EXCHANGE RATE ECONOMIC EXPOSURE AND HEDGING: THE SIGNIFICANCE OF CURRENCY OPTIONS.

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June 1993

The University of Aston in Birmingham

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1993

Synopsis

This thesis focuses on the theoretical examination of the exchange rate economic (operating) exposure within the context of the theory of the firm, and proposes some hedging solutions using currency options.

The examination of economic exposure is based on such parameters as firms' objectives, industry structure and production cost efficiency.In particular, it examines an hypothetical exporting firm with costs in domestic currency, which faces competition from foreign firms in overseas markets and has a market share expansion objective.Within this framework, the hypothesis is established that economic exposure, portrayed in a diagram connecting export prices and real exchange rates, is asymmetric (i.e. the negative effects of a currency appreciation are higher than the positive effects of a currency depreciation).In this case, export business can be seen as a real option, given by exporting firms to overseas customers. Different scenarios about the asymmetry hypothesis can be derived for different assumptions about the determinants of economic exposure.

Having established the asymmetry hypothesis, the hedging against this exposure is analysed.The hypothesis is established, that a currency call option should be used in hedging against asymmetric economic exposure. Further, some advanced currency options strategies are discussed, and their use in hedging several scenarios of exposure is indicated, establishing the hypothesis that, the optimal options strategy is a function of the determinants of exposure.

Some extensions on the theoretical analysis are examined.These include the hedging of multicurrency exposure using options, and the exposure of a purely domestic firm facing import competition.

The empirical work addresses two issues:the empirical validity of the asymmetry hypothesis and the examination of the hedging effectiveness of currency options.On the basis of the behaviour of export prices of ten commodities exported from the UK to the USA from 1980 to 1988, the asymmetry hypothesis appears to be empirically supported.In the hedging part, the work addresses, initially, some practical issues related to the implementation of a currency option hedging scenario (i.e.type of option, hedge ratios determination and timing of placing and removing the hedge).Then, it provides a statistical test of the effectiveness of currency options in eliminating economic exposure for five of the previous commodities.The empirical findings do support the hypothesis that currency options can hedge economic exposure.

Keywords: Exchange Rate Pass Through, Export Prices, Currency Options Strategies, Asian Options, Hedging Effectiveness.

To my mother, Eleni,
and my father Giorgos.

Acknowledgements.

I want to thank all those who taught me over my undergraduate and postgraduate studies in the Athens University Of Economics and the University of Strathclyde, for providing me a strong background to undertake doctoral studies.I believe that, according to an Ancient Greek saying 'Our being is owed to our parents, but our well being, to our teachers'.

Over my doctoral studies, Prof. E.W. Davis of Aston University offered me significant support and encouragement. Further, Mrs A.Spooner of Aston University, and Prof.E. Fisher of Cornell University, USA, offered me valuable insights, at various stages of the work. Support from the Mobil North Sea Oil Fund in Aston University was important for the completion of this work.

This research was financed by a full, three year scholarship, from the State Scholarships Foundation of Greece (I.K.Y.).

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INTRODUCTION

The significant variability of nominal and real exchange rates affects firms with international interests, in many ways.Nominal exchange rate changes affect the domestic currency value of a foreign currency receivable or payable, a foreign currency loan. dividends, foreign assets and working capital.These are transaction exposures.Real exchange rate changes affect the competitive position of the firm within the industry, in terms of costing and pricing. This type of exposure is known as operating or economic exposure, and will be the focus of this thesis.It must be emphasized that the two previous terms (operating exposure and economic exposure) will be used here interchangeably, and both will imply the same concept.

The work is mainly theoretical. It consists of two conceptual parts, which are put together.

First, it provides an investigation of the problem of operating exposure, within the context of the theory of the firm, focusing on the importance of such parameters as firms' objectives, industry structure and production cost efficiency.In particular, the focus is on an hypothetical exporting firm which faces competition from foreign producers in overseas markets, and has an objective of long term market expansion in these markets.The experiment is to model the behaviour of market equilibrium export prices, and comment on the implications of these prices on the profitability of the specific firm.These implications are assumed to capture the concept of economic exposure.The main theoretical hypothesis, established here, is that, the economic exposure of an exporting firm, under the assumptions of international competition and a market share objective. is asymmetric.

Second, it deals with hedging against economic exposure, in general, and the economic exposure discussed in the first part, in particular.It provides a critical evaluation of the hedging propositions, put forward by the previous literature, and establishes the hedging hypothesis that, asymmetric economic exposure can be effectively hedged using a currency (call) option. An attempt is made to highlight that different types of economic exposure, which may arise by assuming different scenarios about the parameters which determine this exposure, can be effectively hedged by different currency options strategies

The work offers some empirical evidence, based on the behaviour of export prices of some commodities exported from the UK to the USA, over the period from 1980 to 1988.The initial aim is to statistically test the first main hypothesis of this work, the asymmetry hypothesis.Then, on the basis of simulations of currency options prices, it attempts to statistically test the hedging hypothesis, namely the effectiveness of currency options in eliminating adverse effects of exchange rate changes on export prices.Overall, the empirical evidence seems to support these two main theoretical propositions.

The thesis consists of eight chapters.

Chapter 1 reviews the different types of exchange rate exposure and provides a brief critical evaluation of each one, on the basis of their significance for purposes of financial analysis.The question of why operating exposure will be the focus of this work is discussed.The concept of this exposure is analysed and the parameters which determine its magnitude are identified.Some examples of firms which have faced this exposure are outlined, to indicate the practical relevance of the problem in question, and thus, the thesis.

Chapter 2 models economic exposure, by imposing certain assumptions on the parameters,identified in chapter 1. The focus is on an exporting firm with domestic currency costs, which exports to an overseas market and faces competition from foreign firms with costs denominated in a foreign currency.The exporting firm is assumed to have a market share expansion objective, in the long run.This objective affects its pricing policy, in terms of the currency in which its price list is expressed.The practical relevance of the assumptions, which underline the model, is discussed.Within this context, operating exposure, portrayed in a diagram depicting export prices and exchange rates, behaves like a written call option.This conclusion establishes the hypothesis that, under certain conditions, export business can be seen as a real option, given by exporting firms to overseas customers.To put it a different way, operating exposure is asymmetric.The level of the asymmetry is a function of the parameters identified in chapter 1 as determinants of exposure.

Chapter 3 provides some empirical evidence on the asymmetry hypothesis.It focuses on ten commodities exported from the UK to the USA, over the period of from 1980 to 1988.The development of the statistical model, and the methodological shortcomings of focusing on commodity-based data to investigate the firm-based problem of economic exposure are commented upon. An economic interpretation of the statistical results is provided.

Chapter 4 starts the analysis of hedging economic exposure.After critically evaluating the hedging solutions proposed by previous authors, it is based on the theoretical findings of chapter 2 and establishes the hedging hypothesis that a currency call option should be used in hedging against asymmetric exposure. A method of theoretically determining hedge ratios is outlined.Finally, different scenarios of economic exposure are derived and different (advanced) hedging strategies, based on currency options, are proposed.These arguments establish the hypothesis that, the final choice of options strategy is related to those (real) factors which determine economic exposure.

Chapter 5 provides some prerequisite information, for the empirical implementation of the hedging hypothesis, outlined in chapter 4.This information refers to the (non-observable) future exchange rate volatilities, required when the firms considers the cost of options and hedge ratios.This chapter focuses on two different methods of estimating this parameter.

Chapter 6 deals, initially, with some practical issues related to the implementation of the hedging proposition, established in chapter 4.It addresses such issues as what type of options should be employed, when the hedge should be placed and removed (with reference to the timing of the marketing and production operations) and how hedge ratios can be empirically determined. Secondly, after simulating the profits on currency options, assumed to have been enjoyed by hedging firms, it statistically examines whether these profits can eliminate the exposure of five of the commodities, examined in chapter 3.

Chapter 7 theoretically discusses some extensions, relevant to the problem of economic exposure and hedging.The main issues involve the exposure of a purely domestic firm facing import competition, the problem of hedging a multicurrency exposure and the case of having a symmetric exposure.

Chapter 8 provides a critical evaluation of the theoretical and empirical findings of this thesis, and proposes areas for future research, which have resulted from these findings.

CHAPTER 1

EXCHANGE RATE EXPOSURE: CONCEPTS AND BACKGROUND

1.1.Introduction.

The purpose of this introductory chapter is to describe the area of exchange rate exposure and to set up the framework of the discussion to follow in the proceeding chapters.It starts by pointing out the implications of the current exchange rate regime on forecasting exchange rates and their variability.Subsequently, it focuses on the different types of exchange rate exposure which have appeared in the literature,defines their essence and parameters which affect the magnitude of exposure and provides a critical evaluation as to which type better reflects the effects of exchange rates on firms' market values.To highlight the practical significance of the exchange rate exposure problem,some 'real world' examples of firms reported to have faced this predicament are quoted.

The chapter concludes with a brief discussion of the theoretical arguments and empirical findings as to whether exchange rate exposure matters in terms of stock markets behaviour.

1.2.The 'Puzzle' Of Forecasting Exchange Rates

The current exchange rate regime is a system of floating currencies, especially vsv the dollar,although the exchange rate policy to be followed by each country may vary from time to time according to the general economic policy. This denotes that there may be cases in which one country's currency is pegged vsv the dollar [(Shapiro 1989), page 68].

The most obvious example of fixed exchange rates can be found in the Exchange

Rate Mechanism of the European Monetary System, in which country members have agreed to maintain the values of their currencies fixed[1] vsv the European Currency Unit (ECU), and thus, vsv each other country's currency.

Since the value of the ECU freely floats vsv the dollar, it follows that the value of each of the participating currencies in the ECU freely fluctuates vsv the dollar.Consequently, the exchange rate between the pound and the dollar (which will be the focus of this work) follows the rules of free float.

When two currencies' values are determined within a floating regime, the main question is if (and/or how) we can consistently forecast the future exchange rate.To put it a different way,what we really need is a theory of exchange rate determination, on the basis of which, we could empirically forecast exchange rates. Theoretical work on the issue of exchange rate forecasting has led to the development of several theories[2] on the issue.The empirical validation of these theories, however, appears to be rather dismal.Studies during the 1970's [Cornell, (1977),Mussa (1979 a,1979 b) and Frenkel (1981)] conclude that exchange rates are largely unpredictable, denoting the empirical collapse of the theoretical approaches to exchange rate determination.Meese and Rogolf (1983 a) find that during the period from 1976 to 1984, no structural or times series (empirical) model could outperform the random walk model at any forecasting horizon shorter than 12 months.Shafer and Loopesko (1983) review the various monetary and asset approaches to the exchange rate determination and conclude that, no single model could adequately explain the dollar's fluctuations against other major currencies over the decade from 1975 to 1985.Alexander and Thomas (1987) and Baillie and Sellover (1987),in dealing with the question of whether the collapse of empirical models is due to theoretical shortcomings of how exchange rates are assumed to be determined or due to inadequate econometric techniques, support the first argument. Finally, with regards to the adoption of the Purchasing Power Parity as a theory of exchange rate determination,it appears that severe mismatching occurs between the forecasts based on this theory and the actual exchange rates [see, Kanas (1989)].

The academic findings that demonstrate that exchange rates are largely unpredictable are compatible with the beliefs of a number of exchange rate traders and/or business executives.For example, Nick Douch, chief dealer in Barclay's Bank,highlights, in an article in the 'Treasurer' (1987), the difficulty of predicting exchange rates.Similar views are shared by Sara Sullivan of Midland Montaque [see Sullivan (1991)].

One may consult diagram (1.1) for a pictorial representation of the difficulties in forecasting exchange rates.This diagram illustrates the evolution of the nominal $/£ exchange rate over the 1980's,along with ranges of forecasts for each (June of that) year.These forecasts were obtained from up to 53 Forecast Houses and Banks.It can be seen that for the first six years of this period,not a single forecast turned out to be successful.For 1987 and 1988, the actual rate fell within the forecast range, although this 'success' can be attributed to the widening of the forecast range compared to the previous period.

These difficulties in forecasting exchange rates are coming together with significant variability which characterises the behaviour of many currencies.Diagram (1.2) portrays the value of both the nominal and real (i.e. inflation adjusted) exchange rate for the pound vsv the dollar over the first eight years of the 1980's. It can be seen that both types of rates were very volatile.The pound experienced a significant depreciation, both in nominal and real terms (using the Consumer Price Index as a proxy of the inflation rate in the UK and the USA),over the first half of the 1980's when its value vsv the dollar was almost

DIAGRAM 1.1

CURRENCY FORECAST ACCURACY : $/£

Aston University

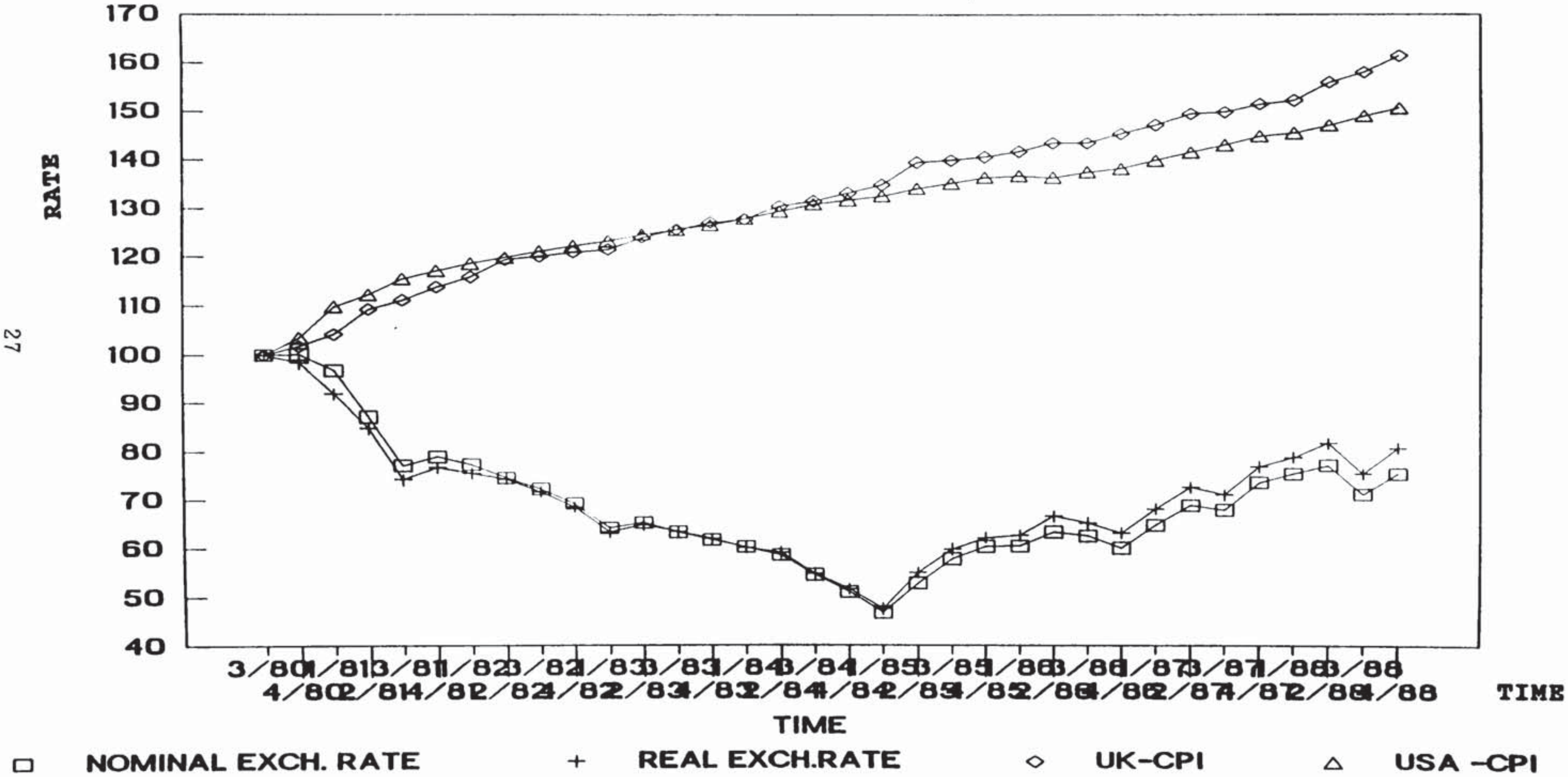
Illustration removed for copyright restrictions

SOURCE : Sullivan (1991).

DIAGRAM 1.2.

REAL vsv NOMINAL EXCHANGE RATE :$/£

1980/III - 1988/IV



halved (from \$2.32 in the end of 1980 to 1.15 in the first quarter of 1985).Over the second half of the 1980's the pound followed an upward movement to reach a level of \$ 1.78 by the last quarter of 1988.

This exchange rate variability carries important consequences for the macroeconomy (depicted in the Balance of Payments), individuals as consumers of internationally traded (imported) goods and investors in international capital markets, and finally, firms with international operations (such as Multinationals, exporting and importing firms) or international interests (such as import competing domestic firms).

This work will focus on the consequences of the exchange rate changes on firms.This question has come to be known in the relevant literature as exchange rate exposure and addresses the question of exchange rate driven uncertainty faced by firms on several aspects of their operations.

1.3.The Types Of Exchange Rate Exposure.

As exchange rate changes create uncertainty for firms, many of them would be willing to eliminate (hedge) it.Eliminating exposure can be achieved only after we have measured it.Measuring exposure assumes that one should focus on some major items, parameters or indicators of business activity, assumed to reflect the exchange rate driven consequences. The existence of many different items that can be considered for this task has led the relevant literature to discuss several groupings of such items and thus,types of exchange rate exposure.Apart from slight differences in terminology, it appears that there is some sort of unanimity in the literature[3], as to how we can define different types of exchange rate exposure.The most commonly cited classification is the following:

1.Accounting Exposure and

2.Cash -Flow Exposure.

This classification is based on the criterion (which automatically forms the first difference between these types of exposure) of which items should be included in each category.In accounting exposure, the focus is on the items which appear on the balance sheet, whereas in cash flow exposure, the focus is upon the money flows due to (either entered or non-entered into) transactions.This first difference leads to several others to be outlined later, after a formal exposition of these types of exposure.

The cash flow exposure can be seen as comprising two separate types of exposure,namely the transaction exposure and the operating (or economic) exposure.The first category is relevant for those transactions already entered into [and thus, transaction terms (selling price and quantities) are certain], whereas the second is for those which, at the time of consideration, are bound to be booked, although the terms are still uncertain.

In the next three sections of this chapter, there will be a discussion of these types of exposure along with a critical appreciation of them on the basis of their relevancy, in terms of financial valuation.

1.4.Accounting (or Translation) Exposure.

Accounting exposure arises from the need to convert financial statements (balance sheet and profit and loss account) from foreign currencies into the local one, for the purpose of consolidating the accounts of foreign subsidiaries (expressed in foreign currencies) with the accounts of the parent company (expressed in local currency).Since accounting exposure focuses on such balance sheet items as assets/liabilities, accounts receivables/payables,depreciation, interest payments of loans, working capital, etc,one could argue that this type of exposure is more relevant for Multinationals with many subsidiaries (and thus, assets, liabilities, etc) in many countries and currencies.The need for consolidating the accounts of all subsidiaries from time to time is due to the fact that shareholders must have an overall view of the performance of the whole group of subsidiaries,as depicted by accounting information. The exposure of these accounts results from the possibility of the nominal exchange rate fluctuating (changing) between the beginning and the end of the accounting period.

The question of measuring accounting exposure is explicitly associated with the issue of whether one should adopt the exchange rate which prevailed at the end or at the beginning of the accounting period to translate the accounts[4].Different solutions, as to which exchange rate should be used, result in different measurements of exposure.This issue is settled by accounting guidelines provided by the Financial Accounting Standards No 52.After the method of translation has been decided, the accounting exposure is readily measurable. However, several strands of criticism have been attached by the literature to accounting exposure [see, Shapiro (1989), Srinivasulu (1983) and Donaldson (1987)]:

a.Accounting exposure is only a paper (that is non-realisable in terms of cash) exposure. Any transaction gains and/or losses are not real in terms of cash changes but only relevant in the firm's accounting books.The local value of foreign currency accounts may change not because their real (economic) value has changed, but because the exchange rate has altered from time to time.For example, the paper value of a machine in a foreign country changes whenever the exchange rate changes, regardless of whether this machine has been idle or not.Thus, as paper values are not always the same as real values, accounting exposure may fail to yield a real (as opposed to paper) measurement of exchange rate exposure.

b.As any translation gains/losses affect the equity account, they may also affect the P/E ratio, which, according to the supporters of accounting exposure, affects the stock price.This argument establishes a link between accounting exposure and capital markets behaviour.One could evaluate the real significance of this point by focusing on the simple valuation formula of a firm with growth investments and no debt [see Copeland and Weston (1988), page 550].This formula is given by (1.1):

$$V_0 = \frac{NOI_1}{p} + I_t * \frac{(r_t - p)}{p * (1 + p)^t} \tag{1.1}$$

where:

V_0 :the market value of the firm at $T_{0.}$

NOI_1:the expected net operating income (cash flow) at time T_1,

p :the market required rate of return,

r_t : the rate of return of future growth investments,

I_t :the value of future investments.

The intuition behind (1.1) is that the market value is dependent on both the value of current assets (NOI_1/p) and the value of future growth [reflected in the second part of the right hand side of (1.1)].

It is obvious that what really matters for financial valuation is the cash flows expected to be generated in the future (NOI_t), rather than the ''today's'' cash flows.To the extent that accounting exposure affects the static version of the P/E ratio (P_0/E_0) and fails to capture the behaviour of its dynamic version (P_0/E_1), one could argue that the link between financial valuation and accounting exposure becomes relatively loose.

Furthermore, it appears from (1.1) that market value is associated with future expectations on investments.Such expectations are not considered by accounting exposure, which is a rather retrospective concept.

Further, as one can see from (1.1), value is determined by cash flows which are different from those items that accounting exposure focuses on.Related to this is some empirical evidence reported in Copeland and Weston (1988) (page 364),that generally. accounting information does not affect capital markets.Markets are rather affected by news on cash flows. And as cash flows are influenced by such factors as industry structure, level of competition, competitiveness,production technology efficiency, inflation and nominal exchange rates (that is, real exchange rates),it follows that these factors lie behind market values.These parameters are not, however, captured by accounting exposure, which arises from nominal exchange rate changes.

Finally, as accounting exposure is due to the uncertainty of daily exchange rates that prevail at the end of successive accounting periods,it fails to reflect the trend of the exchange rate over a period (that can be approximated by the average rate) which determines profitability and possibly the behaviour of stock prices in the markets.

Showers (1988) provides an argument in favour of the financial valuation implications of accounting exposure.She argues that as accounting exposure affects equity, the Debt/Equity ratio may be altered, with consequences on the discount rate r which enters (1.1).Some criticism that can be attached to this argument is that the change in this ratio is again a paper one,i.e not resulting from a real change in the financial structure of the firm.For as long as markets are well informed about the reason of the change in the ratio, the consequences of accounting exposure upon the borrowing ability of the firm will be relatively mitigated.

