	120	128	248	7.79	122.87	-.05
Mar	1985	129	110	133	243	7.64	119.41	1.32
Mar	1986	134	125	136	261	7.99	129.27	.66
Mar	1987	99	122	127	249	7.81	123.45	-3.07*
Mar	1988	129	139	150	289	8.41	143.29	-1.64
May	1982	115	115	132	247	7.74	121.91	-.83
May	1983	109	129	118	247	7.76	122.26	-1.64
May	1984	125	129	120	249	7.80	123.34	.28
May	1985	125	118	128	246	7.75	121.80	.48
May	1986	135	125	148	273	8.13	134.53	.12
May	1987	115	127	121	248	7.79	122.93	-.95
May	1988	127	135	152	287	8.37	142.00	-1.73
Jul	1981	116	104	129	233	7.46	114.16	.31
Jul	1982	119	106	129	235	7.51	115.37	.55
Jul	1983	94	118	119	237	7.62	117.50	-3.02*
Jul	1984	120	110	126	236	7.56	116.46	.53
Jul	1985	102	96	137	233	7.31	111.89	-1.29
Jul	1986	109	111	127	238	7.60	117.46	-1.05
Jul	1987	103	102	116	218	7.27	107.55	-.56
Jul	1988	125	125	151	276	8.16	135.78	-1.26
Sep	1981	122	115	133	248	7.75	122.35	.02
Sep	1982	104	104	137	241	7.53	117.24	-1.69
Sep	1983	99	108	123	231	7.48	114.01	-1.94
Sep	1984	115	106	141	247	7.62	120.02	-.59
Sep	1985	125	115	135	250	7.77	123.20	.30
Sep	1986	102	117	129	246	7.74	121.71	-2.48*
Sep	1987	108	108	138	246	7.64	120.17	-1.53
Nov	1981	107	103	143	246	7.55	118.75	-1.49
Nov	1982	112	124	122	246	7.76	121.99	-1.22
Nov	1983	114	127	122	249	7.81	123.45	-1.15
Nov	1984	117	115	134	249	7.76	122.78	-.68
Nov	1985	116	130	129	259	7.97	128.50	-1.51
Nov	1986	93	122	121	243	7.71	120.50	-3.50*
Nov	1987	122	139	152	291	8.44	144.21	-2.57*

* Significant at the 5% level, Z is (0,1). Jan, Mar, Jul, Sep and Nov stand for January, March, July, September and November.

Table 5-A.2.1 Results from the analysis of the forecasting performance using the linear regression method for the July, September and November contracts, with Friday closing prices[++].

July

1-month lag : $P^f_t = -6.21 + 1.07\ P^f_{t-1}$ R^2 Adj = 0.68 ; DW = 2.65; F_{Ho} = 0.01
(-0.18) (0.26)

3-month lag : $P^f_t = 21.23 + 0.81\ P^f_{t-3}$ R^2 Adj = 0.54 ; DW = 2.62; F_{Ho} = 0.01
(0.69) (-0.76)

6-month lag : $P^f_t = -173.20 + 2.44\ P^f_{t-6}$ R^2 Adj = 0.71 ; DW = 1.95; F_{Ho} = 2.65
(-2.52)* (2.52)*

9-month lag : $P^f_t = -54.93 + 1.47\ P^f_{t-9}$ R^2 Adj = 0.64 ; DW = 2.12; F_{Ho} =0.65
(-1.56) (1.62)

September

1-month lag : $P^f_t = 24.87 + 0.77\ P^f_{t-1}$ R^2 Adj = 0.83 ; DW = 2.62; F_{Ho} = 0.02
(2.09)* (-2.11)*

3-month lag : $P^f_t = 18.41 + 0.85\ P^f_{t-3}$ R^2 Adj = 0.65 ; DW = 2.99; F_{Ho} = 0.01
(0.88) (-0.78)

6-month lag : $P^f_t = 24.59 + 0.79\ P^f_{t-6}$ R^2 Adj = 0.58 ; DW = 2.64; F_{Ho} = 0.31
(0.91) (0.78)

9-month lag : $P^f_t = -54.93 + 1.47\ P^f_{t-9}$ R^2 Adj = 0.65 ; DW = 2.12; F_{Ho} = 0.65
(-1.56) (1.62)

November

1-month lag : $P^f_t = 10.47 + 0.91\ P^f_{t-1}$ R^2 Adj = 0.97 ; DW = 2.54; F_{Ho} = 2.33
(2.71)* (-2.57)*