1.5.Transaction Exposure.

Transaction exposure refers to cash flows which result from specific, already entered into transactions.These cash flows are in foreign currency and should be translated in the future into domestic currency, using the then nominal exchange rate.The uncertainty about the future spot exchange rate creates this exposure.Cash flows which can be included in this type of exposure are accounts receivable, due to the awarding of a credit period from the firm to overseas customers, accounts payable, dividends and loan repayments.Further, other obligations such as contracts for future sales or purchases are also items to be treated as causing transaction exposure.The former category of items are included in the balance sheet, and thus, constitute part of accounting exposure.The latter does not.

As soon as a contract for future delivery of goods or future purchase of input is signed by the firm, transaction exposure is created.For the purposes of this exposure, the terms of the contract (i.e. selling/buying price, currency of invoice and quantities) are considered as given.There are no negotiations on those terms, implying that there are no considerations of the costs of production over the production period (which is different from the credit award period) and prices when the contract is due to be signed.This implies that parameters such as competitiveness, industry structure and level of competition are irrelevant for transaction exposure.This exposure does not focus on how the terms of the contract are established and treats the amount of a foreign currency receivable/payable as given.

The exposure of a specific (already entered into) transaction is readily measurable.It reflects a one-to-one change in the local currency value of the transaction with the change of the nominal exchange rate.Thus, transaction exposure can be seen as being symmetric, that is, a 10% appreciation (depreciation) of the pound may lead to a 10% decrease (increase) in the pound value of a dollar denominated receivable. As such, transaction exposure can be optimally hedged using either a forward or futures contract or a foreign currency loan whose risk profiles are symmetric[5].

This type of exposure is very common to Multinationals and exporting or importing firms, but is not relevant for domestic firms facing import competition.

Similarly to accounting exposure, transaction exposure, in considering the terms of contracts as fixed, fails to capture the previously mentioned real parameters assumed to determine market values.Transaction exposure is a simplistic type of exposure with the hedging solutions being fully investigated in the relevant literature [see Shapiro (1989),Donaldson (1987),Buckley (1986) and Holland (1986)].

1.6.Operating Exposure

1.6.1. Concept.

When a contract is signed (and transaction exposure starts to arise), the terms of contract are already established.The question of how these terms have been reached is the main focus of the concept of operating exposure.And since by the time a contract is signed the terms are determined,it follows that the period of operating exposure ends when the period of transaction exposure starts.Thus, operating exposure refers to a different time span from the time span of transaction exposure and, in fact, comes before transaction exposure.

The timing of operating exposure starts when the firm decides to embark in a market or into a specific transaction, the terms of which are uncertain and in fact, contingent upon the evolution of the exchange rates,from when the decision is to be made.This uncertainty comes as a result of the existence of other producers which participate in the market.These competitors offer bid prices to enter into the specific transaction.The final winner of this transaction is determined by the actual exchange rate which enables the lower cost producer (after the realisation of inflation and nominal exchange rates) to take a part or the whole of the transaction, whereas the others face operating exposure.

At the beginning of the period over which operating exposure arises, a firm hires personnel and incurs investment costs in order to produce a specific product to supply a specific export market.In this market, there are other producers with costs denominated in their own currencies.Each firm establishes forecasts about the future exchange rate and determines a bid price to undertake a specific contract.That is,each producer establishes an expected selling price based on the expected exchange rate.After the actual (real) exchange rate has been realised, the bid offers of all producers are compared and the most competitive is expected to win the transaction.At this time, the period, over which operating exposure arises, terminates and the transaction exposure period starts.

The timetable given in diagram (1.3), highlights the timing of both transaction and operating exposures.

To appreciate the essence of operating exposure, one has to understand how the cost of production of a specific firm which participates in the market, is affected by inflation and nominal exchange rates at the same time (that is, real exchange rates)[6], and what the consequences of these cost changes are on the profit margin or market share. One must also consider the fact that several competitors may exist in the market, whose costs may be affected by real exchange rates in different ways.Thus, the problem of operating exposure is due to two factors: many producers offering a more-or-less homogeneous commodity and differential effects of real exchange rate changes on the costs of these producers.

Diagram 1.3 :The Timetable Of Operating And Transaction Exposure.

T_0	T_1	T_2
-Decision of future involvement in a specific	-Each producer bids an offer price.	-Receivables are collected transaction is made.
-Investments are made.	-The actual real exchange is realised.	
-An expected bid price is determined.	-The best (cheapest) bid is chosen. -The transaction is booked.	

Operating Exposure Period

Transaction Exposure period.

How reasonable in terms of practical existence are these factors that create operating exposure? The practical significance of the fact that many producers may participate in markets around the world is justified by the evolution of the term 'globalisation' of international markets[7].An indication of this increasing globalisation (which resulted from the collapse of trade barriers and the signing of trade agreements) is provided by George and Schroth (1991) who argue that in recent years, the percentage of internationally traded products has increased at a faster rate than the world product.Lessard and Lightstone (1986) pinpoint the trend towards market globalisation, and highlight the importance of this development on the creation of the problem of operating exposure.

The question of whether real exchange rates changes exist is discussed in a latter section of this chapter.It should be pointed out that it is both inflation and nominal exchange changes that matter for operating exposure and not only nominal exchange rates.This is so, since operating exposure is a problem of value added (costs, competitiveness).These changes are due to both inflation rates which change the production cost in terms of the domestic currency and to nominal exchange rates that affect the cost of production when expressed in foreign currency terms, to be compared with the costs of other producers.

Taking for granted that many producers may participate in one market, operating exposure exists if the currency, in which the value added (cost) of one producer is denominated, differs from the currency in which the cost of other producers are denominated. This statement is compatible with the proposition that operating exposure is due to differential effects of real exchange rate changes on the cost of the producers participating in the market.If the costs of all producers were denominated in the same currency, then they would face the same cost changes due to (the common) inflation rate, relevant for the currency concerned.The nominal exchange rate changes, in this instance, would be irrelevant.It is the existence of different currencies, in which costs are denominated amongst different producers, that gives rise to possible differential cost effects due to both inflation and nominal exchange rate changes.This is the essence of the problem of operating exposure.Producers with costs in different currencies will be termed as 'international producers' or 'international competitors'.If producers in the market have costs denominated in the same currency, then the relevant risk is the general business risk which arises from inflation rates or income changes.[See also,section (7.2), in chapter 7]. Operating exposure risk is a specific type of business risk due to the existence of international (rather than domestic) producers with costs in different currencies.

To illustrate the essence of the problem of operating exposure, an example capturing the main parameters involved,is provided below.We focus on an hypothetical UK-based firm with production costs (wages, inputs costs and loans repayments) in pounds.This firm exports its output to the USA market where it faces competition from a USA firm with production costs in dollars.The variability of the ratio of costs of the two producers, when expressed in a common currency, is created by the variability of real exchange rates and indicates the existence of operating exposure.We also assume that the product supplied by both firms is homogeneous and thus, the price elasticity of demand is expected to be relatively high.Table (1.1) portrays the situation both at T_0 and T_1.

Let's assume that over T_1, the inflation rate in the UK was 10% (increasing the UK firm's costs from 10 to 11 pounds), the inflation rate in the USA was zero (leaving the dollar-cost of the USA-firm unaffected) and that the nominal exchange rate moved from £1=$2 to £1=$1.9.

Let's focus on the differential cost effect of inflation and nominal exchange rates upon the two firms:the relatively higher inflation in the UK has caused a competitiveness problem for the UK firm.This problem would have been completely eliminated should the pound have devalued 'enough' vsv the dollar:that is PPP was maintained[8].

In this case,the inflation rate driven increase of the cost of the UK firm would be completely eliminated by the pound's devaluation at a level of about £1=$1.82, so that, when expressed in dollar terms, the cost of the UK firm will be the same as the cost of its USA competitor.In fact, it is the relatively low devaluation of the pound vsv the dollar that has created this competitiveness problem and changed the cost ratio, when both costs are expressed in a common currency.A cost ratio higher than 1 implies competitiveness problems for the UK firm and vice versa.The cost ratio remains unchanged, only if the pound depreciates `sufficiently enough'.

The first consequence of this differential cost effect is a situation, where the price of the product of the USA firm remains the same, whereas the UK firm faces pressures for price increases due to both higher inflation and relatively high nominal (and thus, real) exchange rates.

TABLE 1.1 :OPERATING EXPOSURE: A NUMERICAL EXAMPLE.

T_0

	UK Firm	USA Firm
Cost/Unit	£10	\$20
Relative Cost Ratio	1	1
Price	£15 (\$30)	\$30
Market Share	100 units	100 units
Profit Margin	£5	\$10

T_1

	UK Firm	USA Firm
Cost/Unit	£11	\$20
Relative Cost Ratio	1.045	1.045
Price	\$30 or \$30.4	\$30
Market Share	100 or 70 units	100 units
Profit Margin	£4.78 or £5	\$10

Assumptions: The exchange rate at T_0 is £1=\$2. The rate at T_1 is £1=\$1.9.
The inflation rate in the UK is 10% and in the USA 0%.

Taking into account that the commodity in the market is homogeneous,the UK firm has to face the trade off between higher profit margin and lower market share or lower profit margin and higher market share.Thus, the firm has two options:either to increase its selling price to \$30.4, so that under the new exchange rate (£1=\$1.9), the £ price will be about £16 preserving its £5 profit margin, or to keep its \$ price at the level of \$30 but face a lower profit margin (£4.78). Choosing the first option implies that although the profit margin is the same, the market share may be reduced depending on the degree of the substitutability of the two brands of the commodity, portrayed by the price elasticity of demand.The less differentiated the product, and thus the higher the elasticity, the higher the negative impact of a price increase on the market share, and vice versa.In the limiting case where the UK firm's product is completely differentiated from that of the USA firm, the UK firm can be considered as a monopolistic supplier in the USA market.The (relatively low) \$30 price of the USA firm will not affect the pricing decision of the UK firm, so that the UK firm can increase the \$ price (passing the higher real exchange rate on to foreign customers), without losing market share to its competitor.

If the firm takes the second option, it protects its market share but suffers a loss in the profit margin.

Consequently, operating exposure may appear as either a reduction in profit margins or as a fall in market share.Firms are always faced with having to make a decision on this issue[9]. Some empirical evidence by Coutts, Godley and Nordhaus (1978) and Calmfors and Herin (1979) suggests that export prices are influenced by foreign prices, indicating that a market share objective appears to be preferred.

To illustrate why operating exposure is a problem of different currencies in which the costs of international producers are set, let's assume that both producers' costs are denominated in,say, pounds.For example, a USA firm has established production operations in the UK and incurs costs in pounds.In this case, the 0% inflation rate in the USA is not relevant for the USA firm.Its costs changes are in line with the UK inflation rate, and can be easily compared with the cost changes of the UK firm, without the interference of the nominal exchange rate.This indicates that the cost ratio (assuming that, at equilibrium, it was 1) has remained at 1, indicating that no competitiveness changes have occurred, and thus, there is no operating exposure.

It should be pointed out that when the UK firm faces competitiveness problems (positive operating exposure), due to a real pound appreciation, the USA firm has a competitiveness advantage (negative operating exposure), expressed as either higher market share (which reflects the market share lost by the UK firm) or higher profit margin (which reflects reduced $ costs after the dollar depreciation).Thus, any real exchange rate change can be seen as a cause of competitiveness 'transfer' (allocation) from one international producer to another.

In the previous example, it was assumed that the UK firm exported its output to the USA market.This, however, was not an important assumption in the illustration of the problem of operating exposure.Following the definition that operating exposure is a problem related to costs, any considerations concerning the nationality of markets in which a firm operates are irrelevant.Although operating exposure is mainly faced by exporting firms producing locally and facing competition from international producers[10], the same problem may be faced by a purely domestic firm facing import competition[11].Further, the nationality of firms is also irrelevant.For example, the problem may be faced by a UK firm with costs in pounds competing with another UK firm with costs in dollars (possibly because of the latter having production operations in the

USA).Finally, it does not follow that the currency in which operating exposure may arise should be the same as the currency in which receivables are denominated (and thus, transaction exposure arises) or the currency of the country in which the firm exports its output.For example, a UK firm which exports to the USA may face operating exposure in Yen, if its competitors (not necessarily Japanese) have costs in Yen.(In this case. transaction exposure arises in dollars).

Thus, generally speaking, operating exposure arises in those industries in which production is internationally diversified.

The analysis of operating exposure can be also carried out on the basis of the concept of 'currency of determination'.This is the currency in which the price of a commodity is determined in world markets.It is different from the currency of denomination of this price, that is the currency in which the price is invoiced.The currency of determination is the currency in which the cost of the more competitive producers in the market are denominated.These producers are in a position to cut their selling price (which, thus, is based on the value of that currency) and still enjoy a satisfactory profit margin.If there are many international competitors in the market, then the currency of determination is a basket of the currencies in which the costs of all producers are denominated.If within the industry, a firm is assumed to be more technologically advanced than the others, then the currency, in which its costs are expressed, may have a greater influence on the value of that basket.This implies that the correlation between the value of the basket and the specific currency will be relatively high.In the limiting case where the correlation is 1, this firm can be seen as the monopolistic supplier in the market, since it appears that only its currency is the determinant of the value of the above basket, and thus, of the price of the commodity.Thus. the higher the correlation in the value of a specific currency and the basket of all currencies, the lower the operating exposure faced by the firm with costs in this currency.

1.6.2.Parameters Affecting Operating Exposure And Their Mechanisms.

As indicated in the previous discussion, the problem of operating exposure is due to real exchange rate changes.The parameters determining the magnitude of the problem are:

1.The geographical distribution of producers/consumers in each country.

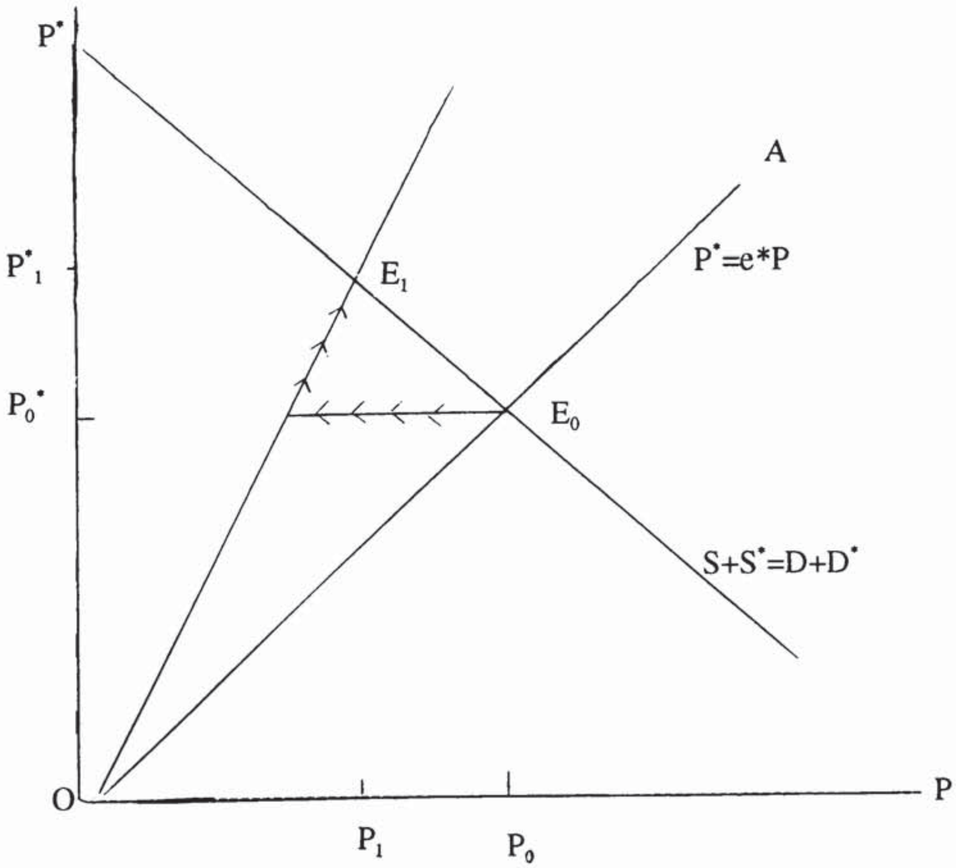
2.The demand and supply elasticities.The demand elasticity captures the level of the competition in the industry, and is concerned with product substitutability. Supply elasticities are linked to the effectiveness of production technology, in terms of the ability of the firm in 'absorbing' and neutralising cost increases.

The mechanisms through which these parameters determine the extent of operating exposure are illustrated below.

1.The geographical distribution of consumers/producers.In the previous example, describing the essence of operating exposure, it was implicitly assumed that the export price was determined by forces in the USA market alone.The argument did not consider the case of having the same commodity being traded in both the USA and world markets, and the implications of the latter on the determination of the market price in the USA.Assuming that the same commodity is traded in the UK and the USA, a linkage between the domestic (UK) and the foreign (USA) prices may be established through the Law Of One Price[12].This association of the two prices may have some implications on the determination of the price in the USA, and thus, on the operating exposure faced by the UK firm.The argument predicts that the higher the distribution of producers/consumers of the product in the UK (and thus, the more significant the UK market in terms of trading this commodity),the more stable the price of the commodity in pounds, and thus, the less operating exposure will be faced by UK exporters in the USA.This argument, known alternatively in the literature as the 'large/small country' effect on the prices of international commodities, is illustrated in Flood (1986).It is reproduced here by diagram (1.4).

Let P represent the pound price of an exportable from the UK and P^* represent the dollar price of the same product.Let also S(P) and $S^*(P^*)$ be the UK and USA supplies and D(P) and $D^*(P^*)$ represent the UK and USA demands respectively.

Diagram 1.4:The Geographical Distribution Of Producers/ Consumers And The Prices of Internationally Traded Commodities.



Simultaneous equilibrium in both markets is given by the market clearing condition:

$$S(P) + S^*(P^*) = D(P) + D^* (P_*). \qquad (1.2).$$

It is also assumed that the Law Of One Price (LOP) holds and is given by OA in diagram (1.4).Mathematically, the LOP is given by:

$$P^* = e * P. \qquad (1.3).$$

where

e :the nominal exchange rate.

Equilibrium in the markets is achieved at the point where the Law of One Price line meets the market clearing condition.Thus, we get P^*_0 and P_0, the initial prices in the USA and UK respectively.

Now, let's consider what happens if the dollar depreciates vsv the pound, assuming that both inflation rates are zero.The line, capturing the consequences of the assumption that the LOP holds,will move upwards, since its slope measures the exchange rate which is now appreciated.The new equilibrium dollar price, P^*_1,is a function of the slope of the market clearing condition line.If the latter is vertical, then the $ price will increase by the full amount of the pound appreciation, leaving the pound price unaffected.This implies no operating exposure for the UK firm.If, on the contrary the line is horizontal, the $ price will be stable, and the consequences of the pound appreciation will be completely borne by the UK firm as a profit margin reduction by the full amount of the pound appreciation.If the line lies somewhere within these extreme positions, the simultaneous interaction of the supply and demand of the product in both markets will lead to a set of domestic and foreign equilibrium prices, complying with the LOP.

Now, the slope of the clearing market condition is a function of the relative distribution of international producers and consumers.If there is a relatively low production and high demand in the USA, the line will be relatively vertical.This is so, since moving from the initial equilibrium point E_0 to E_1 and under the assumption of low production and high demand, the higher dollar prices will hardly change the supply and demand in the USA.Thus, the UK producers will be in the position to pass a relatively high amount of the pound appreciation on to the USA customers, and thus face relatively low operating exposure. Similar arguments are true, if we assume that the USA is the large country in the trade for the specific commodity.

An example of a firm which has faced operating exposure due to the geographical distribution of producers/ consumers, is Rolls-Royce, the British jet-engine producer, which exported engines to the USA. As reported in its 1979 annual report, the firm lost £58 million in that year, after a pound appreciation.As mentioned in the annual report, this result was 'because of the US dominance in civil aviation, both as producer and customer' implying that '... these engines are usually priced in US $ and escalated according to American indices'.This indicates a relatively low ability of the UK firm to pass on the 1979 pound appreciation to USA customers which led to the previous loss.

Some evidence of the empirical validity of this argument is provided by Flood (1986) whose empirical findings comply with the theoretical predictions.

2.Demand and supply elasticities. Keeping the geographical distribution of producers and customers stable, one can study the effects of the demand and supply elasticities on the magnitude of operating exposure.Such analysis has been carried out by Flood and Lessard (1986) and Karikari and Collins (1989).

Consider the case of a UK exporting firm to the USA.Assuming that the LOP does not hold, and thus, prices are based solely on the USA market conditions, one can see how a real pound appreciation affects the pound profit margin of the firm. The case is depicted in diagrams (1.5) and (1.6).

Consider diagram (1.5).If the price elasticity of demand is relatively high, then the increase in the dollar price will be relatively low.

Diagram 1.5:The USA Market Equilibrium After A Real Pound Appreciation.

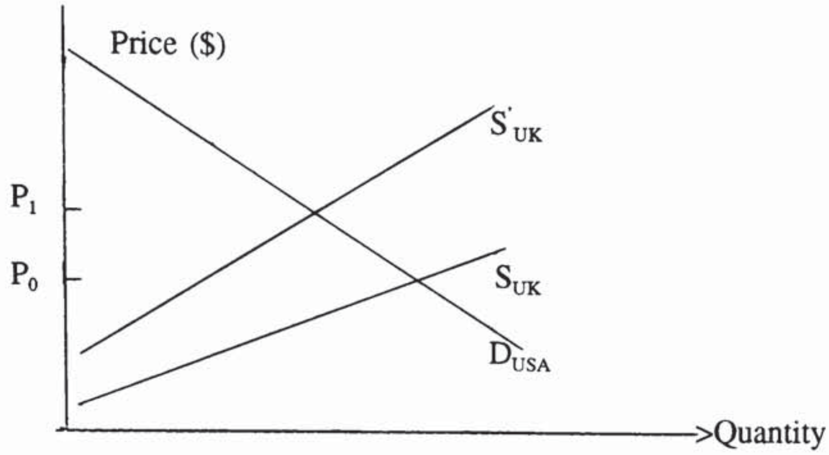
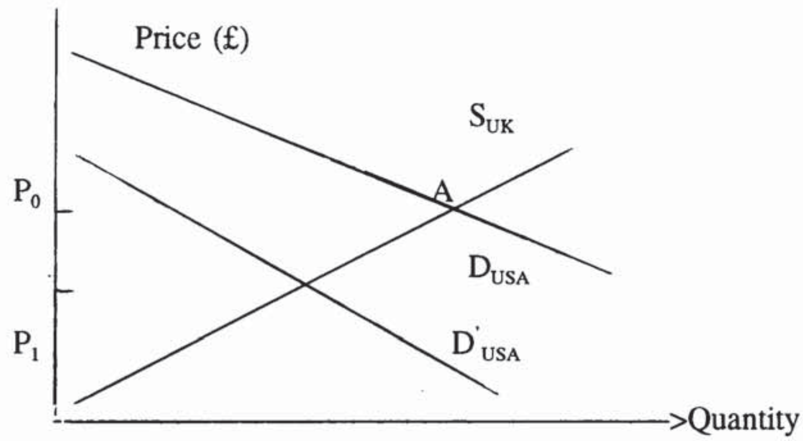


Diagram 1.6. :The Effect Of A Real Pound Appreciation On The Cost Of The UK Firm.

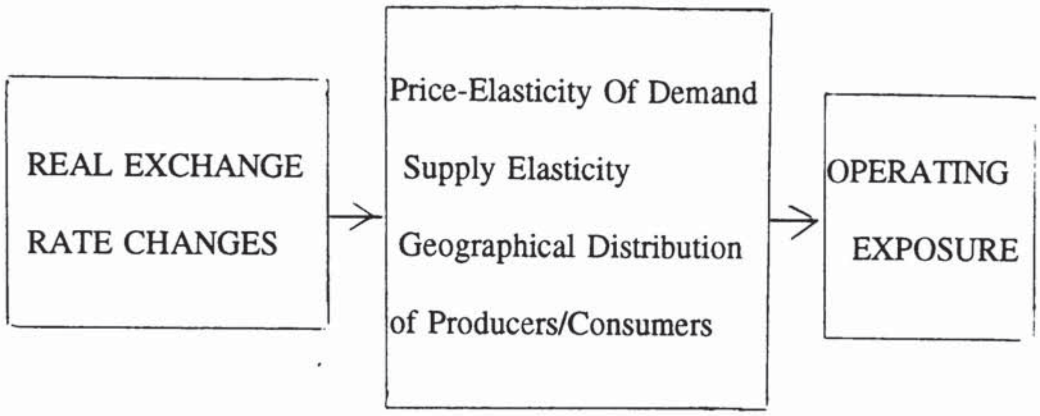


When this price is translated into pounds, the price received by the UK firm will be reduced.If the demand curve is completely horizontal (implying a perfectly competitive market), the dollar price will be fixed and the full cost of the pound appreciation will be borne by the UK firm, expressed as a decrease in the £ price by an amount equivalent to the percentage of the pound appreciation.The exporting quantity will be reduced, implying that the UK firm will face a reduced demand.Diagram (1.6) is equivalent to diagram (1.5), if the latter is expressed in pounds.It portrays the effects of lower demand, after the pound appreciation, on the cost of the firm.The lower the elasticity of supply curve, the higher the cost cut after the pound appreciation. In the limiting case where the supply curve is completely horizontal the cost decrease will be minimal. If this is put together with the effects of the pound appreciation on the price, one can have an idea of the extent of the problem of operating exposure.The less horizontal the demand curve and the less elastic the supply curve, the lower the operating exposure, after a real pound appreciation .The worst case is when the demand is completely elastic (so that the pound price is decreased by the full amount of the pound appreciation) and the supply curve is completely horizontal so that the cost can not,even partly, decrease to somehow offset the reduced price.In this case, the profit margin is reduced by the full amount of the pound appreciation and operating exposure is maximum.On the contrary, if the demand curve is completely inelastic and the cost curve is completely horizontal, the firm manages to increase its dollar price by the full percentage of the pound appreciation and thus, maintain its £ price, whereas its costs remain at the same level as before. In this case, the firm has managed to pass the full amount of the cost increase (when expressed in dollars) on to USA customers, whereas its profit margin is unaffected.

The slope of the supply curve (and thus, the firm's ability to cut costs) depends on the production technology that the firm possesses.The more flexible the production technology in terms of absorbing cost increases [and thus, the more sloped the marginal cost curve for the area on the left of the point A in diagram (1.6)], the easier for the firm to neutralise the adverse effects of operating exposure.

Diagram (1.7), below, summarizes the parameters which create and determine operating exposure.

Diagram 1.7:The Determinants of Operating Exposure.



1.6.3. Real Exchange Rates Changes.

In the previous section, it was argued that operating exposure is caused by real exchange rate changes.Real exchange rates do not change,if nominal exchange rate changes are completely offset by the inflation rate differential of the countries whose currencies are concerned.This is what the Purchasing Power Parity (PPP) asserts.According to PPP, under conditions of perfect capital markets, no taxes, no transportation costs and commodity homogeneity, the currency of a country with relatively high inflation will devalue vsv the currency of the country with lower inflation, by the exact amount of the inflation rate differential. If this argument is violated, then real exchange rates change, and as a result, a competitiveness transfer is realised from one international firm to another.The actual validity of PPP is, in fact, an empirical question.

Diagram (1.2) provides a pictorial representation of the behaviour of quarterly real exchange rates of the £ vsv the \$, from 1980/VI to 1988/IV.It can be seen that this real exchange rate did fluctuate implying that, over this period, UK firms, with local production and exports to the USA, did face operating exposure to international competitors with costs in dollars.

Evidence on the empirical validity of PPP, in general, is provided by Shapiro

(1989).This evidence tends to support that in the long term, PPP appears to hold. whereas in the short run, significant violations from it arise.This implies that operating exposure may be a relevant problem for the short term, an idea expressed by Lessard and Lightstone (1986).

Even though PPP may hold, operating exposure may arise for some firms whose costs do not change in line with the general inflation rate used to evaluate to empirical validity of PPP. Suppose that a UK firm heavily uses an input whose local price increases by 10%, whereas the inflation rate in both the UK and USA is zero and the nominal exchange rate remains unchanged. Although the real exchange rate (measured on the basis of general inflation rates) remains unchanged, the UK firm does face operating exposure (if the price of the same input remains unchanged in the USA), due to the firm-specific cost increase failed to be captured by the inflation rate measure in the UK.This case is known in the literature as 'relative price' changes in the domestic country.Empirical evidence regarding the variability of relative prices within the domestic economy is found by Parks (1978) and Domberger (1987).

The same issue is approached by focusing on the empirical variability of the Law Of One Price for disaggregated commodities.If the pound price of an input used by a UK firm does not change in line with the dollar price of the same input in the USA , the Law Of One Price is violated, and thus, operating exposure arises. Evidence on the empirical validity of LOP is rather divided.Flood (1986), reviewing the major empirical studies on the issue, contends that these studies appear to support the existence of deviations from LOP, even for narrowly defined goods.

Thus, operating exposure may arise due to two reasons:first, relative aggregate price changes between two countries (where PPP does not hold) and second. relative disaggregate (commodity specific) price changes, even though PPP may hold.

Finally, it should be stated that the real exchange rates which matter for operating exposure are not daily rates (since prices of internationally traded goods do not change every day), but rates which capture the trend over a period.Such rates can be the average rates over a period. Thus, the importance of daily rates is rather reduced in terms of operating exposure.

1.7.Operating Exposure Compared With The Other Types Of Exposure[13].

It can be inferred from the previous discussion that many differences exist between accounting, transaction and operating exposure.Clearly, for the first two types of exposure, it is the nominal daily exchange rates which matter, whereas in the latter, it is the real average exchange rates.The most significant difference, in terms of financial valuation is the fact that operating exposure focuses on real (as opposed to nominal) parameters which determine the future profitability of a firm.As operating exposure requires a microeconomic analysis of international pricing, it goes beyond transaction exposure, which treats pricing as fixed.As a result of the nature and the determinants of operating exposure, it (operating exposure) can hardly be quantified and measured, compared to accounting and transaction exposures.Consequently, and since efficient hedging requires accurate measuring of exposure, it follows that hedging operating exposure may be difficult. As will be illustrated in chapter 4, the hedging propositions against operating exposure, put forward by the relevant literature, are characterised by several shortcomings. These difficulties have led Madura and McCarthy (1989) to conclude that there is little research on this type of exposure.

This work will focus upon operating exposure, on the basis of the assumed links between this type of exposure and the market value of firms.The analysis in the following chapters will focus on a hypothetical UK firm with production in the UK (and thus costs in pounds), exporting to the USA and facing competition from USA firms with costs in dollars.(This hypothetical case looks similar to that of Jaguar cars).

Finally, it should be mentioned that,although operating exposure is explicitly associated with the macroeconomy as a whole (Balance of Payments), the analysis in these proceeding chapters will be microeconomic in nature, assuming any macroeconomic considerations away.

1.8.Examples of Operating Exposure From Corporate Practice.

To draw attention on the practical significance of operating exposure, highlighted below are some examples of firms which have faced the problem in question.

1.According to an article in Euromoney (September 1991), Caterpillar, the USA construction machinery manufacturer, faces economic (operating) exposure in Yen,as its competitor is Komatsu of Japan, with Yen denominated costs. An executive of the company argued: 'Our main competitor is Komatsu in Japan.If the Yen weakens against the dollar, we are at a competitive disadvantage because our profit margin will suffer'.And he continues:'Most transaction exposures are not transaction-specific.The US manufacturer who manufactures and sells only in the USA certainly faces competitive exposure from foreign manufacturers but can not identify that exposure with any specific transaction'.

In 1979, Caterpillar was a low cost producer in the industry. After the $ appreciation vsv the Yen in 1985, most of its product lines were priced over 40% above Komatsu's.As a result, Komatsu penetrated many markets and increased market shares.Caterpillar, suffering market share losses and profit margin cuts, experienced a decrease in its credit rating 3 times (leading to a higher required rate of return and thus lower market values).A weakening dollar in 1986, helped Caterpillar recover its credit rating position in 1987.

2.Eastman Kodak, the USA photographic materials producer, is reported in an article in Cash flow (19/11/90) as facing operating exposure in Yen, since its main competitor is Fuji of Japan.Kodak realised that its profit fell when the value of the Yen fell vsv the dollar, because Fuji was able to sell its products cheaper.It is reported that Eastman Kodak was amongst the first firms to have identified and hedged operating exposure [Corporate Finance, (August 1988)].

3.Happy Pets Products, a British toys and accessories manufacturer, has been put out of business because of the pound's strength against the dollar over the period from 1985 to 1988 [see diagram (1.2)] (Financial Times, 6/6/88).This example highlights the problem that small firms face when adverse exchange rates arise.According to a CBI article, small firms face problems, if they are supplying to price sensitive mass markets (where the price elasticity of demand is expected to be relatively high).

4.In 'Helsinki Hanomat' (20-11-90), it was reported that the future of the Finnish forest industry was expected to be poor over 1991 and 1992, due to the suppressed state of foreign markets and lower exchange rates in importing countries.

5. The Airbus industry, with costs in DMs, Spanish pesetas, pounds and FF, has an operating exposure to the dollar, since its main competitors are Boeing and McDonnell Douglas, whose costs are in dollars.(Independent, 7/12/90).

6.In an article in the Financial Times (4-9-92), it is argued that the weak dollar over the first half of 1992 depressed Rolls Royce's first half profits. The firm lost about £10m compared to the previous year's profits.The same article mentions that the weak dollar is benefiting Rolls-Royce's main competitors (General Electric and Pratt & Whitney), whose costs are in dollars.

In the same newspaper, it was reported that Courtauld's Textiles, the UK's biggest textiles and clothing manufacturer, issued a bleak warning on the prospects of future trading due to '... the overvaluation of European currencies against the US$' which '...undermines competitiveness'. Courtaulds Textiles is especially exposed to the dollar exchange rate with other European currencies, since about 80% of its production costs are incurred within Europe.According to the article '...the dollar's fall has left the company vulnerable to cheap imports from the Far-East, where many companies are dollar linked'.

7.Finally, the USA automobile industry, especially Chrysler, felt the effects of a high dollar during the first half of the 1980s.USA firms saw their market shares in the domestic car market fall from 88% in 1980 to 69% in 1987.This was partly because the appreciated dollar enabled the Japanese to price their products competitively.

1.9.Does Exchange Rate Exposure Really Matter?

The above discussion of exchange rate exposure was concerned with how to measure and ultimately hedge against such exposure.It was assumed that exposure will affect the market value of a firm, and hedging may eliminate these assumed market value changes.

However, do exchange rate changes alter market values?

This question requires both theoretical and empirical analysis. A paper by Dufey and Srinivasulu (1983) provides a summary of the theoretical arguments for and against the significance of exchange rate exposure on market values.If one assumes a world of perfect capital markets, no taxes , no transportation costs, where the Miller-Modigliani (MM) theorem[14] holds, then the Purchasing Power Parity will hold at an aggregate level and the relative disaggregated prices (LOP) will be stable.In such a world,there is no such problem as operating exposure (although transaction or accounting exposure may arise).Any hedging policy to eliminate transaction exposure should not add market value,since in efficient capital markets, all available information is automatically embodied in the cost of hedging, rendering the hedging transaction a zero-NPV transaction.

However, as pointed out previously, PPP and LOP appear to be violated.But even if PPP does not hold, the Capital Asset Pricing Model (CAPM) contends that, although exchange risk is relevant in terms of market values, nothing can be done to alter this value through hedging.It really does not matter if the risk is managed in foreign exchange markets or passed to capital markets.As, therefore, it makes no difference whether to hedge or not, it follows that exchange rate exposure does not affect market values.

Several arguments can be put forward in favour of the hypothesis that exchange rate exposure matters.One stresses the importance of hedging on default risk.As hedging can reduce the variability of cash flows, it can also reduce the default risk, and thus add to the firm's debt capacity.It is the minimisation of the bankruptcy risk that is achieved by hedging, and because of this, hedging may be of some value to the firm.

Finally, several market imperfections such as information asymmetries, taxes etc may abate the MM argument regarding the significance of exchange rate exposure.These imperfections have led Hodder (1978) and Aliber (1978) to argue that exposure does matter.

The empirical evidence on the effects of exchange rate changes on share prices is rather vague. Jorion (1990) tests the statistical significance of such effects on the stock prices of 287 USA Multinationals.Using a regression model,he finds that most exposure coefficients are small relative to their standard errors.He concludes that this result does not mean that exposure does not matter but rather that exposure is imprecisely measured.He also finds significant correlation between the level of foreign involvement (measured by the ratio of foreign sales to total sales) and the coefficient of exposure.Finally, his empirical findings lead him to argue that the more domestic a firm is, the less exposure it faces.Based on this, Jorion contends that the cost of capital (and thus, market values) can be altered by hedging.

Another study on this issue is that by Yakov Amihud, reported in the Economist (6/6/1992).Amihud focuses on 32 of America's biggest exporters between 1982 and 1988.After allowing for capital market changes, he finds that exchange rate changes did not alter the market values of these firms.He, then, focuses on 8 of the biggest firms and finds that although exchange rate effects come through more powerfully, they were still insignificant in statistical terms.

John Bilson, as reported in the same article, tests the exchange rate effects on the share price of American Airlines between January 1985 and December 1991.He finds only weak evidence of currency effects on share prices.This result is similar to Amihud's.

The article concludes that it is hard for analysts to calculate a firm's exchange rate exposure.In the case of American Airlines,Bilson argues that a weaker dollar may have two opposite effects on the share price:it may boost short term cash flows (causing an upward trend on the share price) but also may reflect a weaker USA economy (causing a downward trend on the share price).

1.10. Conclusion

This introductory chapter has attempted to provide a background for the problem of exchange rate exposure.It analysed and critically evaluated different types of this exposure and justified why operating exposure will be the main theme of the chapters to follow.It also attempted to identify the parameters which cause and determine operating exposure.In the next chapter, specific scenarios will be assumed for each of these parameters, in order to model operating exposure.On the basis of such modelling, some hedging propositions will be theoretically considered and empirically evaluated in the following chapters.

Finally, this chapter provided some 'real world' examples of firms which have faced operating exposure, and discussed the issue of whether exposure really matters in terms of capital markets behaviour.Although it appears that operating exposure is a significant problem of firms with interest in international commodity markets, evidence from capital markets is not clear as to whether exchange rate exposure is truly considered.

NOTES

1.Currently, the exchange rates in the ERM are allowed to fluctuate +/-2.25% (short band) or +/-6% (wider band) around their central parities with ECU.See Shapiro (1989).

2.Generally, there are two different approaches in forecasting exchange rates.One relies on the capital markets and the other on the development of theoretical models which encompass significant economic parameters expected to affect exchange rates.In the first category, one could classify the efficient international capital markets relationships:The Purchasing Power Parity, the International Fisher Effect and the Expectations Hypothesis connecting the future spot exchange rate with the forward rate.In the second approach, exchange rates changes are considered as a result of the general macroeconomic conditions. Here, there are also two (controversial) approaches: the first focuses on the Balance of Payments and its determinants (relative inflation rates, relative income growth, relative money supply and relative interest rates).It is known as 'the monetary approach to exchange rate determination' and predicts that high domestic inflation will lead to a Balance of Payments deficit which will cause a currency devaluation. Devaluation is also predicted if relatively high income comes up (which will boost imports).Finally, high real interest rates will lead to a currency appreciation.

In the second approach, known as 'the asset approach to exchange rate determination', a currency is a financial asset whose value is determined in the context of an efficient market, influenced by information pertinent to the economic and political stability of the countries concerned.Although it focuses on the same parameters as the previous approach, the sign of the assumed effect of some of these parameters is not the same.For example,it predicts that high relative income (due to a growing economy) will lead to a currency appreciation, and not a devaluation as predicted by the monetary approach.Empirical evaluation of these models is based on the construction of structural (econometric) models including the parameters previously mentioned.

3.For several classifications (and terminology) of exchange rate exposure, see:Shapiro (1989), Flood and Lessard (1986), Srinivasulu (1983), Douch (1987), Hertzell and Caspar (1988) and Donaldson (1987).

4.There are several methods of translating foreign currency accounts into local currency ones:See Shapiro (1989) and Buckley (1986).

5.See Diagrams (A.2.1) and (A.2.2) in Appendix A.

6.Real exchange rates are not observable.They can be calculated using the nominal exchange rate along with a proxy of inflation rates and the following formula:

$$RER = NER * \frac{1 + i_{UK}}{1 + i_{USA}}$$

where:

RER :the real exchange rate

NER :the nominal exchange rate

$i_{UK,USA}$:the inflation rate in the UK and USA.

7.With regards to the evolution of this term.see M.Porter (1986) and the article by Lessard

'Finance And Global Competition: Exploiting The Financial Scope And Coping With Volatile Currencies', in the same book.

8.About PPP,see later in the chapter, in section 1.6.3.

9.The following report,appeared in the Financial Times (11/3/1986).illustrates the strategic interactions of international producers and the dilemma between profit margins and market shares encountered by firms which face operating exposure.Following the depreciation of the pound vsv the DM from November 1985 to March 1986, many analysts thought that this depreciation would result in higher profits for UK exporters in Europe.In this report, Baker Parkins, the Peterborough based manufacturer of printing , chemical and food machinery claims that

> '...much depends to what extent, we plan to go for greater volumes, and also what our German competitors,for example, decide to do. Will they cut margins to compete or will they take the view that margins are already so squeezed that they will leave prices alone for now?'

10.See the following papers:1.'Economic Exposure-What is It And Should A Company Deal With It?', in Cash Management News (4/10/89).2.'Risk And Arbitrage:Corporates Must Broaden Their Appreciation Of Risk To Survive',in Euromoney, (20/2/89).3.'Companies Are Becoming Increasingly Sensitive To Full Range Of Risk, That Growing International Trade And Acquisitions Are Exposing Them To', in Euromoney Cash Flow (18/4/88).

11.For some practical examples, see chapter 7,section 7.3.

12.The Law Of One Price asserts the abstracting from tariffs and transportation costs, prices of internationally traded commodities should be the same across world markets, to prevent spatial arbitrage opportunities.See also section 1.6.3.

13.See Srinivasulu (1983) for a classification of exchange rate exposure.

14.The Miller-Modigliani (MM) theorem states that there is no such thing as financial policy (i.e capital structure and dividend policy) exposure for firms.See Copeland and Weston (1988).Extending this argument to the international arena, it can be argued that under specific assumptions,outlined in the text, there is no such thing as exchange rate exposure.

CHAPTER 2

MODELLING EXCHANGE RATE ECONOMIC EXPOSURE.

2.1.Introduction.

In the previous chapter, the parameters causing and determining the magnitude of operating exposure were identified. This chapter, provides a model of operating exposure.

Modelling operating exposure requires the statement of specific assumptions for each of the parameters (type of competition in the industry, production technology and firm's choices over the trade off between market shares and profit margins), which affect operating exposure, and the examination of the effects of (real) exchange rate changes on real export prices.In the relevant literature, the microeconomic analysis which addresses the effects of exchange rates on import/export prices,on the basis of a given market structure, production technologies amongst competitors and firm's objectives,is known as 'Exchange Rate Pass Through' (ERPT).As will be illustrated below, this concept is quite close to the concept of operating exposure, and will be used as the basis towards modelling operating exposure.

This chapter provides a new model of exchange rate pass through (and thus, operating exposure).The main assumptions are the existence of international producers and a market share objective by the exporting firms in the long run.The practical relevance of such assumptions and their implications are also discussed.

Our aim is to theoretically prove that, under these assumptions, the relationship between exchange rates and export prices (to be depicted in a diagram which will be called a 'risk profile') indicates that the export business (i.e the fact that a good produced in the UK is available in the USA market) can be seen as a real (business) option given by exporting firms to overseas customers.(The concept of real option is only briefly introduced here.Further analysis is provided in chapter 4).

Finally, some (financial) hedging implications of the model will be briefly discussed.This topic will receive full coverage in chapter 4.

2.2.Exchange Rate Pass Through:Concept And Previous Work.

The significant real and nominal exchange rate changes in the 1980's [see diagram (1.2)] have triggered considerable theoretical and practical interest on the influence of these changes on the prices of imported/exported goods.This interest stems from two reasons:the effects of exchange rate changes on the competitiveness of an economy as a whole (depicted in the inflation rate and Trade Balance) and the competitiveness and profitability of specific firms which participate in (or are affected by the conditions in) international markets.The latter reflects the concept of operating exposure.

The relationship between exchange rate changes and the prices of imported/exported goods is known as 'Exchange Rate Pass Through'. [Fisher (1989 a), Flood and Lessard (1986)].This concept examines to what extent a given exchange rate change is passed through to the market equilibrium prices of internationally traded goods. Operating exposure can be thought of as a concept which can be derived (or inferred) from exchange rate pass through, as it considers the implications of a so determined market equilibrium price on the profitability (i.e profit margin and/or market share) of a specific firm in the market.Exchange rate pass through is a market based concept (focusing on the effects of exchange rates upon the market prices of goods), whereas operating exposure is a firm specific concept (focusing on the latter effects on the profitability of specific firms).