3-month lag : $P^f_t = 66.93 + 0.39\ P^f_{t-3}$ R^2 Adj = 0.51 ; DW = 2.24; F_{Ho} = 3.91
(4.45)* (-4.48)*

6-month lag : $P^f_t = 47.52 + 0.58\ P^f_{t-6}$ R^2 Adj = 0.62 ; DW = 2.26; F_{Ho} = 1.85
(2.49)* (-2.47)*

9-month lag : $P^f_t = 57.93 + 0.49\ P^f_{t-9}$ R^2 Adj = 0.54 ; DW = 2.61; F_{Ho} = 3.74
(3.59)* (-3.42)*

[++] The t values of the intercept and the slope coefficients are in brackets and correspond to the test of the null hypothesis H'_o : a=0 and H''_o : b=1 respectively.
* t values significant at 5%; ** t values significant at 10%.

Table 5-A.2.2 Results from the analysis of the forecasting performance using the linear regression method for the January, March and May contracts, with Friday closing prices[++].

January

1-month lag : $P^f_t = -12.68 + 1.12\ P^f_{t-1}$ R^2 Adj = 0.93 ; DW = 1.78; F_{Ho} = 0.01
$(-2.81)^*$ $(3.01)^*$

3-month lag : $P^f_t = 21.99 + 0.81\ P^f_{t-3}$ R^2 Adj = 0.75 ; DW = 2.65; F_{Ho} = 0.04
(1.29) (-1.26)

6-month lag : $P^f_t = 60.41 + 0.47\ P^f_{t-6}$ R^2 Adj = 0.95 ; DW = 2.09; F_{Ho} = 0.01
$(2.79)^*$ $(-2.67)^*$

9-month lag : $P^f_t = 66.86 + 0.41\ P^f_{t-9}$ R^2 Adj = 0.37 ; DW = 2.75; F_{Ho} = 2.68
$(3.52)^*$ $(-3.47)^*$

March

1-month lag : $P^f_t = -6.14 + 1.07\ P^f_{t-1}$ R^2 Adj = 0.94 ; DW = 1.89; F_{Ho} = 0.09
(-0.58) (0.78)

3-month lag : $P^f_t = -31.91 + 1.31\ P^f_{t-3}$ R^2 Adj = 0.47 ; DW = 2.85; F_{Ho} = 0.01
(-1.13) (1.24)

6-month lag : $P^f_t = 27.49 + 0.77\ P^f_{t-6}$ R^2 Adj = 0.34 ; DW = 2.71; F_{Ho} = 0.18
(0.66) (0.63)

9-month lag : $P^f_t = 16.25 + 0.89\ P^f_{t-9}$ R^2 Adj = 0.09 ; DW = 2.38; F_{Ho} = 0.03
(0.43) (-0.34)

May

1-month lag : $P^f_t = 17.04 + 0.85\ P^f_{t-1}$ R^2 Adj = 0.92 ; DW = 2.58; F_{Ho} = 1.06
(1.64) (-1.73)

3-month lag : $P^f_t = 6.32 + 0.96\ P^f_{t-3}$ R^2 Adj = 0.83 ; DW = 2.72; F_{Ho} = 0.07
(0.35) (-0.26)

6-month lag : $P^f_t = 11.39 + 0.91\ P^f_{t-6}$ R^2 Adj = 0.18 ; DW = 1.76; F_{Ho} = 0.01
(0.16) (0.16)

9-month lag : $P^f_t = 63.01 + 0.49\ P^f_{t-9}$ R^2 Adj = 0.28 ; DW = 2.87; F_{Ho} = 2.95
$(2.96)^*$ $(-2.85)^*$

[++] The t values of the intercept and the slope coefficients are in brackets and correspond to the test of the null hypothesis H'_o : a=0 and H''_o : b=1 respectively.
* t values significant at 5%; ** t values significant at 10%

Table 5-A.2.3 Results from the comparative analysis of the forecasting performance of the wheat futures market from 1980/81 to 1987/88 for one-month lag.