To outline the essence of exchange rate pass through, we consider the hypothetical

UK firm discussed in chapter 1, and assume that the UK inflation is 10%, whereas the USA inflation is 0%.We further assume that at equilibrium, the cost of the UK firm ,when expressed into dollars, equals the cost of its USA competitor, and thus, the market equilibrium price is optimal for both firms (and no operating exposure arises).We assume, now, that the pound appreciates by 10%, and thus in real terms, by 20%.The question is, by how much the market equilibrium price will be affected,after this real pound appreciation. This involves reconsideration of the pricing decision by firms participating in the market and, in fact, reflects the essence of exchange rate pass through.

Before proceeding, one should note that this question is relevant (and thus exchange rate pass through is meaningful) only if real (as opposed to nominal) exchange rate changes occur.This is so, since if the pound had depreciated, instead of appreciating, by 10%, then the two cost curves, when expressed in a common currency, would have been unaffected, creating no reason for an export pricing reconsideration.Thus, exchange rate pass through arises only when operating exposure arises. Both concepts are due to the same cause:the real exchange rate change.When real exchange rates are unaffected, exchange rate pass through (and thus, operating exposure) is muted.

Coming back to our example, one would argue that the UK firm's costs, when expressed in dollars, have increased by 20%, whereas the costs of the USA competitor are stable.This may cause a disequilibrium situation in the market, in terms of pricing. The UK firm will be inclined towards increasing its export price, to account for higher costs.The extent to which the actual market equilibrium price will increase is examined by exchange rate pass through, and depends on the level of competition in the market (the price elasticity of demand and the extent to which the competing brands are homogeneous), the production technologies of producers and the relative significance of the UK producers in the USA market ('small'/large country effect) [Dornbusch, (1987)].In fact, the parameters which affect exchange rate pass through are the same as those which affect operating exposure. Now, if the market equilibrium price is not affected by the real pound appreciation,then the exchange rate pass through ability of the UK firm is zero.In this case,one can infer that operating exposure arises and the cost of the pound appreciation is borne by the UK firm, as a profit margin reduction by the percentage of that appreciation.The firm, however,preserves its market share by complying with the (fixed) market price.If the UK firm neglects this market price and sells at its optimal (profit maximising) price, it preserves its profit margin,but endangers its market share.If,however, the firm manages to pass the entire amount of the appreciation of the pound on to the market, then its pass through ability is 100%, implying that its profit margin (in pounds) is unaffected by this appreciation (without loosing market share to its competitors).In this case, operating exposure does not exist.In fact, the lower the pass through ability, the higher the exposure faced by the firm and vice versa.

In general, the higher the homogeneity of the brands in the market, and thus the higher the competition [Mann, (1986)], the lower the pass through ability of international competitors and thus, the higher the operating exposure they face.Further, the higher the significance of the UK firm in the USA market, the higher its pass through ability and the lower its operating exposure. Finally, the more technologically efficient the UK firm compared to its USA competitor, the higher its ability to absorb relative cost increases, and thus the lower the importance of cost shocks on the market equilibrium price,and on the operating exposure problem faced by it.

In the relevant literature, there have been several efforts to model the parameters which determine exchange rate pass through. and to study the behaviour of export/import prices, due to a given exchange rate change.There are two 'groups' of models addressing the question of export/import pricing, due to exchange rates changes[1].According to the terminology of Krugman (1986), Dohner (1984) and Froot and Klemberer (1989), the first group includes 'static' models and the second, 'dynamic' models.The common feature of the first group is that, these models do not allow for intertemporal dependence in the firms' (pricing) optimisation problem.The ''today's'' pricing decision is not affected by expectations on the future behaviour of exchange rates, future market shares or profits.Expectations remain the same, and thus, do not enter the decision process.Models of this type are provided by Dornbusch (1987), Mann (1986), Fisher (1989) and Feenstra (1989).

Dornbusch (1987) analyses in a theoretical context,the question of why the exchange rate changes effects on import prices may vary between different categories of goods. He observes that over the first half of the 1980's (when the dollar was appreciating), the dollar import prices of food, materials and semi-manufactured commodities were decreasing in dollar terms (indicating that the foreign currency export prices were relatively stable), whereas the prices for finished manufactured goods were increasing.In the former category, the ability of USA producers to pass through the appreciation of the dollar to the market was relatively low (and their operating exposure was relatively high), whereas in the second category, the pass through was higher.He considers several theoretical models from the area of industrial economics, to highlight the importance of market segmentation (from world markets),the level of competition and product homogeneity in the determination of actual exchange rate pass through.All of these models led to the conclusion that the higher the level of competition, and the less segmented the market, the lower the pass through (and therefore, the higher the operating exposure).In this case, dollar import prices are expected to fall (indicating that foreign currency export prices are relatively fixed, when the foreign currency depreciates vsv the dollar). Using this conclusion as a yardstick to explain the relative $ import price stickiness of finished manufactured goods, one could argue that these products are expected to be relatively less homogeneous than food, materials or semi-manufactured goods, and thus, the competition may be relatively lower.

Fisher (1989 a) offers a unique model of exchange rate pass through, based on Bertrand competition.This model allows for export prices to be determined on the basis of the expected exchange rate and highlights the importance of market structure for the actual exchange rate pass through.In the context of this model, if the market is competitive (i.e there are at least two producers), a currency appreciation will cause prices to fall, whereas if it is monopolistic, a currency depreciation may cause prices to rise.Fisher (1989 b) tests this hypothesis on the basis of the 1984 and 1986 depreciations of the yen and the DM, for Japanese and German exports.Unfortunately, only weak evidence appears to support the previous theoretical arguments regarding the importance of market structure on exchange rate pass through.

Mann (1986) provides a model of export pricing, based on the concept of price leadership in the market.It can be inferred from this model that the actual pass through can be determined by '...such aspects of market structure as the number of firms producing the good, strategic interfirm behaviour and the degree of product substitutability'.From the supply side, the production technologies of international competitors seem to determine pass through as well. Mann also argues, that macroeconomic shocks (inflation, booms and recessions) affect exchange rate pass through.She then provides some evidence, regarding the behaviour of aggregated and disaggregated export price data for the USA, from 1977 through to 1985.This time span included an initial period of dollar depreciation (1977-1980), followed by a period of dollar appreciation (1980-early 1985).Mann finds that over the first period, foreign currency profit margins of exporters to the USA fell, implying that the latter were unable to pass the full amount of the dollar depreciation on to the USA market. She explains this as a means of foreign exporters preserving their market shares in the USA market.Over the second period, foreign currency profit margins of some imported goods seem to increase, although for a number of goods imported from other industrialised countries, foreign currency import prices appear to be relatively stable.She adds that '...stiffened competition for the USA market between established suppliers and newly industrialised countries may lead to permanently low profit margins on some imports'.This indicates that over periods of local currency depreciations,some exporting firms with a market share expansion objective may keep their local currency export prices stable, resulting in a low exchange rate pass through.

Feenstra (1989) offers a model of import pricing based on the concept of imperfect competition.He argues that the shape of demand and marginal cost curves along with the number of (differentiated) imported varieties of a specific product determine the level of actual exchange rate pass through.

The second category of international pricing models includes 'dynamic' models, which emphasise the role of long term expectations concerning the exchange rate on ''today's'' pricing[2]. According to this group of models, the current exchange rate can be either temporary or permanent.The today's actual export/import price is assumed to be a function of the firms' perception about the permanence of this rate.Some of the models in this category emphasise the role of exchange rate expectations on the demand side of the market equilibrium (demand side dynamics)[Dohner (1984), Krugman (1986) and Froot and Klemberer (1989)].Other models emphasise the role of expectations on the supply side of the market equilibrium (supply side dynamics) [Krugman, (1986)].

Models focusing on demand side dynamics associate today's pricing with the future market share of firms.Froot and Klemberer (1989) argue that, when a firm is concerned about its future market share, it chooses a price which is lower than if this objective had no value for it.This may imply that when the local currency depreciates, an exporting firm may prefer to lower its foreign currency export prices (and therefore keep its local currency price fixed), in order to attract new customers. According to the previous authors, this occurrence is reinforced if the local currency depreciation is perceived as permanent.In this case, firms are assumed to have strong incentives to shift profits from 'today' to 'tomorrow'. They thus use a possible currency depreciation, not to increase their short term profit margins, but to augment their market shares, which will result in higher long term profits.In this case, these authors argue that a foreign currency depreciation may cause the dollar prices of imports to the USA to decrease more than what static models would predict.Similar conclusions are drawn by Giovannini (1988), Dohner (1984) and Krugman (1986), who argue that exchange rate changes perceived as temporary will leave dollar import prices relatively unaffected.Applying these authors' findings to the case of the hypothetical UK firm (with the assumption that it has a market share objective and anticipates a long term pound depreciation vsv the dollar), then one could conclude that its dollar export price would be relatively decreased, implying that its pound price would be constant.This point will be utilised later in the analysis.

Supply side dynamics focus on the need of new investments by firms to expand their production capacity.following an exchange rate depreciation, which appeared as a decrease in prices.Short term production capacity restrictions prevent firms from responding quickly to a currency depreciation by cutting prices, as they will be unable to satisfy new customers.If the depreciation is perceived as temporary, then no change in prices will occur.If on the other hand, the depreciation is perceived as permanent, then prices will be cut gradually, as new investments in expanding production capacity are undertaken.Thus, exchange rate pass through will be slow.

To conclude this section, one could argue that exchange rate pass through is due to the same cause and depends on the same parameters as operating exposure.In the next section, we present a model of exchange rate pass through, which is in line with the demand side dynamics previously reviewed.The purpose is to depict diagrammatically, the market equilibrium export prices, for different actual exchange rates.Such a diagram will be called a 'risk profile'.From the risk profile of exchange rate pass through, we will derive a diagram which gives the effects of the previous market equilibrium prices on a specific firm's profit margins, for the same exchange rates, assuming that firms always accept these equilibrium prices.This will be the risk profile of operating exposure.

2.3. A Model Of Exchange Rate Pass Through.

2.3.1. Assumptions.

The model aims to highlight the strategic interdependence of international producers and illustrate the contingent feature of actual export prices due to unpredictable exchange rates.It,then, focuses on how we can depict (measure) the operating exposure, faced by a specific firm.The assumptions are:

1.We have a partial equilibrium export pricing model.Inflation rates in the countries concerned are assumed to be zero. There are no income changes.Exchange rate determination is a non-problem[3].

2.We study a UK firm with production costs and borrowings in pounds.It exports its output to the USA market, where it faces competition from a USA producer with production costs and borrowings in dollars.The USA market is not affected in terms of equilibrium pricing by the conditions in the UK market.This implies that we neutralise the effect of the relative importance of the UK producer in the USA market (which,according to the discussion in the previous section, is a parameter which affects exchange rate pass through)[4].

3.The market has an oligopolistic structure, in which personal competition arises, and each producer's actions affect the position of the other.There is an intimate interdependence amongst international producers, which is the real cause of operating exposure (in which, it is the relative,and not the absolute, cost changes that matter).(Modelling exchange rate pass through using a monopolistic competition approach,instead, would not account for the producer's interactions).The firms' behaviour is assumed to be captured by the price leadership model.Which firm is going to end up being the price leader is contingent and dependent on the future actual (real) exchange rate.The firm which turns out to be the price leader, after the actual exchange rate has realised, establishes its optimal price as market equilibrium price, and the other firm is assumed to accept this equilibrium price, which in consequence,creates operating exposure for it.The product is assumed to be only slightly differentiated, and thus, the price elasticity of demand is relatively high.

Before the actual exchange rate realisation, [period T_0 in the timetable in diagram (1.3)], each firm establishes some expectations, with regards to the future (and unknown at that time) exchange rate. Each firm will determine an expected selling price, on the basis of this exchange rate forecast.This price can be seen as the bid-price by each firm to win the order to supply the market.In fact, this bid price is the price list published by the firms, before the time when the winning firm is to be announced.

4. After the UK firm has established its expected price, it is assumed that it fixes this price in terms of both pounds and dollars, whereas the USA firm is assumed to fix its price in dollars.In fact, the UK firm fixes its expected price (for a specific period, say, of 3 months) in pounds and then translates this price into dollars, using the expected exchange rate. According to the practical jargon, the UK firm publishes a 'dual-currency' price list[5].Further, the UK firm is willing to accept any lower dollar price, if market conditions (due to the actual future exchange rate) require so.This assumption is very crucial for the analysis to follow, and will be further elaborated below.

5.At equilibrium (T_0), it is assumed that the UK firm is as technologically efficient as its USA competitor.This implies that, if costs are expressed in a common currency, their ratio will be equal to 1.This assumption will be relaxed later, in order to illustrate the consequence of having relatively efficient firms on exchange rate pass through and operating exposure.

6.The UK firm is assumed to have a well established export pricing commitment in the past, for it to see the foreign export price as distinct from the domestic one.If the firm makes occasional exports, it would not bother to pay much attention to export pricing.

7.The exchange rate is a random variable.It is assumed that in terms of export pricing, what really matters is a 'significant' exchange rate movement over the period during which the export price is fixed.Such a significant exchange rate can be captured by the period average rate, so that we avoid the noise of daily exchange rates on export pricing.

Before turning to the description of the model, we discuss why the UK firm is assumed to fix its price in both pounds and dollars.After the determination of the selling price (using the price leadership model),the currency (-ies) in which the selling price is expressed is the result of two arguments:first, the UK firm is assumed to have a long term market expansion objective, and second, the existence of international competitors.

Froot and Klemberer (1989) mention that the importance of a market share objective is indicated by the emphasis given by many business executives on this corporate goal[6].These authors, examining the effects of this objective on actual exchange rate pass through, argue that firms choose prices lower than they would, if market share had no value.For our case, this implies that if the pound depreciates vsv the dollar, the UK firm would be willing, under this goal, to cut its dollar price by the full amount of the pound depreciation.This can be achieved, only if it has published its selling price in pounds, which, when translated into dollars, will pass the full benefit of the pound depreciation on to USA customers.If the pound appreciates, the UK firm will stick to its dollar quoted price, acting in this case as a price taker.

In fact, the existence of international competitors causes the UK firm to think of ways to price strategically in the USA market.Such a pricing strategy would be for it to exploit,in cases of pound depreciation, the fact that its costs are denominated in pounds, and quote a price in pounds.This argument is reinforced, if we assume that the UK firm perceives the pound depreciation as relatively permanent.For example,if one focuses on the 1980-early 1985 pound depreciation vsv the dollar, this could have triggered, on an a-priori basis, expectations about a long lasting pound depreciation[7].According to Froot and Klemberer (1989), Giovannini (1988) and Krugman (1986), a market share expansion objective along with expectations about a 'permanent' exchange rate depreciation, would result in producers (whose currency is to depreciate), cutting their foreign currency selling price. Such action would be meant to 'satisfy' overseas customers, as opposed to keeping any resulting depreciation for themselves, in the form of increases in profit margins.In essence, the fact that the UK firm may give up higher profit margins portrays the today's cost in investing in tomorrow's growth (expansion).It can be seen as a concession given to USA customers, which aims to gain their allegiance, if the pound depreciates. In practice,such a concession could materialise,if the UK firm offers a price list expressed both in pounds and dollars.If the pound were to depreciate,the USA customers would prefer the price quoted in pounds, which results in a dollar price lower than that quoted by the USA firm.In this case, the pound price (and thus,the profit margin) of the UK firm is fixed (not increasing). This action enables the firm to invest in future market expansion[8].If the pound were to appreciate, then USA customers would prefer the dollar quoted price by the USA firm.In order for the UK firm not to outprice itself by being stuck with the pound price (which now results in a higher dollar price), it (the UK firm) must publish a dollar price, which effectively is the same as the price of its USA competitor.

USA customers, on the other hand, may want to exploit the fact that a firm with costs in pounds participates in the market, by asking for price concessions, if the pound depreciates.In fact, these concessions reflect the benefits of the pound's depreciation. Consequently, they will ask for a pound quoted price, so that if the pound depreciates, they will buy from the UK firm at a reduced price.However, if the dollar depreciates, they will buy from the USA firm (and the UK firm,since it publishes a dollar price as well), at,once again, a relatively reduced price.Therefore, what USA customers want is to have the right (option) to buy the product at a price quoted in the currency which depreciates.Responding to this, the UK firm offers this option by publishing dual - currency price lists.

2.3.2. Practical Validity Of The Assumptions.

To shed some light on the practical relevance of the above assumptions, we utilise the empirical findings of Moreno (1991) who attempts to explain the extraordinary performance of USA exports, over the second half of the 1980's. He points out that, after a dismal export performance over the first part of the 1980's, USA export sales featured a remarkable boost during the period of the dollar depreciation (1985-1987), which persisted even after the period of the dollar depreciation.

After ruling out world market conditions (i.e the development of new export markets, and the possible growth of foreign GNPs) as possible reasons to which this boost can be attributed, he examines whether this performance was due to increased competitiveness, which might have resulted after a change in the pricing behaviour of USA exporters, over the period of the dollar depreciation.He notices that,over the previous period, USA export prices were reducing compared to domestic prices and, as a result, the foreign currency export prices were declining sharply in the overseas markets.His empirical findings support the argument that the export pricing behaviour of US exporters had, in fact, changed when the dollar depreciated.And, although he fails to identify the causes of such a change, he argues that such a pricing behaviour:

> '... would be consistent with the growing competitive pressures caused by the entry of producers from Japan, and later newly industrialising Asian economies, in world markets previously dominated by US producers, such as capital goods and electronics, beginning in the 1970's'.

This justification is in line with the existence of relatively globalised markets (see chapter 1) and brings out the consequences of international competition on the export pricing behaviour of (and thus,on the operating exposure faced by) market participants.Lessard and Lightstone (1986) and George and Schroth (1991) indicate the consequences of the existence of globalised markets on the (creation of the) problem of operating exposure.

Further, Hooper and Mann (1987) argue that US producers may be tempted to price competitively relative to foreign producers in industries where there is strong competition for market share, because the traded brands are close substitutes.

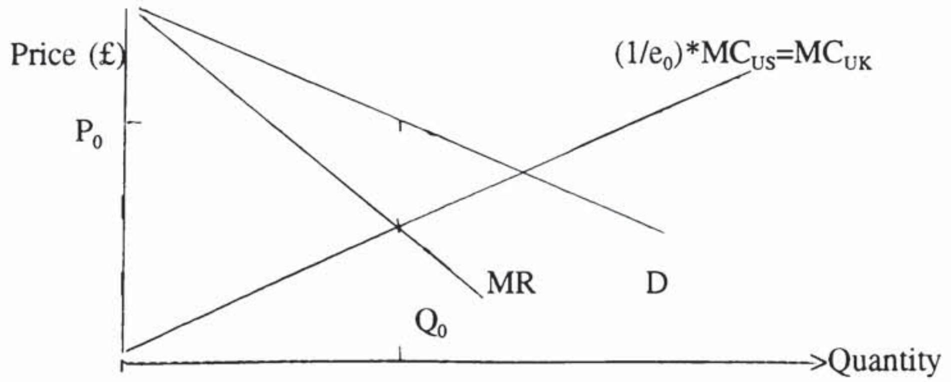
Finally, Cavusgil (1988) interviewed several business executives regarding their export pricing behaviour, and reported several examples of firms, which follow a rather passive export pricing policy, by reducing profit margins for the sake of market shares.On the basis of this evidence, Cavusgil argues that as competition grows, firms tend to move from a profit maximising pricing behaviour to a more managerial one, stressing the importance of market shares in the decision making process.

2.3.3. Model Description.

The model will be presented in diagrams.

Just before the new expected (bid) export price is set, the exchange rate is assumed to be at equilibrium, given by e_0.At this rate (and assuming that both the UK and the USA firms are at the same level of technological efficiency), the marginal cost curves of the two producers coincide.The market for the specific commodity is at equilibrium, portrayed in diagram 2.1.

Diagram 2.1. Market Equilibrium Before The Exchange Rate Changes (T_0).



where:

P_0 :the equilibrium pound price at T_0.

Q_0 :the overall quantity sold by the two firms.

$(1/e_0)* MC_{US}$:the marginal cost of the USA producer expressed in pounds.

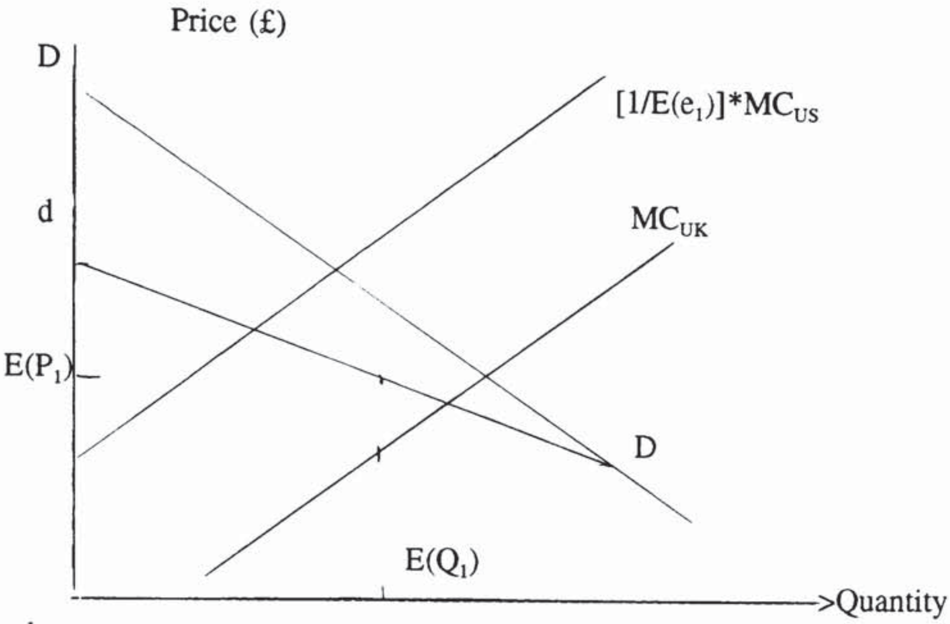
MC_{UK} :the marginal cost of the UK producer

e_0 :the equilibrium exchange rate at T_0 (expressed in dollars per pound).

At T_0, both firms obtain a (unique) forecast about the average exchange rate expected to prevail in the next period (over which the bid price will be fixed).This forecast,$E(e_1)$, will affect the position of expected marginal costs of the firms and thus,will shock the market equilibrium.Let's assume that there is an expectation that the pound will depreciate, and both firms accept this expectation.Both firms reconsider their pricing on the basis of this forecast.The expected pound depreciation will cause the expected MC curve of the USA producer to move up, indicating an expected relative cost advantage for the UK firm.From this,the UK firm is expected to end up being the price leader in the market.The new expected market equilibrium is given by diagram (2.2).

In the this diagram, dD is the expected residual demand curve faced by the UK firm, after it has gained the competitive advantage.The new expected price, $E(P_1)$,is fixed in pounds, and submitted to USA customers as a bid price.The USA firm acts as a price taker and submits a dollar bid price, given by the product of the so determined pound price and the expected exchange rate.According to the previous discussion, the UK firm will also submit this dollar price, in addition to the submission of a pound price.