RMSE*	Futures price	Forward price	Naive forecast	SARIMA models	Intervention price
1980/81	2.092		2.334		7.808
1981/82	1.803	2.210	2.313		7.735
1982/83	3.359	2.361	3.617	3.080	12.663
1983/84	2.979	3.345	3.766	4.045	9.323
1984/85	1.860	3.111	3.755	3.829	10.776
1985/86	1.165	2.184	1.836	2.368	9.859
1986/87	3.182	2.038	2.476	3.318	9.500
1987/88	2.202	1.744	2.090		6.319
Period 1980/88	2.439	2.326	2.873	3.380	9.431
RMSPE**	Futures price	Forward price	Naive forecast	SARIMA models	Intervention price
1980/81	.0196		.0211		.0698
1981/82	.0161	.0187	.0196		.0646
1982/83	.0261	.0182	.0286	.0235	.0930
1983/84	.0236	.0264	.0292	.0321	.0688
1984/85	.0179	.0298	.0362	.0368	.1010
1985/86	.0101	.0210	.0168	.0237	.0961
1986/87	.0287	.0192	.0228	.0300	.0795
1987/88	.0213	.0170	.0198		.0611
Period 1980/88	.0211	.0205	.0250	.0297	.0806
Overall Ranking	2	1	3	4	5

*, ** Root Mean Square Error, Root Mean Square Percentage Error

Table 5-A.2.4 Results from the comparative analysis of the forecasting performance of the wheat futures market from 1980/81 to 1987/88 for a two-month lag.

RMSE*	Futures price	Forward price	Naive forecast	SARIMA models	Intervention price
1980/81	2.597	3.476	7.446		7.808
1981/82	2.964	3.239	6.133		7.735
1982/83	5.310	4.133	7.941	3.878	12.663
1983/84	4.923	4.776	8.614	4.259	9.323
1984/85	3.792	5.011	15.502	3.947	10.776
1985/86	3.612	4.381	9.678	4.922	9.859
1986/87	4.745	4.480	4.386	4.808	9.500
1987/88	4.861	3.865	10.010		6.319
Period 1980/88	4.206	4.210	9.245	4.401	9.431
RMSPE*	Futures price	Forward price	Naive forecast	SARIMA models	Intervention price
1980/81	.0234	.0310	.0744		.0698
1981/82	.0272	.0282	.0563		.0646
1982/83	.0428	.0320	.0673	.0304	.0930
1983/84	.0379	.0369	.0700	.0342	.0688
1984/85	.0346	.0444	.1528	.0347	.1010
1985/86	.0323	.0398	.0978	.0500	.0961
1986/87	.0441	.0414	.0394	.0421	.0795
1987/88	.0467	.0370	.0976		.0611
Period 1980/88	.0369	.0367	.0881	.0392	.0806
Overall Ranking	1	1	4	3	4

*, ** Root Mean Square Error, Root Mean Square Percentage Error

Table 5-A.2.5 Results from the comparative analysis of the forecasting performance of the wheat futures market from 1980/81 to 1987/88 for a three-month lag.

RMSE*	Futures price	Forward price	Naive forecast	SARIMA models	Intervention price
1980/81	3.503	3.442	7.015		7.808
1981/82	2.547	2.547	7.476		7.735
1982/83	5.632	4.907	10.531	5.375	12.663
1983/84	4.131	3.244	8.263	4.960	9.323
1984/85	4.478	4.670	13.242	4.392	10.776
1985/86	4.430	4.695	10.993	8.617	9.859
1986/87	5.209	3.927	6.502	7.158	9.500
1987/88	6.894	6.153	9.330		6.319
Period 1980/88	4.768	4.331	9.420	6.327	9.431
RMSPE**	Futures price	Forward price	Naive forecast	SARIMA models	Intervention price
1980/81	.0315	.0310	.0664		.0698
1981/82	.0230	.0220	.0685		.0646
1982/83	.0441	.0377	.0867	.0423	.0930
1983/84	.0329	.0258	.0662	.0397	.0688
1984/85	.0403	.0426	.1290	.0396	.1010
1985/86	.0396	.0422	.1107	.0787	.0961
1986/87	.0478	.0368	.0588	.0606	.0795
1987/88	.0657	.0584	.0908		.0611
Period 1980/88	.0423	.0386	.0878	.0548	.0806
Overall Ranking	2	1	4	3	5

*, ** Root Mean Square Error, Root Mean Square Percentage Error

Figure 5-A.3.1 Risk premium for a one-, two- and three-month lag with realized data as proxies for expected future spot prices from 01/1975 to 05/1989