Diagram 2.2. Market Equilibrium When The Pound Is Expected To Depreciate.



where:

$E(P_1)$:the expected market equilibrium price (set by the UK firm)

$E(Q_1)$:the overall quantity expected to be demanded.

$E(e_1)$:the expected exchange rate.

DD :the overall demand in the USA.

The dollar price submitted by the USA firm is:

$$\$ [E(P_1) * E(e_1)]. \tag{2.1}$$

The pound price submitted by the UK firm is :

$$£ E(P_1). \tag{2.2}$$

When the latter price is translated into dollars, after the realisation of the actual exchange rate, s, we get:

$$\$ [E(P_1) * s]. \tag{2.3}$$

After the actual exchange rate realisation, USA customers face the two bid prices given by (2.1) and (2.3).The equilibrium price (that is,the price which will be finally chosen) will be the lowest of these two prices.To see this diagrammatically, consider diagrams (2.3), (2.4) and (2.5).

Diagram (2.3) depicts the USA bid price vsv the actual exchange rate (on which the actual selling price is determined).This is parallel to the horizontal axis, as this price is independent of the actual exchange rate.

Diagram (2.4) depicts the pound bid price expressed in dollars.It varies exactly in line with the actual exchange rate.In fact, diagram (2.4) is an explicit result of the assumption that the UK firm fixes its export price in pounds.

What we want is the locus (risk profile) which depicts the market equilibrium price. for different actual exchange rates.Such a profile can be derived by integrating the two diagrams together into diagram (2.5), and recalling that USA customers will buy at the lowest price available at different exchange rates.

Diagram 2.3. The Bid Price Submitted By The USA Firm.

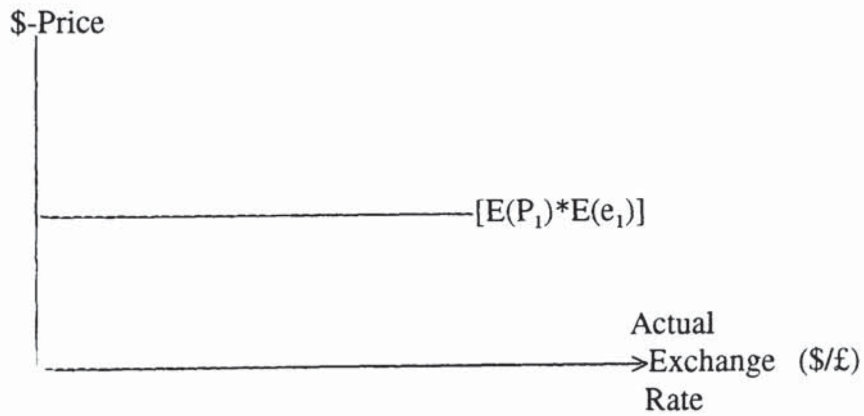


Diagram 2.4.The Bid Price Submitted By The UK Firm.

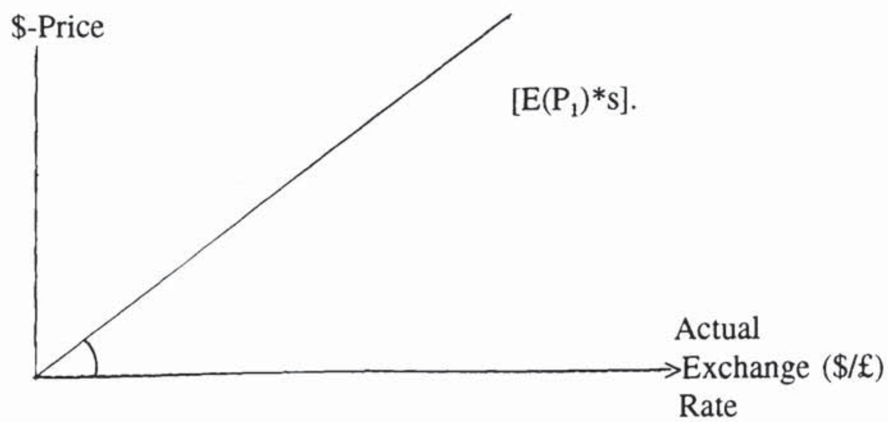
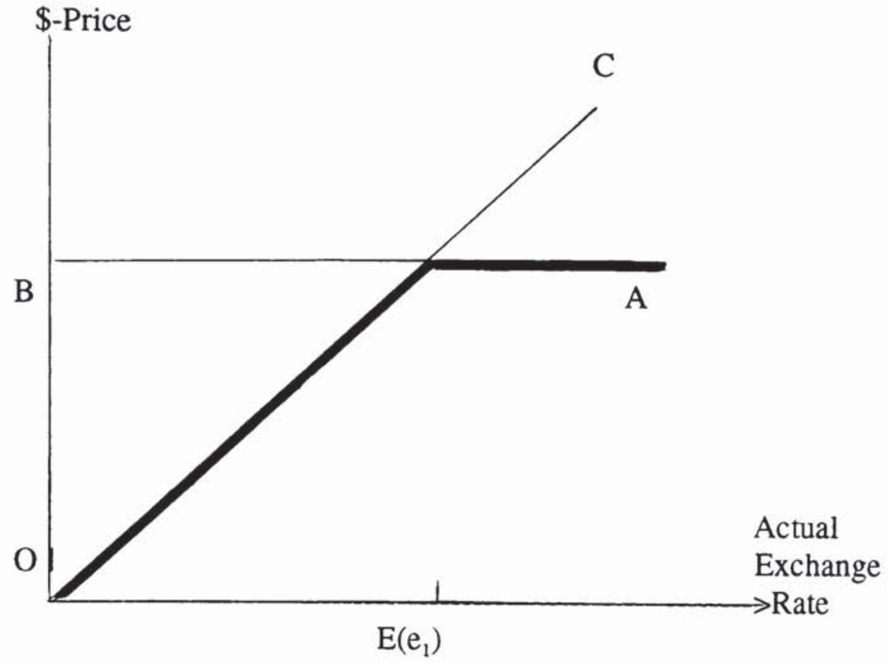


Diagram 2.5. The Market Equilibrium \$-Price.



The relevant risk profile is given by OA in diagram (2.5).This diagram portrays the exchange rate pass through, under the assumptions previously stated.It appears that exchange rate pass through is asymmetric.When the pound appreciates (exchange rates on the right of e_0), the dollar export price remains fixed (and the pound export price reduces by the full amount of the pound appreciation), implying a zero pass through ability by the UK firm.In this case, the US firm is the price leader.If the pound depreciates, the UK firm reduces its dollar export price by the full amount of the pound depreciation.In this case, the UK firm is the price leader and the US firm's ability to pass the dollar appreciation on to the market is zero.

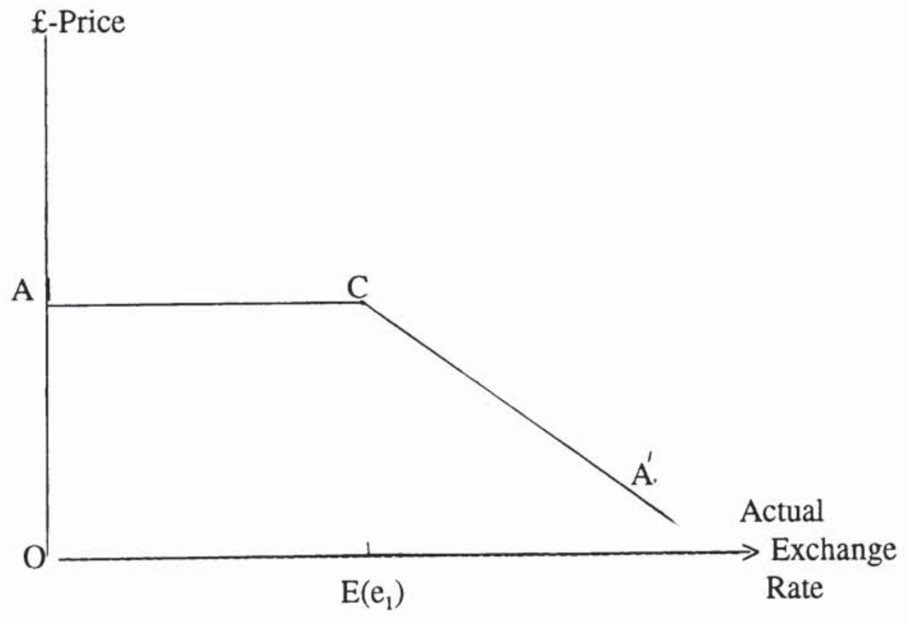
Mathematically, the market equilibrium price is given by the following relationship:

Market Equilibrium Price= MIN $[E(P_1)*E(e_1),E(P_1)*s]$ (2.4)

Fisher (1989 a) reaches the same theoretical conclusion,with regard to the asymmetry of exchange rate pass through.He focuses, however, on a Bertrand competition model. in which the firms' bid prices are fixed in their own currencies.Here, the asymmetric behaviour of exchange rate pass through is established on the basis of the price leadership model along with the assumption of the market share objective.

The next step is to derive a locus,giving the pound export price reactions to exchange rate changes.Such a locus will reflect the operating exposure of the UK firm and can be derived from diagram (2.5).For pound appreciations, the UK firm is the price taker, accepting the fixed $ price.In pound terms, its export price declines in line with the pound appreciation[9].For pound depreciations, the dollar price declines in line with the exchange rate, and thus, the pound price is fixed.Diagram (2.6) portrays the risk profile of the operating exposure of the UK firm.

Diagram 2.6. The Risk Profile Of The UK Firm's Operating Exposure.



This diagram shows that the actual export price that the UK firm can obtain from its export business, under the assumptions of international competition and a market share expansion objective, is given by the following formula:

$$\text{£-Export Price} = \text{MIN}\left[E(P_1)\ ,\ \frac{E(P_1)*E(e_1)}{s}\right] \qquad (2.5).$$

In fact, diagram (2.6) indicates that export business, under the previous assumptions.

can be seen as a real (business) option[10], written (awarded) by the UK firm to USA customers.The fact that we have a written option implies (unlimited) exposure[11] depicted by the downward sloping line in diagram (2.6) (CA').This granted option reflects the flexibility which USA customers possess to purchase the good at a reduced price due to a potential pound depreciation. The existence of international competitors prevents the UK firm from increasing its pound price when the pound appreciates. Further,the goal of market expansion forces acceptance by the UK firm to keeping its pound price fixed, if the pound depreciates.This is the intuition behind diagram (2.6).

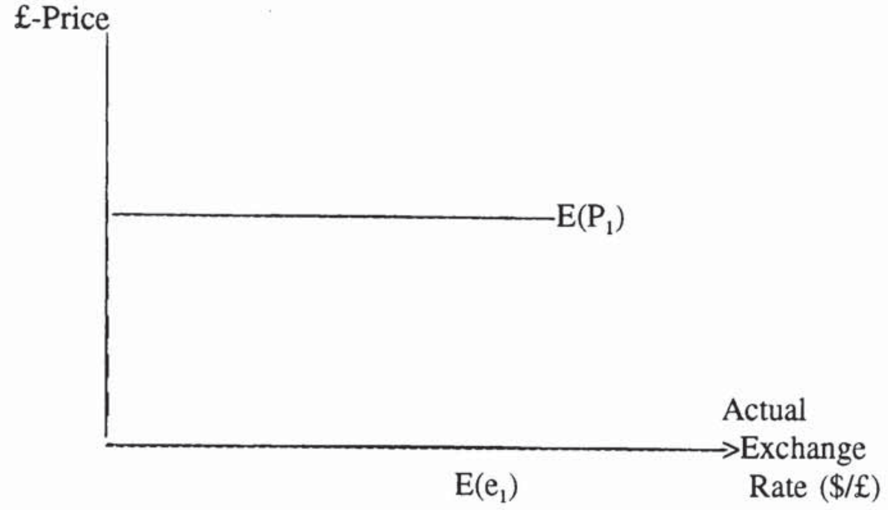
We now relax the previous assumptions concerning the existence of international competition, the equality of technological efficiency amongst firms and the market share objective.These are relaxed one at a time,in order to study the effects of each of these parameters on the shape of the risk profile in diagram (2.6), and thus, on operating exposure.

What is the risk profile of operating exposure, if the UK firm is the monopolistic supplier in the USA? The answer can be reached with reference to diagram (2.5),if we remove the horizontal line (BA). The market equilibrium price is denoted by OC in this diagram, and when translated into pounds, is given as in diagram (2.7).

The horizontal line implies no operating exposure (the downward sloping line has disappeared). The UK firm has a 100% ability to pass through exchange rate appreciations to the market.This diagram indicates the consequences of the absence of international competition for operating exposure.

We now turn to our initial assumption about the oligopolistic structure and relax the assumption that all firms face the same production technology.This point will enable us to illustrate the effects of having an efficient production technology on operating exposure.

Diagram 2.7.Operating Exposure Of A Monopolistic Firm.

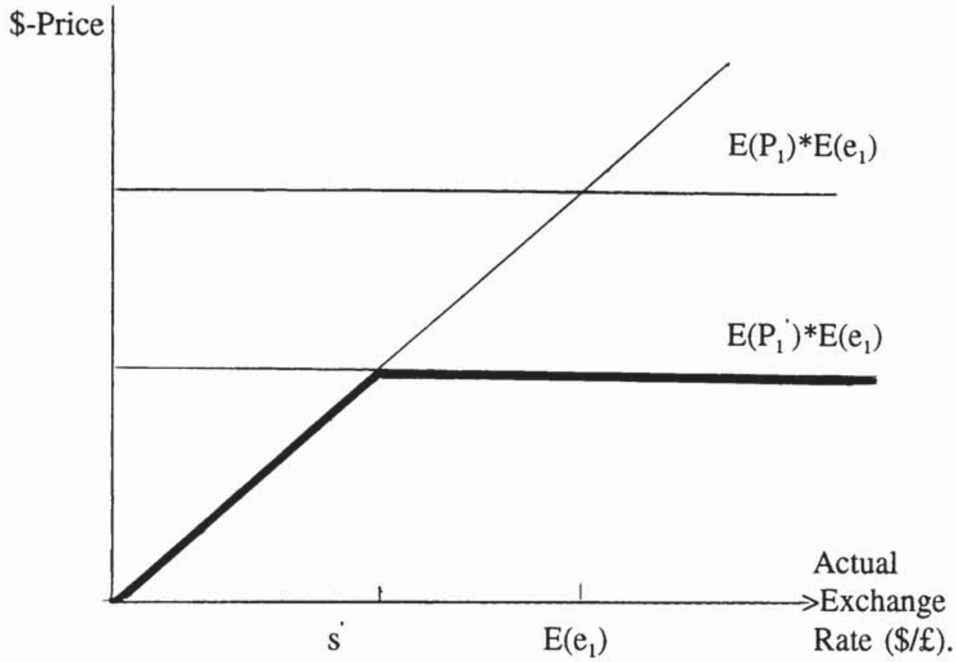


Let's assume that the USA producer is relatively more efficient (implying that his marginal cost curve lies below the cost curve of the UK firm, when the exchange rate is e_0).Based on diagram (2.2), the more efficient the USA firm, the higher the actual pound depreciation required to wipe out the cost advantage of the USA firm and make the UK firm relatively more efficient. The latter implies that the more efficient the USA firm, the higher the range of actual exchange rates for which the UK firm faces operating exposure.This case is depicted in diagram (2.8). Holding the expectations about the future exchange rate constant [$E(e_1)$],the more efficient the USA firm, the lower its \$-bid price [$E(P_1)'*E(e_1)$] vsv [$E(P_1)*E(e_1)$], and the higher the range of actual exchange rates for which operating exposure may arise for the UK firm.

Based on this diagram, one could reach the risk profile of operating exposure, under the assumption that the USA firm is more efficient.Diagram (2.9) portrays this case.The operating exposure that the UK firm faces (B'C') is more severe than the exposure depicted by BC (which corresponds to the case when both firms are equally efficient).

In fact, the more cost efficient the production of the UK firm's competitor, the higher the range of exchange rates for which the $ price is horizontal and thus, the higher the range of exchange rates for which the £ price follows a downward route.The latter implies a more severe exposure than the case of having equally efficient firms.

Diagram 2.8. Exchange Rate Pass Through Profile When The USA Firm Is More Efficient.



In the extreme case where the USA firm produces under a very advanced production technology, we have a situation depicted in diagram (2.10).The USA firm can cut its bid price even when the pound depreciates vsv the dollar, eliminating any exchange rate driven relative cost advantage (due to the pound depreciation) of the UK firm.Such a policy can be adopted by the USA producer, in order to force the UK firm to drop out of the market, and thus, eliminate import competition.In this (rather extreme) case, the USA firm is assumed to be able to reduce its costs, and thus,effectively cut its dollar price as the dollar appreciates.

In terms of diagram (2.2), the MC curve of the UK producer comes down (as the pound depreciates), but so does the MC curve of the USA firm, which enables it to cut its bid price further.

Diagram 2.9:The Operating Exposure Profile Of The UK Firm When Its Competitor Is More Cost Efficient.

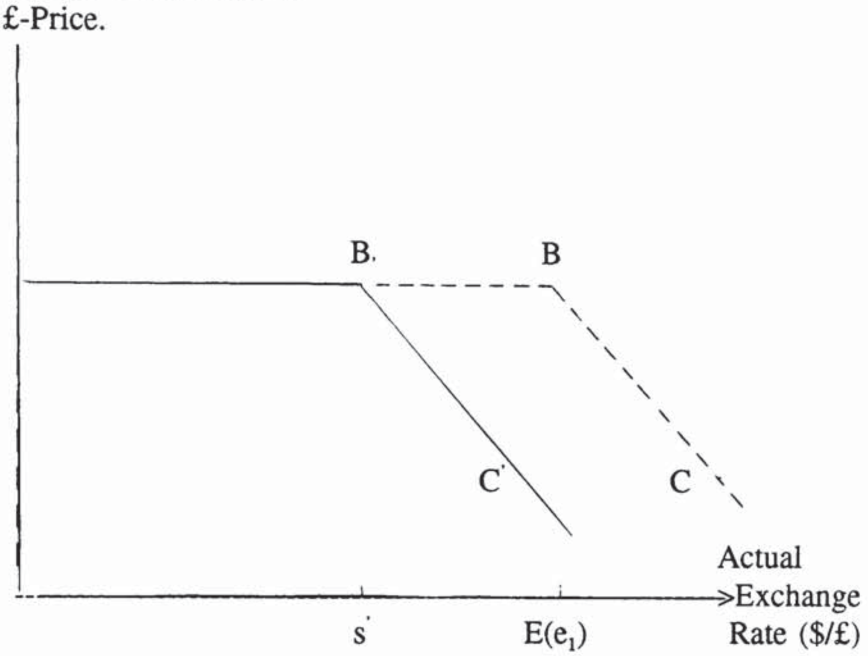


Diagram 2.10:The Operating Exposure Profile Of The UK Firm When Its Competitor Is Very Cost Efficient.

This can be the case of a USA firm with production operations around the world and the ability to move the location of production costlessly, when this is necessary (due to dollar appreciations).

The above results regarding the effects of cost efficiency on operating exposure are compatible with Lessard and Lightstone (1986).

We now turn to the examination of different attitudes about the trade-off between profit margins and market shares, and their implications on the profile of operating exposure.Let's assume that the UK firm has a more balanced attitude over this issue: when the pound depreciates, it goes partially for higher profit margins and partially for market share expansion.This can be achieved by publishing price lists quoting a bid price expressed partly in pounds and partly in dollars.For example, if under the assumption of a market share objective its bid price is £10, under a more balanced attitude towards profit margins its bid price may be £5 + $10 (assuming that the expected exchange rate is £1=$2).If the pound depreciates (£1=$1.8), then the £ selling price will be £10.5 (instead of £10, under the assumption of market share expansion).The more inclined the firm towards higher profit margins, the higher the proportion of the bid price [determined by diagram (2.2)] expressed in dollars, and vice-versa.This leads us to diagram (2.11), depicting operating exposure under a more balanced objective between profit margins and market shares.

One can construct many different risk profiles of operating exposure, according to different assumptions regarding the trade off between profit margins and market shares (that is, 'games' or behavioural assumptions).For example, the UK firm may fix its bid price in pounds up to a certain (depreciated) exchange rate [$E(e_2)$], and in dollars for exchange rates lower than that.In this case, the profile of operating exposure is given by diagram (2.12).

Diagram 2.11. The Profile Of Operating Exposure When The UK Firm Has A Balanced Attitude Over Profit Margins.

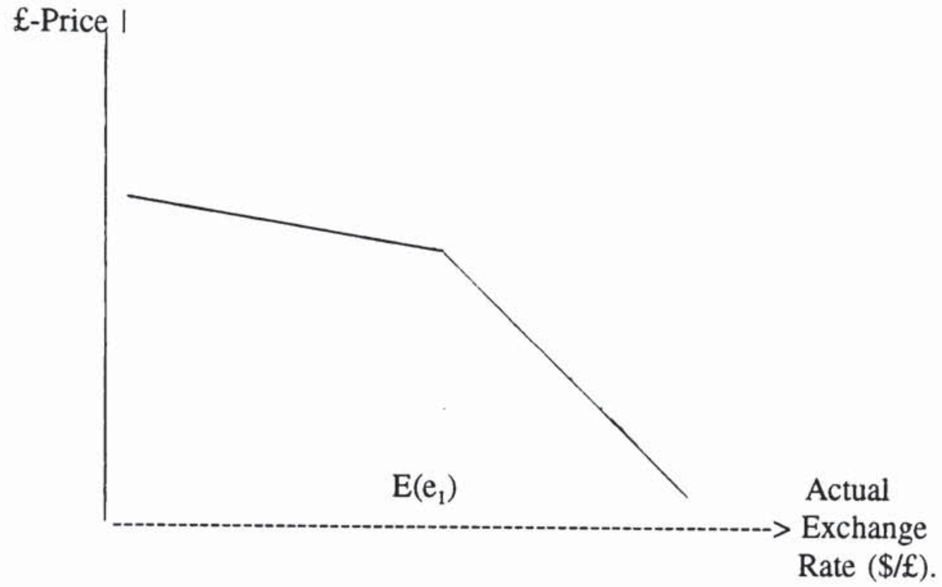
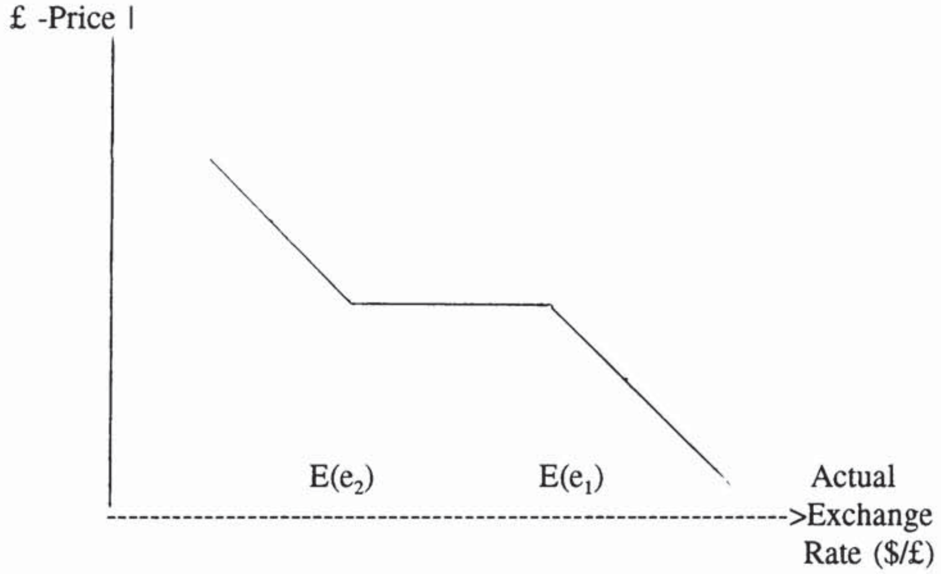


Diagram 2.12. The Profile Of Operating Exposure When The UK Fixes Its Price In Pounds Up To A Certain Exchange Rate [$E(e_2)$], And In Dollars For Lower Rates.