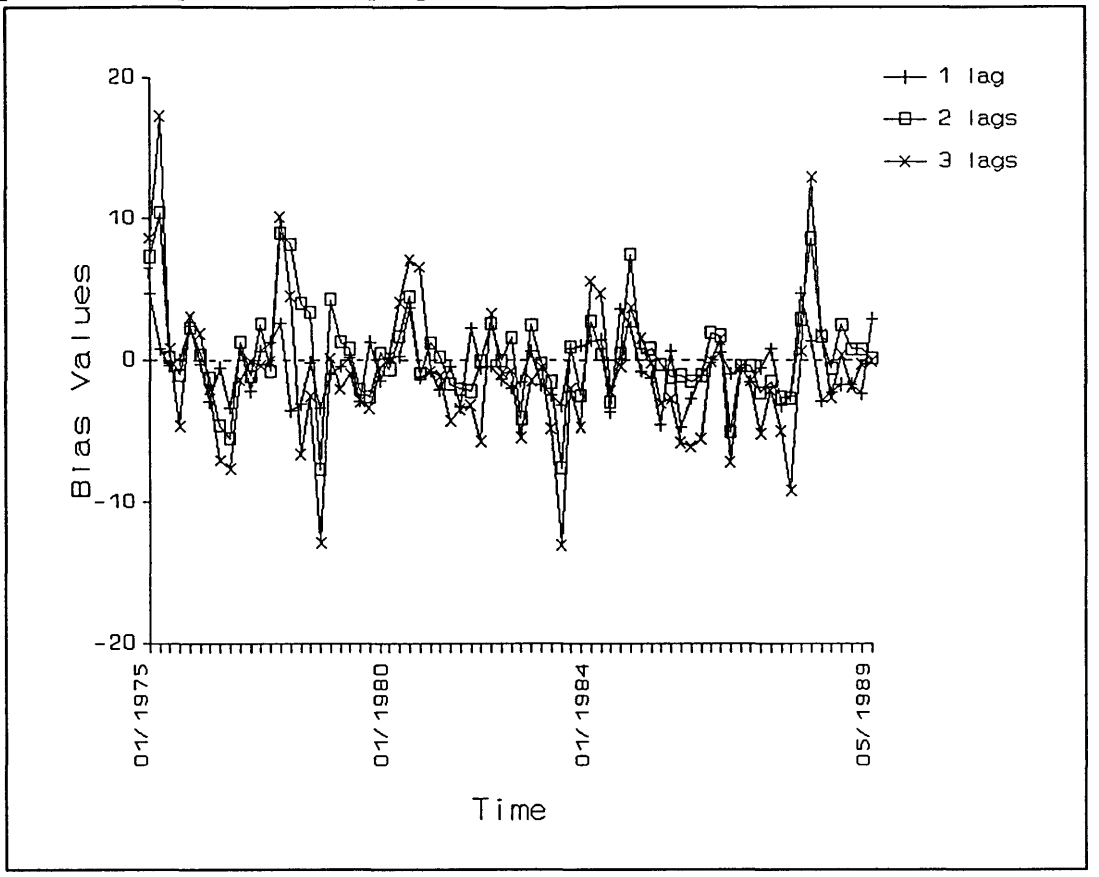


Table 5-A.3.2 Characteristics of the Risk Premium*

With Realized Data	Mean	Standard deviation
One-month lag	-.598	2.105
Two-month lag	.411	3.434
Three-month lag	-.957	5.053
Six-month lag	-1.195	6.890
Nine-month lag	-1.532	7.256
With forward prices	**Mean**	**Standard deviation**
One-month lag	-.291	2.211
Two-month lag	-.711	3.928

* from 01/1975 to 05/1989 and ** from 09/1981 to 05/1989

Figure 5-A.3.3 Risk premium for a three-, six- and nine-month lag with realized data as proxies for expected future spot prices from 01/1975 to 05/1989.

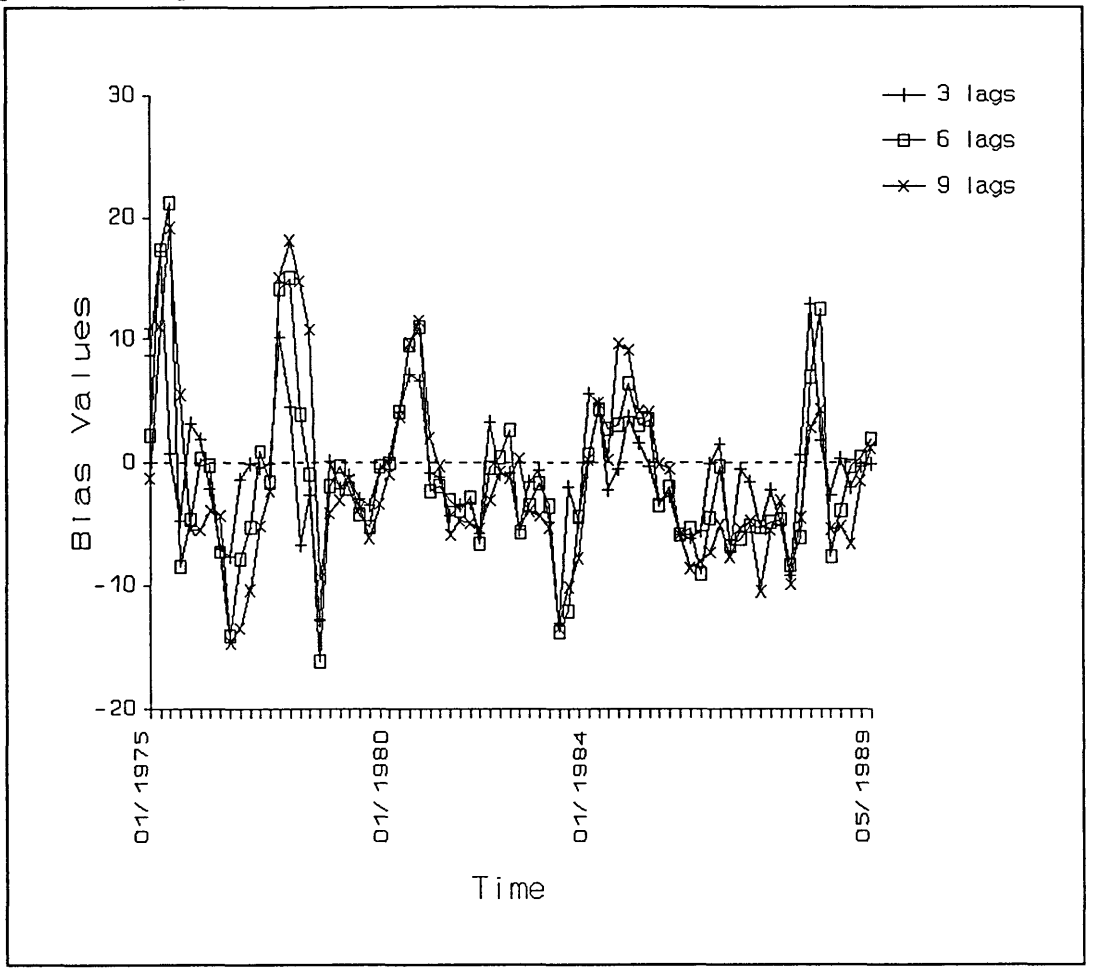
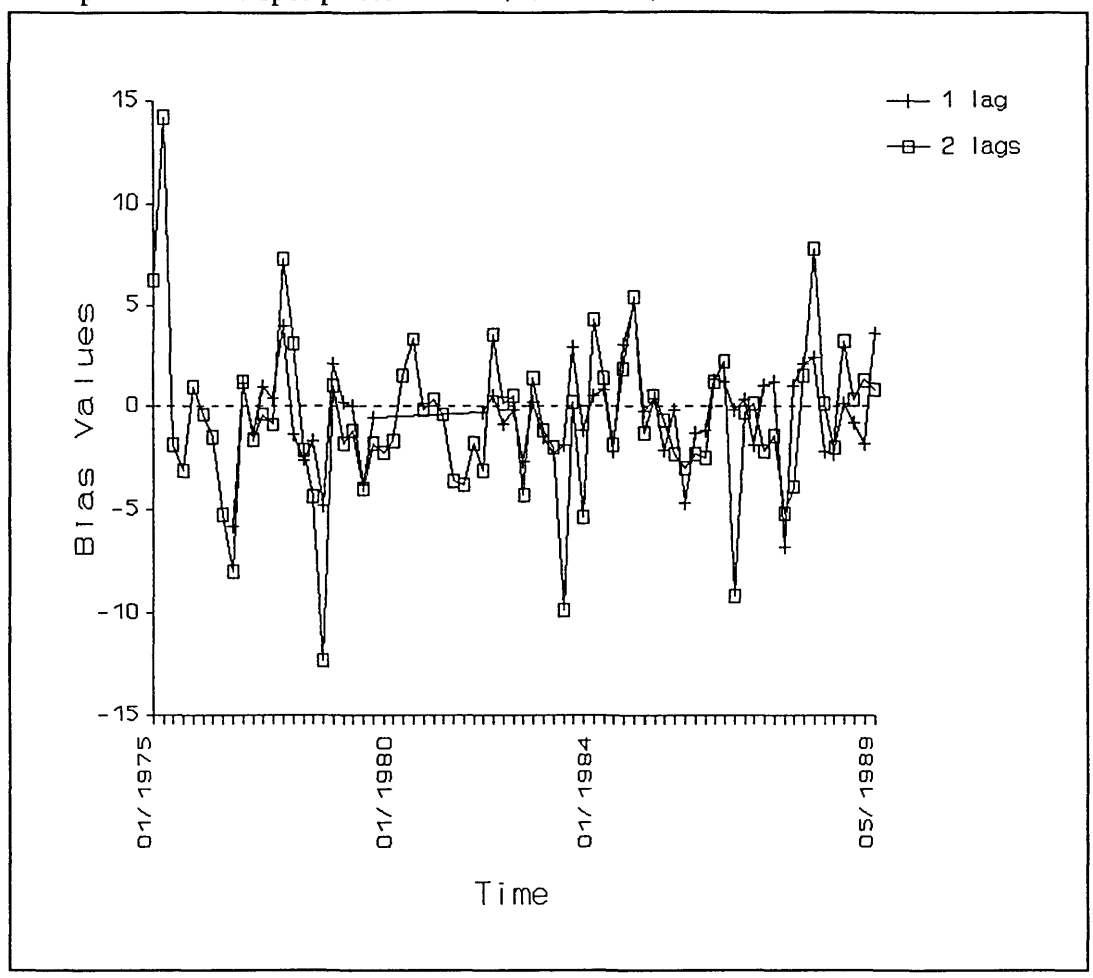