Generally speaking, the UK firm can construct many different scenarios, regarding the currency in which its price lists will be denominated.The criterion for such scenarios will be the maximisation of the firm's competitive position in the industry, given the level of competition and the firm's objectives.Each of these scenarios entails a different profile for operating exposure. [Further analysis of this issue is provided in section (4.5), in chapter 4].

To conclude this section, the existence of international competition and the market share expansion objective make the risk profile of operating exposure look like the risk profile of a written call option[12].The exact position of the risk profile is critically dependent on the level of competition, the relative cost efficiency of producers and the firms' objectives.Further, diagrams (2.6) and (2.11) establish the hypothesis that the effects of exchange rates on operating exposure may be asymmetric.In fact, diagram (2.6) reflects the 'strong' form of this hypothesis, whereas diagram (2.11) reflects the 'weak' form.

A non-linearity hypothesis for operating exposure has been established by Ware and Winter (1988).They argue that if firms have some flexibility in their production technology or import/export decisions, their profit function is convex (and thus asymmetric) to exchange rates.Here, the established asymmetry tends to be concave.

The practical implications of the assumptions and the model are that publishing dual currency price lists provides the UK firm with an export business, the profitability of which is given by the risk profile of a written call option.This conclusion is in line with Warren's (1987) comments, according to which ''a dual currency price list giving the customer the choice of paying either in his own or his suppliers' currency effectively offers the customer a currency option''.Further, as reported in an article in Euromoney (November 1988), Beecham is an example of a firm, which identifies economic (operating) exposure in publishing price lists denominated in domestic currency.These price lists are applicable to overseas transactions, where the volume of orders would be affected by currency movements.

Finally, in the relevant literature of the currency in which export pricing should be denominated, there is a widespread impression that export pricing should be in terms of the customers' currency.This may be valid for discussions of transaction exposure.In terms of operating exposure, pricing in dollars only, implies that the firm expects a dollar depreciation.As exchange rates can not be forecast with consistent accuracy, pricing in the customers' currency may not be an always optimal policy. (This point can be seen as another difference between transaction exposure and operating exposure).

2.3.4. Exchange Rate Exposure In The Sourcing Market.

In the previous model, we assumed that the UK firm had costs denominated only in pounds.To the extent that the firm imports some materials from overseas, the previous assumption may not be valid.

Let's assume that the UK firm has a portion (say 20%) of its costs in DMs.It is assumed that the USA firm has costs only in dollars.(If the USA firm had costs in DMs, then there would be no operating exposure for the part of costs expressed in the DM).In this case, the UK firm has a portfolio of exposures, involving:

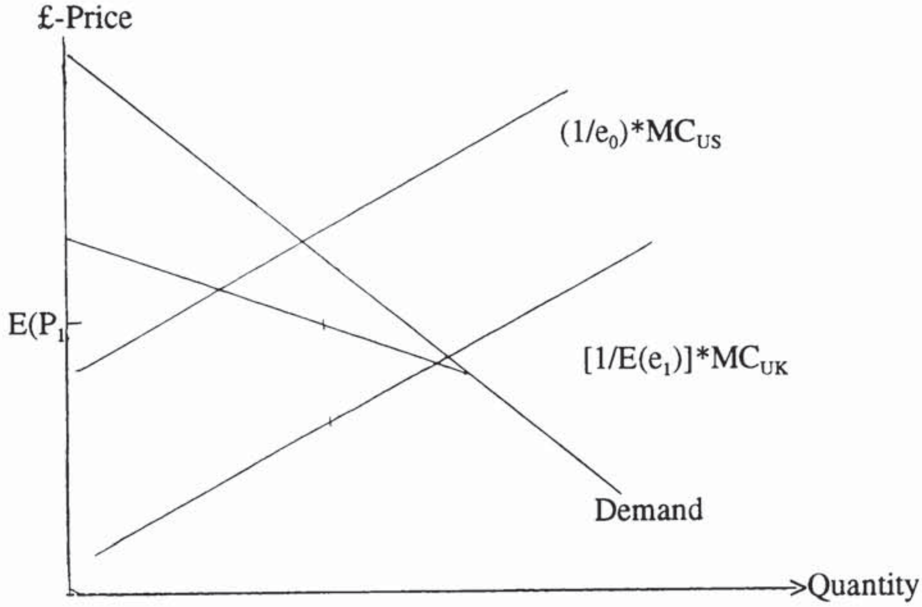
-an exposure in the DM/£ rate, for 20% of its costs,

-an exposure in the $/£ rate for its overall costs.

We further assume that changes in the DM/£ rate leave the imported materials' price fixed in DMs (assuming that either German suppliers perceive this exchange rate as transitory[13], or that this price is determined in world markets).Therefore, the exposure in DMs is only a transaction exposure.

In terms of diagram (2.2), the marginal cost curve of the UK firm will be partially a function of the expectations on the DM/£ rate, which will affect the $-equilibrium market price.This influence, however, will be lower than that of the expectations about the \$/£, because of the higher proportion of costs in pounds (80%), than in DMs (20%).In order to analyse the effects of an expected pound appreciation vsv the DM on the expected market price, we hold expectations on the \$/£ rate constant. Diagram (2.13) portrays how the expected equilibrium is influenced.

Diagram 2.13.Market Equilibrium When The Pound Is Expected To Appreciate vsv The DM.



where:

e_0 :the \$/£ - rate,

e_1 :the DM/£ -rate.

The expected appreciation of the pound will drive the expected marginal cost curve of the UK firm down, enabling the firm to act as price leader.Its export price will be £$E(P_1)$, and when expressed into dollars (assuming that the \$/£ rate is unchanged), will be \$$[E(P_1) * e_0]$.

The USA firm has now to cope with a relatively low (competitive) price, due to the pound appreciation vsv the DM.Thus, although this firm has no transaction in DMs, it faces operating exposure due to fluctuations in the DM/£ rate, because part of its competitor's costs are expressed in DMs.Similar conclusions can be drawn for the UK firm , if a part of its competitor's costs were expressed in a third currency.

The key question is how we can reach an export price, if we expect that both exchange rates ($/£ and DM/£) can change.This problem can be resolved, if we assume that the exposure in the source market is perfectly hedged using forward contracts[14,15].This implies that the UK firm will know its pound costs with certainty when it is to reconsider its export price due to changes in the $/£ rate (period T_0), and can proceed towards establishing its bid price according to diagram (2.2).

2.4.Hedging Implications Of The Model.

In this section, the focus is on the financial hedging implications of the previous model. A more thorough discussion of (strategic and financial) hedging of exposure is provided in chapter 4.

Any hedging policy against operating exposure should be decided after the relevant risk profile of operating exposure has been determined.The key question is which derivative instruments (based on the behaviour of exchange rates) we should choose, in order to end up with a perfectly hedged position [similar to that in diagram (2.7)].

In general, there are two alternative hedging instruments:a forward (or futures) contract (or their equivalent,if foreign capital markets are efficient, foreign currency borrowing) and a currency options contract.

The main question is which instrument's risk profile, when combined with the risk profile of operating exposure, yields a perfectly hedged position portrayed by a horizontal line, for any exchange rate.The risk profiles of a forward (or futures) and a currency option contract are given by diagrams (A.2.1) and (A.3.1) respectively, in the Appendix

A. Here, the focus is on the major implication of the model, given by diagram (2.6) and examine the risk profile of which instrument, when vertically added to the profile of diagram (2.6), yields a perfectly horizontal line.

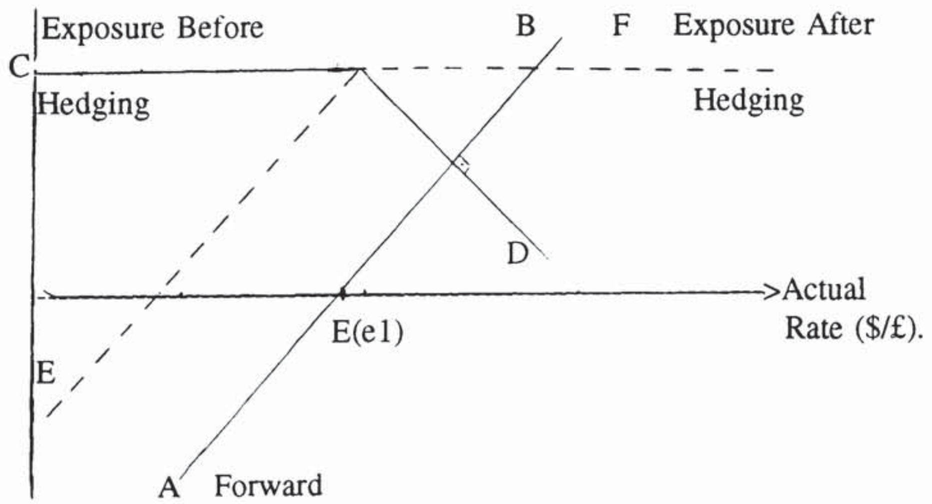
Does a forward contract perfectly hedge operating exposure?

Consider diagram (2.14), which integrates the risk profile of operating exposure with the risk profile of a forward contract. Vertical addition of the two profiles (AB and CD) gives the profile of exposure after hedging (EF).As this is not perfectly horizontal (for any exchange rate), it can be inferred that forward contracts can not hedge the asymmetric operating exposure implied by the model.In general, when exposure is asymmetric, a forward contract (whose profile is symmetric) can not produce a perfectly hedged position.

Does a call currency option lead to a perfectly hedged position?

Consider diagram (2.16), which integrates the profile of operating exposure with the risk profile of a currency call option on the pound, which is reproduced in diagram (2.15) for convenience.

Diagram 2.14: Hedging Asymmetric Exposure Using A Forward Contract .



In the previous diagram, note the following:the upward sloping line (K`B) of the call's risk profile forms a 45' angle with the horizontal axis (see Appendix A) and matches with the 45' angle of the downward sloping line (KD) of the profile of operating exposure.This implies that, for exchange rates on the right of $E(e_1)$, the exposure after hedging will be horizontal (that is, any losses in export prices will be exactly offset by gains on the call).The line ELF differs from CK, due to the cost (premium) of the call, given by OA.Thus, the net export price after hedging (i.e actual price + possible gains on call -call premium) is perfectly horizontal, for any exchange rate (EF).This line depicts the exposure after hedging.Thus, it can be inferred that a currency option can effectively hedge the type of asymmetric operating exposure depicted in diagram (2.6).Since export business can be seen as a real option written by the firm, the exposure generated by this real option can be optimally hedged only by another (here, currency) option[16].

Diagram 2.15.The Risk Profile Of A Long Call

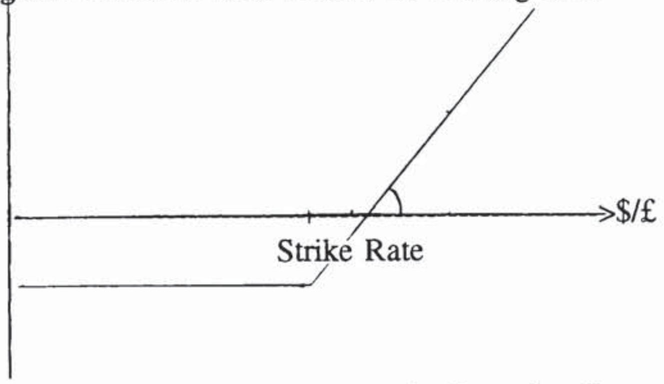
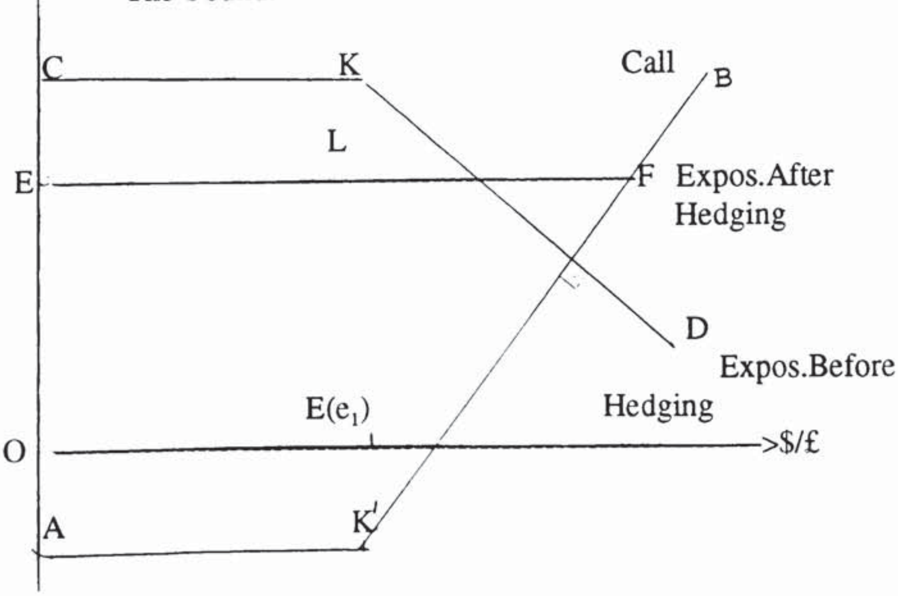


Diagram 2.16.Hedging Asymmetric Operating Exposure Using A Long Call Option On The Pound.



Finally, the extensions of the model, regarding different levels of production technology efficiency and different attitudes towards market shares, have their implications on the currency option hedging strategy to be adopted.Chapter 4 analyses these issues and illustrates how several currency options strategies can match several operating exposure profiles, regardless of how complicated the latter may be.It will be illustrated in chapter 4, that the choice of a currency option hedging strategy is based on the level of competition, relative cost efficiency of international producers and their corporate objectives.

2.5. Conclusion

After introducing the concept of exchange rate pass through and reviewing some of the work on the issue, we provided a model of operating exposure.The concept of exchange rate pass through was meant to provide a step towards the development of the model.

The basic assumptions of the model were the existence of international competition (which stems from the globalisation of international markets) and the importance of future market share in firms' pricing decisions (which is indicated by some tentative evidence discussed here). Adopting the price leadership model, we reached the conclusion, that operating exposure can be depicted in a diagram (with the horizontal axis representing exchange rates and the vertical, real export prices), which is similar to that of a written call option.In fact, it was argued that export business is a real option, given to overseas customers for free, if the exporting firm has a market share expansion objective.This result establishes the hypothesis (which is one of the hypotheses proposed by this work), that operating exposure is asymmetric. Generally speaking, there are two forms of this hypothesis:the 'strong 'form and the 'weak' form.

On the basis of these theoretical results, it was argued that the best hedge against asymmetric exposure is a currency call option.The theoretical and empirical discussion on hedging exposure is provided in chapters 4 through to 7.In chapter 3, we provide some empirical evidence on the hypothesis of asymmetric exposure.

NOTES

1.Two early models which examine the effects of exchange rates on import/export prices are the 'Law Of One Price' and the 'Elasticity Approach' (outlined in chapter 1).See Dornbusch (1987) and Kravis and Lipsey (1978).

2.These models have been used to explain the phenomenon of 'pricing to market'.This phenomenon reflects the observed inflexibility of US import prices due to the dollar appreciations over the first half of the 1980's, in comparison to import prices in other markets.This phenomenon gave raise in arbitrage opportunities.See Krugman (1986),Dohner (1984) and Froot and Klemberer (1989).

3.For a general equilibrium exchange rate pass through model which establishes a link between exchange rates, import prices and the Trade Balance, see Murphy (1989).

4.This can be valid, if we are prepared to assume that the LOP does not hold.See Flood (1986) for a brief review of the major empirical studies on the empirical validity of the LOP.

5.The practical relevance of dual currency price list is highlighted by an article in the 'Treasurer' (February, 1987).
Further, it should be mentioned that the currency (-ies) in which price lists are denominated is (are) different from the currency of invoicing of international transactions. The latter is linked to transaction exposure and arises due to the existence of credit period. If we have a dual currency price list and no credit period, then the issue of the currency of invoice is muted. To illustrate this, consider the following example:

Price list: £10 or $20.
Actual exchange rate : £1=$1.8.
Price faced by USA customers: £10 or $18.

If no credit period is awarded, then it does not matter whether the invoice is in dollars or in pounds (since payment is due immediately at the above rate). If now, credit period is awarded then the decision on the currency of invoice depends on the function of profits of the exporting firm [see Giovannini (1988)].

6.Several reasons can be provided to justify a market share expansion objective.Froot and Klemberer (1989) provide a list of such reasons.Briefly, as soon as a customer base is established, the following reasons may prevent customers from changing between brands: a. switching from one brand may be costly,b.network externalities which give incentives to purchase products which other customers have purchased previously and c.personal sales relationships in industrial transactions.

7.Over the first half of the 1980's, the pound depreciation was largely due to the dollar appreciation vsv the main currencies. Such a dollar behaviour could have been expected on the basis of the political and economic developments in the USA at the beginning of the 1980's.The political situation in the USA was highly improved in the early 1980's as a new president was elected, who was committed to cutting taxes and inflation rates [Shapiro, (1989), pg 45-47)]. The economic developments featured high rates of growth indicating a prosperous and healthy American economy.All these developments could have triggered in the early 1980's, expectations that the dollar would appreciate in the then forceable future.Fisher (1989 b) states that expectations changed in 1985 with regards to the dollar behaviour.

8.According to a NEDO Report (1977), the firm's reaction to a real currency depreciation can only hardly be predicted.This report states that the firms' reaction may be influenced by judgmental factors involving the interaction between short term profit margins and long term market shares.This interaction is of considerable interest to capital markets,as market values are determined by both current profits and future growth opportunities.See Brealey and Myers (1988).

9.The line CA' in diagram (2.6) forms a 90' angle with the dichotomy of O^. Its slope is -1.

10.For the concept of real options, see chapter 4,section 4.3.

11.In the financial literature, writing financial options always results in unlimited losses.See Brealey and Myers (1988) and Copeland and Weston (1988).

12.For a detailed analysis of the terminology and risk profiles of currency options, see Appendix A. For currency option pricing, see chapter 5.See also, Copeland and Weston (1988), Tucker (1991), Cox and Rubinstein (1985) and Fitzgerald (1987).

13.See Dohner (1984) and Krugman (1986).

14.For a brief introductory analysis on forward (or Futures) contracts, see Appendix A.See also Copeland and Weston (1988) and Tucker (1991).

15.Section 7.2 examines the question of operating exposure if a portion of costs is expressed in a third currency and no hedging is undertaken.

16.Geoff Waren of Midland Bank's financial engineering group, argued that exposure which arises from a dual currency price list can only be hedged using a currency option.

CHAPTER 3

AN EMPIRICAL EXAMINATION OF THE MODEL OF OPERATING EXPOSURE

3.1.Introduction

In the second chapter, the hypothesis was established, that under the assumptions of international competition and a market share expansion objective by the exporting firm, the operating exposure that this firm faces is asymmetric.The degree of the asymmetry depends on such factors as the level of competition in the industry, the relative production technologies of producers and the firm's corporate goals.

In this chapter, some empirical evidence is presented supporting this hypothesis.The focus is on the prices of a number of commodities exported from the UK to the USA, over the 1980's.The effects of exchange rates on these prices are examined,looking for the empirical validity of diagrams (2.6) and/or (2.11) of chapter 2.

Discussion in this chapter concentrates on the statistical model,the sample of commodities chosen and the type of data on export prices and cost indices available. Methodological points which can be relatively critical for the whole analysis are indicated.The discussion also covers the economic interpretation of the statistical results, on the basis of information regarding the level of competition in the industry of each of the commodities considered.

3.2.Hypotheses To Be Tested.

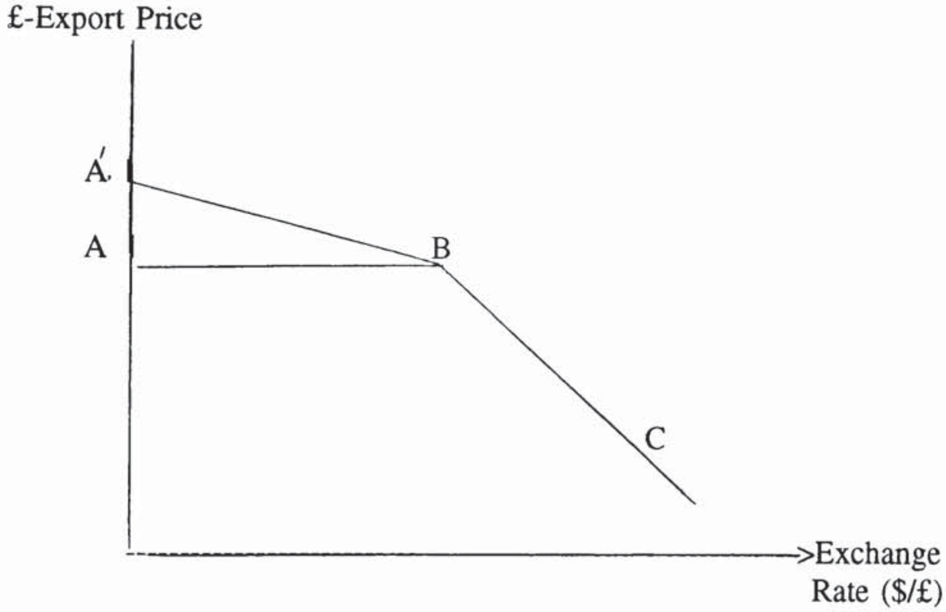
Below, we formally outline the hypotheses to be tested in this chapter:

1.When the pound appreciates vsv the dollar in real terms, the pound denominated real export price follows a downward sloping line,indicating that operating exposure exists.

2.When the pound depreciates, the positive effect of exchange rate on export prices is either zero (strong form of the 'asymmetry' hypothesis), or at least lower than the negative effect on the export price of a pound appreciation (weak form of the asymmetry hypothesis).