Figure 5-A.3.4 Risk premium for a one- and two-month lag with forward data as proxies for expected future spot prices from 01/1975 to 05/1989.



Appendix 6-A Autocorrelations between stationary series (from the Pierce and Haugh test)

Table 6-A.1 Cross-correlations between the French spot price and next to nearby futures price

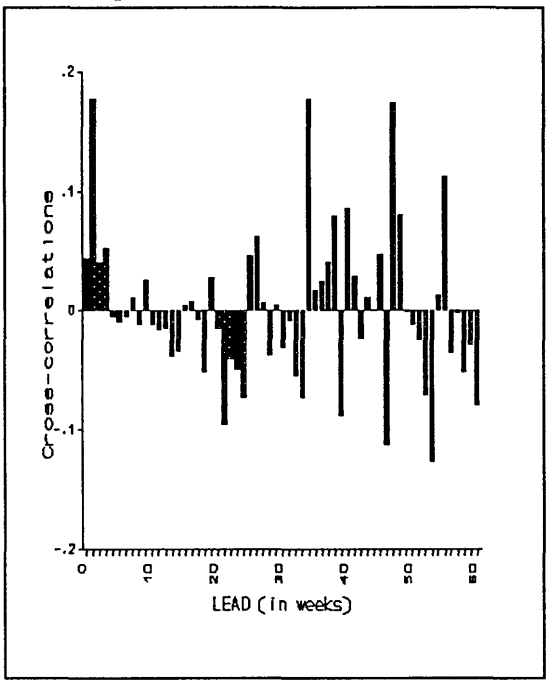


Table 6-A.2 Cross-correlations between the nearby futures price and the next to nearby futures price

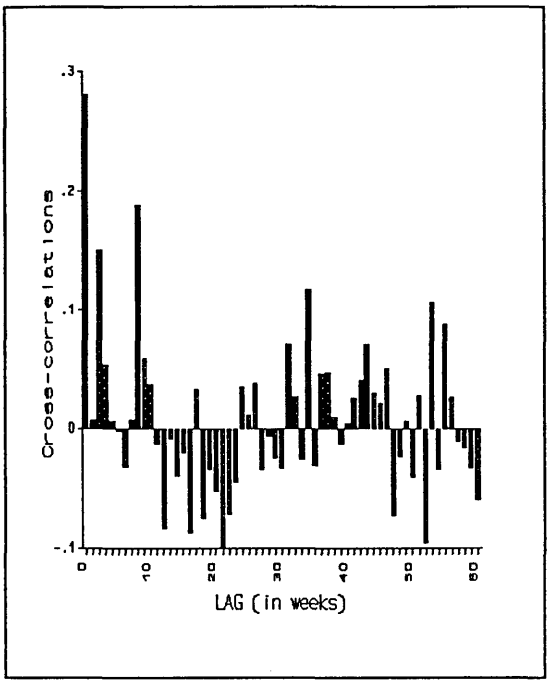


Table 6-A.3 Cross-correlations between the nearby futures price and the UK spot price

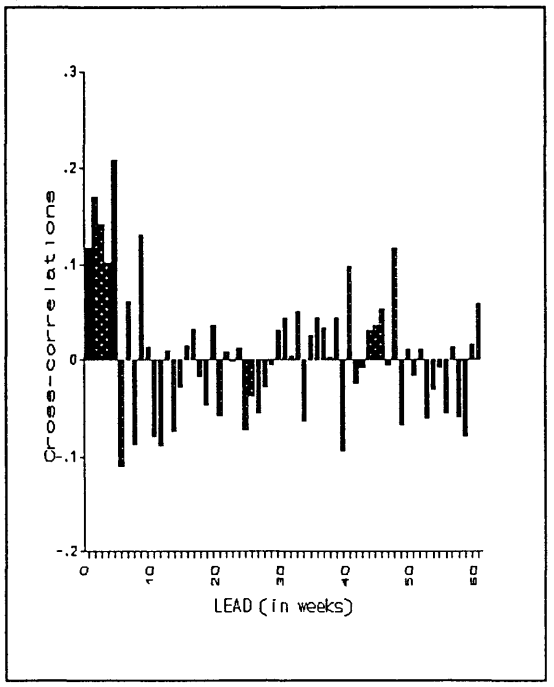


Table 6-A.4 Cross-correlations between the French spot price and the UK forward price

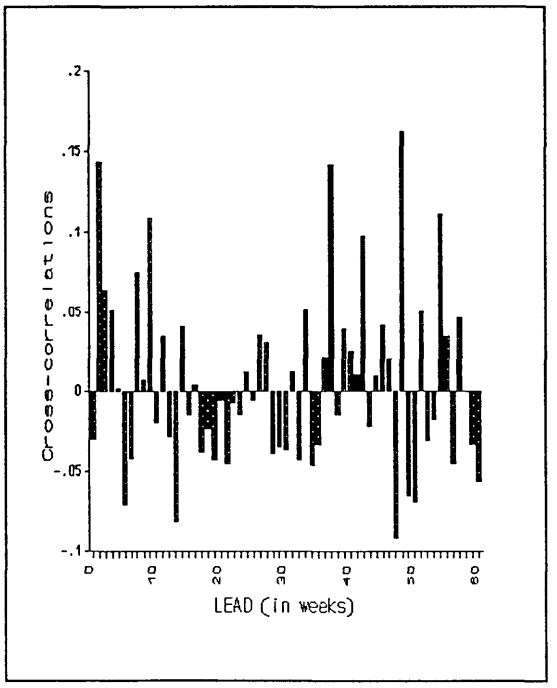


Table 6-A.5 Cross-correlations between the UK spot price and the UK forward price

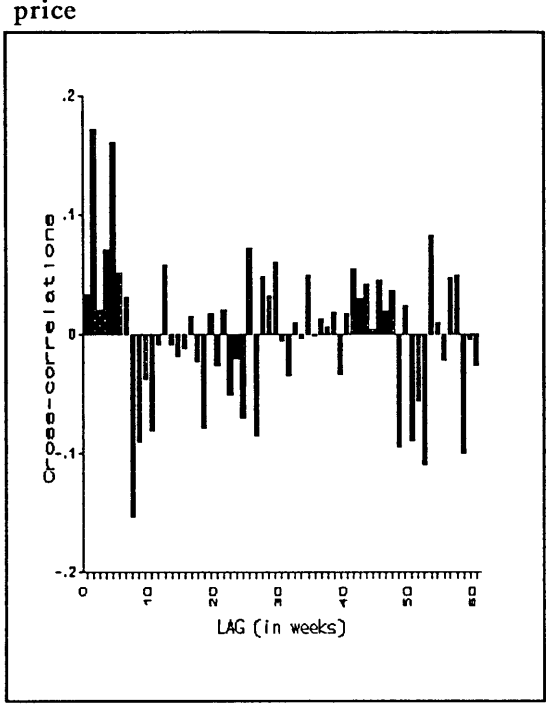


Table 6-A.6 Cross-correlations between the UK spot price and the next to nearby futures price

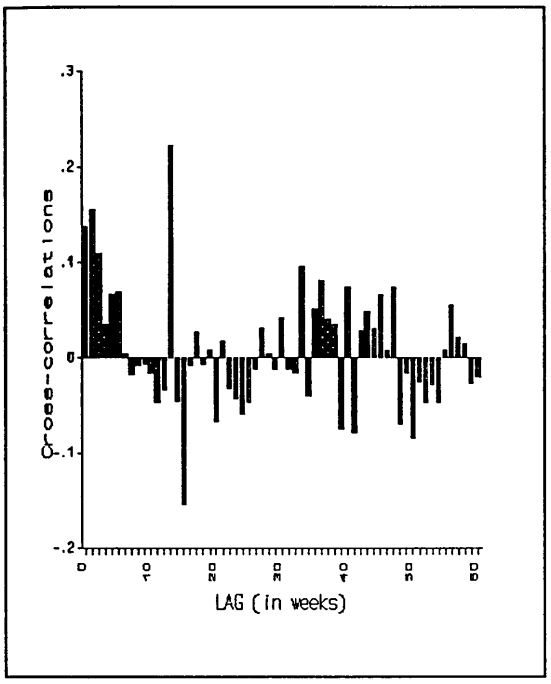


Table 6-A.7 Cross-correlations between the next to nearby futures price and the UK forward price