Diagrammatically, these hypotheses are summarised by diagram (3.1), which reproduces here diagrams (2.6) and (2.11).

Diagram 3.1:The Strong And Weak Form Of Asymmetry Hypothesis Of Operating Exposure.



The first hypothesis addresses the question of a negative slope, for the part of the profile given by BC.The second hypothesis examines the question of a horizontal line, given by AB (strong form of asymmetry hypothesis) or of a partially sloped line, given by A'B (weak form of asymmetry hypothesis).

These hypotheses will be empirically tested. over the period from the third quarter of 1980 (1980/III) through to the fourth quarter of 1988 (1988/IV).As indicated by diagram (1.2) in chapter 1, there were significant real exchange rate changes over this period, which must have given rise to the problem of operating exposure. Further. this period offers a good opportunity to test the asymmetric behaviour of export prices, between a period of long term pound depreciation and a period of long term pound appreciation.In fact, there was long term depreciation of the pound over the first half of the 1980's (1980/III to 1985/I), followed by long term pound appreciation (1985/II to 1988/IV).

3.3.The Statistical Model.

On the basis of the theoretical results of chapter 2, one could consider the export price as a random variable, dependent upon the actual exchange rate.Therefore, a probabilistic measure of the effect of the latter on export prices is needed.Such a measure could be the ordinary least squares coefficient given by:

$$\hat{b} = \frac{\text{Cov}\ (Y, X)}{\text{Var}\ (X)} \qquad (3.1)$$

This approach assumes the adoption of the regression model[1] given w (3.2).

$$Y_t = b_0 + b_1 * X_t + u_t. \qquad (3.2)$$

where

Y_t :export price at period t,

X_t :exchange rate at period t,

b_0 and b_1:coefficients to be estimated,

u_t :a disturbance term.

[For a description of the data which enter the model, see section (3.6)].

The usefulness of regression analysis, in measuring the effects of exchange rate changes on a firm's operating (or generally macroeconomic) exposure. is indicated by an article in Euromoney Corporate Finance (March, 1989).

The significant element, that the regression methodology brings into the measurement of the exchange rate effects on export prices, is that it segregates the exchange rate risk from the remaining business risk arising due to inflation factors, income changes and industry structure.For the purpose of the statistical analysis here, these factors will be captured by the disturbance term.

The model given in (3.2) is a first step towards developing a model to enable us to test the two hypotheses outlined in section (3.2).This model can be used to test the operating exposure hypothesis. It can not be used,though, to test the asymmetry hypothesis.To perform this test, we have to segregate the effects of exchange rates on export prices when the pound appreciates, from the effects of exchange rates when the pound depreciates.The latter implies that we have to divide the testing period into two subperiods, one for the (long term) pound depreciation and one for the (long term) pound appreciation.

Such a separation can be established by including a dummy variable into the model (3.2).We define the dummy as follows:

$$D = \begin{cases} \to 1, & \text{if £ depreciates (in the long run)} \\ \to 0, & \text{if £ appreciates (in the long run).} \end{cases}$$

The next question is whether this dummy should be a slope dummy or a constant term dummy.As we are looking for a differential effect of exchange rates on export prices, one can conclude that the dummy should allow for different slopes. Therefore, model (3.2) with the inclusion of the above slope dummy becomes :

$$Y_t = b_0 + b_1 * X_t + b_2 * (X_t * D) + w_t. \qquad (3.3)$$

where:

w_t :the disturbance (error) term,

Y_t, X_t, b_0, b_1 :as in (3.2),

b_2 :coefficient to be estimated,

D: the dummy.

From (3.3), we get the following:

- if the pound depreciates, the relevant statistical model becomes:

$$Y_t = b_0 + (b_1 + b_2) * X_t + w_t \qquad (3.4)$$

-if the pound appreciates, the relevant model becomes:

$$Y_t = b_0 + b_1 * X_t + w_t. \qquad (3.5)$$

From (3.4) and (3.5), one can see that the asymmetry hypothesis is captured by b_2.In essence, this parameter captures the difference between the export price change when the pound depreciates and the export price change when the pound appreciates.

Before stating the a priori assumptions about the coefficients of the model (3.3), it is worth formally commenting on the implications of using a regression methodology to estimate the exchange rate effects on export prices.It follows from (3.4) that:

$$Var (Y) = (b_1 +b_2)^2 * Var (X) + Var (w) \qquad (3.6)$$

where

Var (A) :the variance of A, A=X, Y.

The regression line helps us segregate the exchange rate risk element of export pricing from the business risk element (captured by the variability of the error term).Exchange rate operating exposure focuses on the first component of the overall variability of export prices.Furthermore, any hedging strategies against operating exposure will aim towards removing (eliminating) the effects of Var (X) on export prices.It can be seen though, that after the hedging of operating exposure, some export price variability will exist, due to the variability of the error term (which reflects such factors as income changes, booms and recessions, etc). Therefore, exchange rate hedging does not remove the overall variability of real export prices.

The a priori expectations, in statistical terms, are as follows:

1.The sign of b_1 should be negative and its t-ratio higher than 2 (for a 95% level of statistical significance).Such an expectation establishes the existence of operating exposure [indicating the empirical validity of the downward sloping line in diagram (3.1)].If the t-ratio is lower than 2, then one could argue that the export price is statistically insensitive to appreciations of the pound.This denotes a relative ability of the exporting firm to pass through this appreciation on to overseas customers, and thus 'hedge' its operating exposure.

2.The sign of b_2 should be positive and its t-ratio higher than 2.The latter establishes the empirical validity of the asymmetry hypothesis.Alternatively, if b_2 is not statistically significant, one can argue that the negative effect of a pound appreciation on export prices is the same as the positive effect of a pound depreciation.In fact, the t-ratio of b_2 tests for the asymmetry hypothesis,without enabling us to say whether this asymmetry is of weak or strong type.

3.When the pound depreciates (and thus, the relevant model is (3.4)],the sum of b_1 and b_2 $(b_1 + b_2)$ enables us to test for the strong form of the asymmetry hypothesis.If this sum is close to zero and statistically insignificant (i.e it has a relatively high standard error), then one could accept the strong asymmetry hypothesis.The standard error of the sum of b_1 and b_2 (b_1+b_2) can be found using the relationship (3.7).

$$Var\ (b_1 + b_2) = Var\ (b_1) + Var\ (b_2) +/- 2 * Cov\ (b_1, b_2). \tag{3.7}$$

where:

Cov (b_1, b_2) the covariance between b_1 and b_2.

The parameters which enter (3.7) can be found from the variance-covariance matrix[2].

The higher the proportion of the exchange rate risk to the overall business risk (and thus, the higher the significance of exchange rate changes in the determination of export prices compared to demand and local cost changes), the higher the R^2 of the regression, and vice versa.

Finally, a beta factor, to allow for income changes in the USA, was ruled out for two reasons.First, we lose one degree of freedom, which may be valuable, especially here, where we have a small number of observations [see section (3.4.2)].Second,we are not interested in obtaining 'accurate' estimations of b_1 and b_2 (to which the inclusion of this beta may contribute).We are rather interested in their t-ratios, because these are the criteria of accepting or rejecting the theoretical arguments of chapter 2.

3.4. Data

3.4.1. Export Prices.

The ideal databank would involve firm-based data on export profit margins, since the analysis is microeconomic in nature.We require data on actual export prices and (actual) costs, for several commodities exported from the UK to the USA.Thus, the data should be bilateral (referring specifically to UK exports to the USA) and not multilateral (referring to the whole UK exports regardless of destination).This imposes a restriction on the available sources of potential data, as export prices may differ across different destinations.Further,export prices should be the transaction prices charged by the UK producers to USA importers, excluding tariffs, costs of transportation and other top-up fees.

One solution would be to focus on actual case studies and examine the problem of operating exposure of a specific firm which exports to the USA market.The drawback of this solution is the requirement of focusing on very specific, firm-based conditions, faced by only the firm in question.These conditions, further, could obscure the essence of the problem of operating exposure, forcing one to deal with a variety of other problems which may be possibly linked to operating exposure. For example, a firm may have a well diversified network of international operations,where the export pricing of one operation may be determined not by exchange rates, but by another possible strategic goal of the whole group of operations. Therefore, focusing on a case study may not be compatible with the task of this work, which is to theoretically describe operating exposure and propose hedging solutions. Further, Davis et.al (1991) provide some criticism against the validity of case study research, regarding the degree to which results can be generalised.

An alternative route of collecting data on export prices is to resort to published (industry or commodity based) data. Ideally, these prices should refer to highly disaggregated data, in order to avoid aggregation problems which arise from adopting a specific weighting pattern required when constructing aggregate prices.Further, we need data spanning a relatively long period, giving a sufficient number of observations (and thus, degrees of freedom) to enable statistical inferences of the regression results.

The first option would be to use data from the 'Monthly Review Of External Statistics'.However, this source was ruled out for the following reasons:

a.Export prices provided by this publication refer to groups of commodities, and thus the criterion of disaggregation is violated.

b.Export prices are not on a bilateral basis.They refer generally to exports of the UK to the world and not specifically to the USA.

The second option is to resort to international trade data which yield unit values.The advantage of this source is that the two previously mentioned criteria are met.Another advantage is that this data is readily available, and provides a variety of disaggregated commodities to choose from.

Unit values of international trade statistics can be obtained from two alternative sources:

1.The UK's Overseas Trade Statistics (OTS), published by the HM Central Statistical Office.

2.USA Foreign Trade Statistics, available in the Foreign Trade (FT) 135 publication of the USA Department of Commerce.

There are two differences in the data which can be obtained from these sources:

1.The data from the UK publication is expressed in pounds, whereas the USA data is in dollars, and should be translated into pounds (since we want pound denominated export prices).

2.The data from the USA source refers to more disaggregated commodities than the UK publication.The UK data refers to commodities classified under a two-digit scheme, whereas the USA data is classified according to a four-digit scheme.The latter is a significant reason for one to adopt the USA source to derive export unit values.

Unit values derived from the USA trade statistics are referred to as 'transaction' unit values.As mentioned in the guidelines of the FT 135 publication, the value of the USA imports is defined as the price actually paid or payable for merchandise when sold for exportation to the USA, excluding USA import duties, freight, insurance and other charges incurred in bringing the merchandise into the USA market.Therefore, one could argue that the criterion of having 'transaction' prices is met as well.On the basis of the above, the USA trade statistics source was used to derive unit values to be used as export prices.

Unit values were derived from the USA international trade statistics, by dividing the dollar costs of imports from the UK with the quantities imported.The resulting dollar unit value was then translated into pounds, using the average spot rate between the pound and the dollar, which prevailed over each period.

Using unit values as export prices, however, does entail some problems.Kravis and Lipsey (1971) provide a discussion of the major shortcomings of unit values[3].

An important problem attached to unit values is the measurement errors, which may arise as a result of the divergence of the statistical month of international transactions and the month of reporting the transaction, dock strikes, etc.

Furthermore, for some commodities, quantities exported are not reported, and thus unit values can not be derived.For other commodities, significant discontinuities in reporting transaction data exist, and again, unit values can not be derived.All these problems reduce the sample of commodities for which data can be collected and unit values derived.

Kravis and Lipsey (1971) mention another drawback of unit values, namely the failure to capture changes in quality of commodities traded.The significance of this problem, though, may be abated by the fact that such changes in quality (possibly due to furtherance of production technology) are captured by the revisions of the industrial classification of commodities.The USA source of international trade data keeps the industrial classification constant over the 1980-88 period.On the contrary, the UK source revised its method of classifying commodities in 1988, creating problems in matching different classifications for before and after this year.

Now, having decided on the source of (industry or commodity based) data for export prices, the next methodological question is whether one can make any inferences out of this type of data, regarding the existence of operating exposure for a specific firm which participates in the specific industry or trades the specific commodity.

First, as a unit value is a (sort of an average) commodity based data (and not specific firm based data), one could argue that a particular firm exporting this commodity may charge another price than the one indicated by this 'average'.However, the more disaggregated the commodity groupings, the more homogeneous the commodities included in these groupings , and the less scope for firms, which trade these commodities, to charge a different price from the industry average.This implies that for highly disaggregated commodities, these 'average' export prices approximate firm-specific prices, and thus depict the problem of operating exposure relatively well.

Second, as indicated above, the problem of the overall operating exposure of a firm requires the examination of the whole network of its overseas operations.The approach taken here focuses on a specific operation's exposure.In concluding about the overall operating exposure of a multi-operational firm, one should examine the individual exposure for each of individual business,to see whether any offsetting effects arise.For example, as reported by the Annual Report of BP for 1988, the firm expected to have a reduced profit margin from its crude oil operations, which could be partially offset by a 'good' margin in its chemical business.Thus, profit margin (and thus, operating exposure) hedging is achieved on the grounds of having a portfolio of operations.Similarly, there are many examples of cars manufacturers being engaged in extensive operations :Fiat, for example, has interests in excavators, General Motors in electronics, financial services etc. Therefore, if we find that operating exposure exists for a specific commodity, we can not necessarily infer that any (multi-operational) firm. which is (partially) involved in trading that specific commodity, faces exposure.

Other firms may be exporting the same product in many overseas markets.The problem of (a positive) operating exposure, that a firm may face in one market then, may be offset by a negative exposure in another market.For example, a UK firm with exports in both the USA and ,say, Germany, may have a competitive disadvantage if the pound appreciates vsv the dollar, and an offsetting competitive advantage if the pound depreciates vsv the DM. This example assumes that in the German market, the UK firm faces competition from German producers.

The conclusion for this section is that one can not infer from commodity based price data about the existence and relevance of operating exposure for firms with a variety of operations and/or overseas markets available.However, examining operating exposure for each operation in each market follows the same procedure as the one followed here.

3.4.2. Commodities To Be Considered.

One conclusion of chapter 2 was that operating exposure may be asymmetric for relatively homogeneous goods, for which strong competition exists and a market share objective is important. Therefore, a first criterion of choosing commodities, to examine the empirical validity of the above hypothesis, would be the a priori homogeneity of a number of goods (although it is hard to define exact rules regarding homogeneity).Second, the commodities to be included in the sample should have been exported from the UK to the USA on a permanent basis throughout the 1980's, implying that export operations are well established, reflect an important part of the firm's business and thus,export pricing attracts a considerable amount of attention.Further, exporting on a permanent basis ensures the collection of a relatively sufficient number of observations, to enable statistical inference of the results.

After an initial inspection on the commodities which could be included in the sample, and on the basis of the previous criteria, initially it was decided to focus on the following goods: (in parentheses are the numbers of their industrial classification,according to the American publication).

1.Cocoa sweetened (073.0040)

2.Cigarettes (122.2000)

3.Tea crude or prepared (074.0020)

4.Calf and Upper Leather (611.3010 and 611.3025)

5.Athletic Leather Shoes (851.0242)

6.Wool in grease or washed (268.1025, 268.1035, 268.1045, 268.1050, 268.1080)

7.Crude Petroleum (Under 25 degrees) (333.0020)

8.Nickel Waste and scrap (288.2000)

9.Articles Of Copper (699.8100)

10.Articles of Tin (699.8600)

11.Office Copying Machines (751.8260)

12.Passenger cars (781.0010)

13.Radio Receivers (762.0042,762.0046)

14.Televisions coloured (761.0060)

15.Food blenders and mixers (775.7320)

16.Aircraft (792.8000).

However several problems, ranging from discontinuities (for televisions, radio receivers, food blenders, aircraft and cigarettes) to high variability (tea and most metals).

in the reported data, altered the focus to the following goods:

1.Cocoa sweetened.

2.Calf and Upper Leather.

3.Wool in grease or washed.

4.Crude Petroleum.

5.Nickel Waste and Scrap

6.Articles of Copper.

7.Articles of Tin.

8.Athletic Leather shoes.

9.Passenger Cars

10.Office Copying Machines

The above sample of goods includes relatively homogeneous (cocoa, leather, wool, petroleum, nickel,tin, copper and athletic leather shoes) and relatively less homogeneous commodities (cars and copying machines).

Unit values for the above goods were collected on a quarterly basis over the period from 1980/III through to 1988/IV, yielding 34 observations. To eliminate the pound dimension of these values, they were transformed into relative terms, by dividing each observation by the unit value which prevailed over the first quarter of the period in question (1980/III).Thus, unit values are expressed in an index form.

3.4.3. Costs.

To allow for the production cost effects on export prices (and thus, to express these prices in real terms), the unit values were divided by the Labour cost index, derived from several tapes of International Financial Statistics.This cost index measures the change in the average earnings in all industries in the UK and is considered. as more representative than the index which captures the costs of inputs and materials used by the manufacturing industry.(The latter index can be found in the publication 'Economic Trends').As these materials can be diversified across industries, this index may turn out to be a poor proxy of production cost changes for some of the commodities to be examined.Instead, the labour cost index was preferred.

Dividing the unit values expressed in an index form by the index of labour costs. an index of real export prices which capture the fluctuations of profit margins is obtained.This is the final form of export prices to enter the left hand side of the regression model given by relationship (3.4).

3.4.4 Exchange Rates.

Data on exchange rates should involve real exchange rates. As indicated, however, in diagram (1.2) in chapter 1, nominal and real exchange rates were quite similar over the period in question.This was because the inflation rate proxy (Consumer Price Index), used to calculate real exchange rates, was approximately the same in both the UK and the USA over the period in question. Therefore, nominal exchange rates can be used as proxies of real exchange rates.

Data on nominal exchange rates was expressed in units of foreign currency ($) per unit of domestic currency (£).This data is collected on a quarterly basis. Period averages are derived from tapes of International Financial Statistics and transformed into index form,by dividing each quarter's exchange rate by the rate of the first quarter (1980/III).

Finally. a comment is made on the use of the dummy variable in the model given by (3.4).As mentioned earlier. the overall testing period is divided into a period of a (long term) pound depreciation and a period of (long term) pound appreciation.The turning point is the first quarter of 1985. This is in line with Fisher (1989 b), who argues that expectations regarding the dollar (and subsequently, regarding the dollar/pound rate), changed in 1985. However, during the first subperiod of the pound depreciation, there were some discrete pound appreciations vsv the dollar [see diagram (1.2) in chapter 1], compared to the exchange rate of the previous period.Similarly, during the second subperiod of the long term appreciation, there were some discrete depreciations.In terms of using the dummy, however, these instances of exchange rate overshooting from the general trend are ignored, assuming that long term expectations can not be altered by discrete periods, over which the exchange rate does not move as expected. Furthermore, these can be ignored, as we want to estimate the average effect of an appreciated (depreciated) exchange rate, during specific periods on export prices.

3.5.Estimation.

The model given by (3.4) was estimated using the Ordinary Least Squares (OLS) method.

Testing and correcting for autocorrelation was considered.Possible reasons which could have contributed to autocorrelation are[4]:

a.Measurement errors in the dependent variable (export prices), which are captured by the error term.

b.Mispecification of the 'real' error term.This is the case, when a significant (long term) exchange rate change can induce changes in the market structure, influencing the way in which export prices are determined.For example, a significant long term pound depreciation,over the first half of the 1980's, could have caused some UK firms to expand their selling operations in the USA market.This might imply that the level of competition could have increased, creating a downward pressure on export prices[5].

Testing and correcting for autocorrelation in residuals was carried out using the method described by Johnston (1972), in pages 263-264.For the corrected model, residual analysis was carried out for some selected commodities such as cars, wool, chocolate confectionery and petroleum.The residuals were plotted vsv the time and exchange rate, in order to provide a pictorial representation of their behaviour. For all of the above commodities, residuals from corrected models appeared to be uncorrelated with each other over time and with the exchange rates.

3.6. Results

Tables (3.1) and (3.2) contain the results from estimating the model (3.4) for the commodities previously outlined.Table (3.1) reports the regression results for those commodities which appear to be subject to operating exposure. Table (3.2) reports the results of those commodities for which the hypothesis of operating exposure is rejected.As stated previously, the criterion for arguing whether a commodity is subject to operating exposure is the statistical significance of (a negative) b_1.These tables report the estimates of the coefficients in model (3.4), the coefficient of determination corrected for the degrees of freedom,R^2 corr.,the D.W. statistic of the corrected model, the estimation of the coefficient of autocorrelated residuals (for those cases where autocorrelation was traced),rho, and thedegrees of freedom for the corrected model,D.F.

For those commodities for which operating exposure was traced,the asymmetry hypothesis was tested.The criterion for testing this hypothesis is the statistical significance of b_2.

On the basis of the results in tables (3.1) and (3.2), it appears that the following exported commodities from the UK to the USA, were subject to operating exposure:athletic leather shoes, calf and upper leather, wool, petroleum, articles of tin,chocolate confectionery, cars, nickel waste and scrap, and office copying machines.On the contrary, operating exposure does not appear to have affected the export price of copper articles. The asymmetry hypothesis can be accepted for the following commodities:athletic leather shoes, wool,articles of tin, petroleum, cocoa sweetened, cars and office machines.The strong form of the asymmetry hypothesis is accepted for the following commodities:wool ,petroleum and articles of tin.

Autocorrelation was traced in 7 out of 10 regressions.

The first question to address is why the export price of copper does not appear to have decreased, when the pound appreciated vsv the dollar. A second question raises the issue of why leather and nickel do not follow the asymmetry hypothesis.One could shed some light on these issues by focusing on the market conditions of each of the above commodities, and attempting to comparatively assess the level of competition in each industry and the production efficiency of major competitors to the UK exporting firms.

Before focusing on these issues, however, it would be worth commenting on the statistical measures given in tables (3.1) and (3.2).

Some comments must be made about the R^2 corr. For a number of these regressions, the coefficients of determination were relatively low. The most plausible explanations are listed below:

a.Operating exposure may arise in currencies other than the dollar. For some commodities (cars, for example), UK exporters compete in the USA market with both USA and Japanese based firms, and thus, face an operating exposure in dollars and Yen.

respectively.Using only the dollar exchange rate may entail relative failure to explain the full extent of export price variability, indicating low R^2s.However, the inclusion of a second exchange rate in the model given by (3.4) could create multicollinearity. to the extent that these two rates fluctuate together.

b.Low R^2s may be explained by the relative dominance of business risks over the exchange rate risk, implying that export prices are mainly affected by booms and/or recessions, and not by exchange rates.

c.The model given by (3.3) ignores the empirical consequences of the small/large country effect on export prices [see chapter 1, section (1.6.2).This argument implies that a pound appreciation (dollar depreciation) may cause a higher proportion of USA domestic production to be exported to the UK.Assuming that the USA is a 'small' producer, this may cause a relative scarcity of the product in the USA, pushing domestic (USA) prices, and thus, export prices, up.In this case, the decrease of the pound export price will be relatively small, compared to what chapter 2 [diagram (2.6)] predicts.

It should be emphasised, however, that our target is not to obtain high R^2 regressions, but rather to test the empirical validity of specific hypotheses.This implies that we are especially interested in the t-ratios of the estimated coefficients.

We turn now to examine the market conditions of each of the commodities which appeared in tables (3.1) and (3.2), in order to provide some economic explanations to these statistical findings.