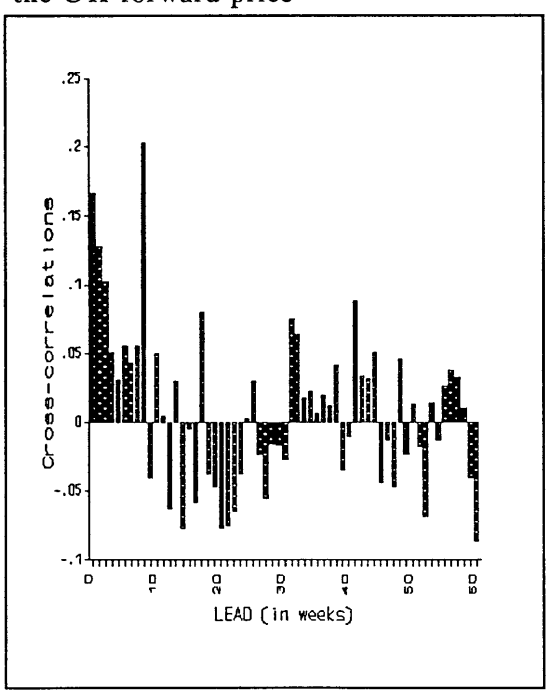


Table 6-A.8 Cross-correlations between the nearby futures price and the UK forward price

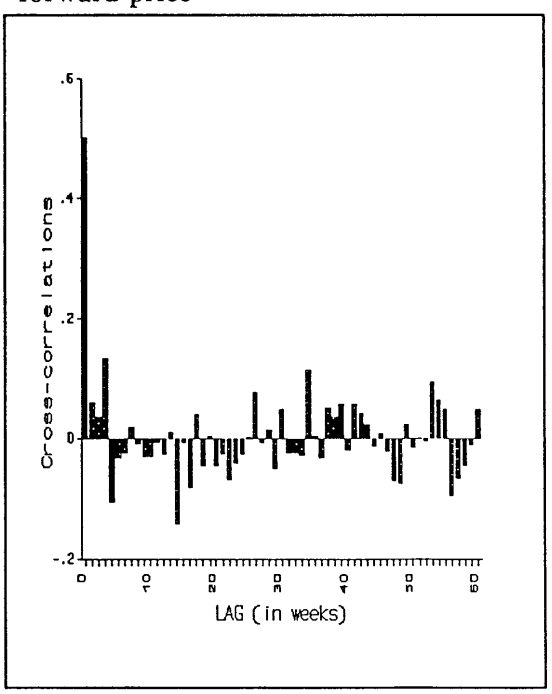


Table 6-A.9 Cross-correlations between the French spot price and the UK spot price

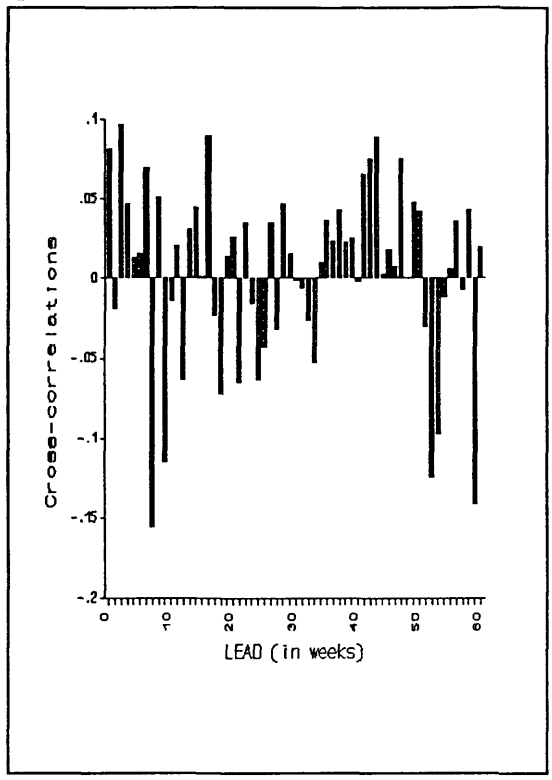


Table 6-A.10 Cross-correlations between the French spot price and the nearby futures price