Nickel: As extracted from several tapes of the Economist's Intelligence Unit, the major nickel producers in the world are the Canadian company INCO, the USA based HANNA, SLN, AMAX and Western Mining and the Greek company Larco.

TABLE 3.1.

COMMODITIES APPEARED TO BE SUBJECT TO OPERATING EXPOSURE

Commodities	b_1	b_2	(b_1+b_2)	R^2	D.W.	RHO	D.F
Athletic Leather Shoes	-1.16* (-5.2)	0.2* (2.0)	-1.14 (4.8)	.44	1.7	.14	30
Calf And Upper Leather	-0.8* (-2.6)	-0.1 (-1.1)	-0.9* (-3.2)	.25	1.62	.13	30
Wool	-0.33* (-2.9)	0.27* (6.7)	-0.06 (-0.6)	.57	1.65	---	31
Petroleum	-1.1* (-2.8)	0.62 (4.6)	-0.48 (-1.2)	.50	1.64	.35	29
Cocoa Sweetened	-0.94* (-5.7)	0.58* (10.6)	-0.36* (-2.3)	.76	1.90	---	31
Cars	-2.2* (-5.5)	0.55* (4.1)	-1.65* (-4.8)	.49	1.52	---	31
Nickel Waste And Scrap	-1.9* (-3.0)	0.1 (0.6)	-1.8* (-2.8)	.21	1.67	.45	28
Copying Machines	-1.55* (-4.2)	0.5* (4.1)	-1.05* (-3.0)	.40	1.77	---	31
Articles Of Tin	-0.34* (-2.0)	0.14* (2.6)	-0.2 (-1.3)	.16	1.80	.25	30

Note: For explanations of symbols, see Table (3.2).

TABLE 3.2.
COMMODITIES APPEARED NOT TO BE SUBJECT TO OPERATING EXPOSURE.

Commodities	b_1	b_2	(b_1+b_2)	R^2	D.W.	RHO	D.F
Articles Of Copper	-0.77 (-1.3)	0.85^* (2.88)		.17	1.6	.5	30

Notes: t-statistics in parentheses.
*: statistically significant (a=95%).
D.W.:Durbin-Watson statistic (The Upper limit at 5%, for D.F=28, 29, 30, 31 is 1.56, 1.56, 1.57 and 1.58 respectively).
D.F.:Degrees of freedom.
Rho :The coefficient of autocorrelation in residuals.

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Holding about 36% of western world production, INCO appears to be the largest nickel producer in the world, and in fact, is the market leader.

INCO has established operations in the UK (one in Wales and one in London), and since it is the main nickel producer, the export unit values derived from international trade data may reflect the operating exposure faced by the market leader. Thus, the problem of operating exposure which appears to have been faced by UK nickel exporters to the USA may be, in fact, the operating exposure faced by a market leader. Being a market leader may imply that a future market expansion objective may not be so important in terms of affecting export pricing.Thus, when the pound depreciates, INCO may not be interested in keeping its pound prices fixed in order to gain new customers.As extracted from the firm's 1989 annual report, its business strategy for future expansion is based on investing in the established operations, to develop new,high value-added diversified products. The emphasis. therefore, for future expansion appears to be given in the supply side and not in the demand side by strategic pricing.As mentioned by several tapes of the

Economist's Intelligence Unit, INCO is the initiator of strategy within the industry.whilst other firms follow its lead. Further, it is reported in the publications mentioned, that over the first half of the 1980's, when the USA economy was in recession, INCO preferred to cut its production instead of cutting prices. These points can justify. in economic terms. the statistical findings regarding the rejection of the asymmetry hypothesis.

Over the second part of the decade, INCO's position was affected by the appreciating exchange rate, since its major competitors are USA based.Its competitors (the USA based HANNA and others) are reported to have cut their prices, whilst INCO failed to pass the pound appreciation on to the market.Further, the competitive position of the Greek company Larco was reinforced in the market, because of the 1985 devaluation of the Greek Drachma vsv the dollar.This is an example of operating exposure arising in a third currency (drachma), in which the firm in question (INCO) has no transactions. Finally, the latter half of the 1980's was characterised by significant business risk, in the form of massive imports of nickel to the USA from the USSR.This fact depressed prices (and possibly increased competition) below levels attributable to the dollar depreciation vsv the pound.These developments provide an economic reasoning of the statistical acceptance of the hypothesis of operating exposure.

Leather :This is another good for which operating exposure appears to exist, although the asymmetry hypothesis can not be accepted.

As reported in the 1986 and 1988 issues of 'Leather Goods', the leather industry in the UK is basically export oriented, as imports account for a high proportion of domestic sales (96%, in 1989).Export performance, as measured on the basis of revenues, steadily increased from £27.5m in 1983 to £75m in 1989.Exports, as a percentage of the UK sales, increased as well from 48% in 1983 to 85% in 1989.

The leather industry is highly fragmented both in the UK and abroad, and is characterised by small, family run firms with under 20 staff, or even far fewer.Few UK manufacturers have turnovers in excess of £10m and the majority are at £200.000 or below. This restricts the prospects of future growth, as many firms can not afford the purchase of new machinery and technology which could make them more competitive.Thus, on the assumption that a larger market share (future demand) can not be met by increased production, the target of achieving higher penetration in export markets through 'modest' pricing,when the pound depreciates, relatively weakens.[Krugman (1986) provides a theoretical model explaining foreign currency export price stickiness when the local currency depreciates, as a result of insufficient production capacity which prohibits exporting firms to meet increased foreign demand].These arguments may explain why the asymmetry hypothesis is not statistically accepted.

The depreciation of the dollar after 1985, is reported by the previous publications mentioned, to have negatively affected the industry's performance, implying operating exposure.

Articles Of Copper. For this commodity, the operating exposure hypothesis is statistically rejected, although the asymmetry hypothesis is accepted.This is an awkward result.

Before we attempt to evaluate this result, it should be mentioned that as copper is traded in organised metal markets (London Metal Exchange), its international price may be affected by factors which determine the behaviour of capital and money markets such as interest rates, and speculation between stocks, bonds and commodities.In the regression model given by (3.4), these factors are captured by the error term.A relatively low R^2 (17%) indicates that these parameters do play an important role in the determination of copper prices,compared to exchange rate changes.

According to the Economist's Intelligence Unit,the USA copper mining industry collapsed over the first half of the 1980's, due to the real dollar appreciation,rendering it unable to compete with lower cost producers from overseas.This may indicate that, foreign (and thus, UK) producers may have used the dollar appreciation to cut their dollar prices.This could have been achieved, if their domestic currency (i.e £) export prices were relatively fixed, which could explain the acceptance of the asymmetry hypothesis.

The critical question is what happened over the second half of the 1980's, during the dollar depreciation, when operating exposure did not appear to exist for UK copper exporters to the USA.According to the 1988 issue of the American Metals Market, during this period,the international price of copper was highly affected by speculative forces in organised markets and relatively less by the dollar depreciation.There were two factors which created speculative pressures for the metals markets, resulting in 'high' raw copper prices:first, investor's expectations for inflationary pressures made them move their money from stocks and bonds into commodity markets, and secondly, options and futures contracts were initiated in the latter markets, boosting trading.

These developments led to relative increases for the price of raw copper.For copper user firms, this implies higher selling prices of their copper-based products, due to higher costs of purchasing raw copper. If the latter are not captured by the correct cost index, these higher selling prices may falsely appear to yield higher profit margins.If the latter are combined with the pound appreciation over that period, one could reach the (wrong) conclusion that operating exposure does not exist, as UK exporters (falsely) appear to have passed the pound appreciation on to higher selling prices.This conclusion is mistaken, because in estimating the model (3.4) for copper, a cost index was used,which failed to reflect the real cost changes in the industry.Therefore, the problem of operating exposure may have been overlaid by market conditions, which failed to be captured by the general specification of the model given by (3.4).

Articles Of Tin: For this product, both hypotheses are accepted. The largest producer of raw tin is Malaysia, with the USA and UK having roughly the same level of production. Prices of tin are quoted in Malaysian dollars, and on the assumption that UK and USA firms use imported raw tin to produce their output, it is argued that there is no operating exposure for the portion of costs expressed in Malaysian dollars [see, also section (7.2) in chapter 7].

The competition in the industry arises from industries producing materials for food cans and beverage cans.Glass appears to be one of these materials and seems to have high appeal to customers.

Over the first half of the 1980's, the international price of tin was high, due to a strong dollar.During this period, the UK production experienced a significant boost (from 3075 metric tons per annum over the 1976-1980 period to 4300 per annum over the next period).This boost in the UK production could have been caused by reduced prices by the UK producers, due to the pound depreciation.

Over the second half, the price of tin was low, due to a declining dollar.The difference now between the market for tin and that for copper, is that for the former product, trading in organised markets ceased in October 1985, so that the price of tin could not be affected by speculation, as the price of copper was. As a result, since speculation in commodities markets did not distort costs for the case of tin, the regression analysis captured the effects of exchange rates on prices as operating exposure.

Wool: For wool, both the operating exposure and the (strong form of the) asymmetry hypotheses can be statistically accepted.

According to several tapes of the Economist's Intelligence Unit, the business risk in the industry is significant, since demand for clothing and textiles is determined by disposable income, inflation and unemployment.

The UK industry is not especially capital intensive, indicating that labour wages and costs of buying raw wool play an important role for the existence of operating exposure.

The competition in the industry arises from man made fibres, synthetic fibres and cotton.According to the previous sources, the industries of man made fibres, synthetic fibres and cotton have developed and improved their production technology, enabling them to produce a variety of commodities quite similar to those products made of wool.Therefore, the 'heterogeneity' factor of woollen products (which could be seen as a factor that offers relative protection against operating exposure) was significantly reduced.Further, after 1985, these industries could have priced their products relatively cheaper, due to lower petroleum prices.They also followed a strong promotion strategy.

This intense competition together with the recession in the USA economy over the first half of the 1980's, created significant downward pressures on the prices of woollen products.In fact, a 'price-war' is reported to have been broken out in 1983.The International Wool Secretariat admitted in this year, that the wool industry's future depends on gaining customer confidence throughout the world, by targeting promotion to expand market segments.On the basis of the above, one could conclude that a 'modest' pricing policy, during periods of pound depreciation, may have been important for UK exporters.

As a result, the level of competition in the industry can explain why the strong form of the asymmetry hypothesis can be accepted.

Petroleum: This is another commodity for which both the operating exposure and the (strong form of the) asymmetry hypothesis can be accepted.

The industry is made up of a large number of subsidiaries of large holdings and a small number of independent firms.Holdings of American origin are highly represented.The industry is dominated by a handful of major firms of the calibre of BP. Shell, Esso and Texaco.Companies in this field operate in a truly international environment and their operations include both exploration, extraction and refining.

Because of the well documented arguments of future unexploited capacity in the North-Sea, many major firms try to augment their presence there, through acquiring smaller market participants. Competition in the industry is presumed to be severe, in the light of poor performances in terms of profit margins, from 1983 onwards.Overall, profit margins fell from 42% in 1984/5 to 23% in 1986/7.The export ratio deteriorated as well, from 21% in 1985 to 18% in 1988.According to the Business Ratio Report of 1988, an oil price war broke out after 1986.

Operating exposure, faced by UK-based companies,arises because some of their competitors have the majority of their operations outside the UK.For example,Shell (UK) and BP(UK) (both with a significant element of their operations in the North-Sea) face operating exposure in dollars, because one of their main competitor, Texaco, has the majority of its operations outside the UK (although, it possesses some operations in the North-Sea, as well). As extracted from the Annual Reports of Shell for 1987 and 1988, competition in the industry is very intense, with the price of petroleum being partially determined by exchange rates (see the Dow Jones News Service, 23/12/91 and 25/11/91).It is also reported in the previous sources that the UK's oil industry was badly affected by the strong pound over the second half of the 1980's, causing economic distress to UK petroleum exporters. For example, when in 1988, Shell (UK) and BP (UK) suffered a decrease in their profit margins due to the expensive pound,the profit margin of Texaco (with operations in the USA, Germany, Denmark, Africa and Asia) increased.

Therefore, severe international competition and the importance of exchange rates in the determination of petroleum prices may be behind the statistical acceptance of the hypotheses in question.

Office Copying Machines:The operating exposure and the asymmetry hypotheses can be accepted here as well.

It was very difficult to obtain information on the market structure of such a specialised product classification.On the assumption that the major participants in this market play in the more general market of office equipment, some general conclusions could be drawn, regarding the economic plausibility of the above statistical results in the light of the conditions in the latter industry.

The industry of office equipment is dominated by powerful American and Japanese producers with well diversified networks of production.Some of the market participants are:Canon, Minolta, Ricoh, Rank Xerox, Panasonic, Toshiba, NEC, Brother and Sharp.British firms include GEC, British and Commonwealth and Bullogh.

The industry is very competitive and very dynamic.Quite frequently, new products appear in the market,rendering previous models redundant.The previously mentioned foreign firms are reported by the Business Ratio Report for 1988,to play a significant role in the domestic UK market.This implies that these foreign firms can be seen as more efficient than their UK competitors.This may indicate a relative inability of UK firms to compete with American and Japanese firms,causing operating exposure for the UK companies. to both the dollar and the Yen. As market followers, these firms may be forced to cut their prices when the dollar depreciates and thus, suffer losses in profit margins.

Passenger Cars. The operating exposure and the asymmetry hypotheses have been accepted for this (relatively heterogeneous) industry as well.

The UK domestic market is reported to be very competitive, leading to fierce price competition amongst producers who dominate the market.Fifty percent of domestic sales are covered by imports.Ford and Vauxhall dominate the market, with Rover in third place.The latter firm holds almost two thirds of the UK's exports, with Jaguar exporting almost 80% of its output to the USA.As reported by the Harvest database, these producers have established a very competitive environment,which frequently leads them to offer substantial discounts and generous terms of payment, as a means of defending and expanding their presence in the market.

The USA car industry is the second in the world in terms of production,with the first being Japan.The industry in the USA has undergone drastic changes prompted in the early 1980's, with massive investments in new products and new manufacturing technology.These developments in the production technology can be seen as a means of the USA industry coping with adverse exchange rates and/or causing operating exposure to foreign competitors during dollar depreciations.

The car industry in the USA is dominated by Ford, Chrysler, General Motors and AMC.The USA manufacturers hold almost one fourth of the European production and are considered as market leaders along with the Japanese, in terms of growth and investments in furtherance of production technology. (International Automotive Review, 3/1984). These technological developments have contributed significant flexibility in the production process and economies of scale.Further, there is more scope in producing relatively differentiated products to meet specific demands.The more differentiated the products, the higher the ability to pass through adverse exchange rates to the market, and the lower the operating exposure.It was reported by the International Automotive Review (1/1984), that the overall position of European manufacturers is subordinate to the position of USA firms.This situation has led some producers to provide costly price discounts in the USA market, over the first half of the 1980's (International Automotive Review, 1/1985, 4/1985), indicating that some of them may have exploited the dollar appreciation to outprice their USA competitors, fixing their export prices in their own currencies.

Further, the position of some USA firms has been strengthened by joint venture operations with Japanese firms which have moved their operations to the USA.These joint ventures include General Motors with Toyota and Mazda with Ford. Further,Honda, Nissan and Mitsubishi are reported to have established production operations in the USA, increasing the level of competition in the industry.

These explanations indicate that USA producers are generally more competitive than UK producers, and this may be behind the acceptance of the (weak form of the) asymmetry and operating exposure hypotheses.

Chocolate Confectionery. This is another product for which we can accept the previous hypotheses.

The price of cocoa beans is expressed in dollars. As the cost of buying cocoa beans is expected to be expressed in dollars for both UK and USA firms,it can be concluded that international competitors face no operating exposure for the proportion of costs denominated in this common currency. [See section (7.2) in chapter 7].

The major players in the international market of chocolate confectionery are the Swiss-based Nestle, the USA-based Mars, the USA-based Nabisco and the UK company Cadbury.This oligopolistic market structure has resulted following acquisitions of smaller firms by those mentioned above.As mentioned by the Harvest database, these acquisitions resulted in intensified competition, which sometimes is especially fierce for milk chocolate.Battles for higher market shares are fierce (especially regarding the positions of Kit-Kat and Mars bars).

Cadbury's chocolate output is exported to the USA and produced in the UK (incurring pound denominated labour costs).It holds about 8% of the USA market share.It competes with three firms considered to be market leaders, each with significant production operations all around the world, offering them flexibility to avoid adverse exchange rate movements.Nabisco, for example, has about 260 factories in about 40 countries, holding a well diversified portfolio of operations ranging from food to tobacco.Nestle has also established a strong production position with about 400 factories in 66 countries.Despite, however, its powerful network of production locations, Nestle appeared to offer price discounts during the period of the dollar depreciation vsv the Swiss Franc, in order to cope with the competition from USA based firms.

Cadbury's products have to compete in a fiercely competitive environment, which can account for the acceptance of the previous hypotheses.

3.7.Conclusion

The purpose of this chapter was to provide some empirical evidence of the theoretical hypotheses established in chapter 2.

To provide such evidence requires that one should deal with significant data collection problems, regarding export prices and cost indices of specific firms.Such data is not available.The remaining solutions are second best options, with some significant shortcomings which were commented upon earlier. Dornbusch (1987) and Fisher (1989) admit that the considerable low number of empirical studies on exchange rate pass through may be due to the lack of relevant data. Therefore,developing more accurate data on export prices may be an area open for future research.

Despite the problems with the data, the operating exposure hypothesis was accepted for 9 out of the 10 commodities examined. The asymmetry hypothesis was accepted for 7 of these 9, and the strong form of this hypothesis for 3 of these 7. In general terms, these empirical findings appear to comply with the theoretical arguments of chapter 2 and diagrams (2.6) and (2.11).

The empirical findings of this chapter will be used in chapter 6, after having outlined how we can hedge operating exposure using currency options (chapter 4).In this chapter, we will examine the empirical performance of a hedging scenario based on currency options, in terms of eliminating the downward sloping line depicted in diagram (3.1) and empirically established here.To pursue this task, the benefits of hedging will be incorporated into the export prices derived here, to see whether the new (hedged) 'export prices' (i.e. 'original' export prices plus hedging gain) follow the downward sloping line that the 'original' price follows.

NOTES

1.The statistical assumptions of this model are as follows:
a. u ~ N (0, c^2), c^2 constant.
b. b_0, b_1 and b_2 are coefficients to be estimated.
c. The residuals are not autocorrelated.
d. The explanatory variable (exchange rates) is independent of the error term.
e.The explanatory variable is measured without error.
See Koutsoyiannis (1973).

2.See Johnston (1972),

3.Despite the data problems, previous studies on the exchange rate pass through used unit values as proxies for export/import prices.See Giovannini (1988), Feenstra (1989), Mann (1986) and Kim (1990).

4.See Johnston (1972) and Koutsoyiannis (1973).

5.See Baldwin (1989).

CHAPTER 4

HEDGING EXCHANGE RATE OPERATING EXPOSURE

4.1.Introduction

In the previous chapter, the hypothesis was established that, the export business can be perceived as a real option, and that its value depends upon the actual exchange rate.In fact, the international pricing model developed in chapter 2, indicates that under certain assumptions, exporting to an overseas market is an option given by the exporting firm to foreign customers. This model can be seen as accounting for the argument put forward by McDonald and Siegel (1984), according to whom, valuing real options may require a deeper understanding of the equilibrium in the market for the underlying asset than valuing options on financial assets.

This chapter focuses on the issue of hedging against operating exposure, in a theoretical context.Initially, it offers a critical evaluation of the propositions of the relevant literature, concerning the management of operating exposure.As will be seen later, these propositions favour the use of strategic hedging against operating exposure.In this chapter there is an attempt to prove that these hedges are nothing but real options that do enable the firm to eliminate its operating exposure.However, there are several drawbacks attached to these real options, as a means for hedging against exposure.The question to which one is led, is whether real options can be replicated by financial (here, currency) options, in terms of hedging exposure. To handle this question, one needs to move from an operational definition of operating exposure (involving the role of market structure, level of competition and production technology) to a financial definition [that is the right thing to do for financial analysis, as stated by Adler and Dumas, (1984)]. The hypothesis is established that a currency (call) option can hedge against the type of operating exposure which was analysed in chapter 2. Furthermore, using a simple theory drawn from the area of financial options pricing, hedge ratios (the number of currency options per unit of the underlying asset) can be theoretically determined.By doing so, the issue of hedging operating exposure is quantified. Finally, a number of currency option strategies are outlined and their significance in hedging different scenarios of operating exposure is commented upon.

4.2.Previous Work On Measuring And Hedging Operating Exposure.

4.2.1.Discounted Cash Flow Models.

In this approach, different scenarios of future exchange rate movements are built up.Under each scenario, the effects of the projected exchange rate are examined upon selling prices and quantities exported, working capital , taxes and interest repayments on loans.[Shapiro (1989)].Each scenario is assigned a subjective probability, that affects the projected results of exchange rates upon cash flows.Then, the newly obtained cash flows are discounted back to the present, using an interest rate that is assumed to allow for the riskiness of cash flows, due to both business risk and exchange rate risk.

The criticism that is attached to this approach is the same as that directed toward the Discounted Cash Flow approach to valuing risky projects, put forward by Brennan and Schwartz (1985).In fact, there are two strands of criticism:First, the stochastic properties of the cash flow stream (i.e.profit margins and quantities exported) are hardly known with certainty.To remove the riskiness of cash flows, certainty equivalents, only approximately specified, are used.As pointed out by the previous authors, the Discounted Cash Flow model is based on the project evaluation under certainty, and its adoption for risky projects yields only approximate and sometimes subjective results.Within this strand of criticism, many authors [Brealey and Myers, (1988), Mason and Merton (1985), and others who have been named as strategists[1]] argue that, adopting this model ignores any active reaction (evaluation of options embodied in projects) in the future.The model assumes that managers behave passively to unexpected events, and thus, decisions based on it are inflexible.Second, the probabilities assigned to each of these scenarios are subjective, and thus, any measure of exposure can be anticipated as being a function of these probabilities.Therefore, different investors (with different probabilities about the future exchange rates) may derive different measures of operating exposure.

4.2.2. Strategic Hedging.

Any strategic policy for hedging against operating exposure follows the analysis of the projected exchange rate effects on cash flows.However, any propositions made are purely qualitative, and emphasise the role of marketing and production efficiency for hedging against this exposure[2].Shapiro (1989), Shapiro and Cornell (1983) and Aggarwal and Soenen (1989) argue that, efficient hedging of operating exposure can be achieved if firms possess strategic alternatives (options).The latter can be utilised (exercised), when bad unexpected results come up.Such strategic management of operating exposure can be segregated into two categories: marketing management and production management.

The first category involves the development of a wide network of international markets along with a balanced promotional strategy and efficient pricing of exports, on the basis of the firm's perception of the trade off between market shares and profit margins.The development of international markets implies that firms should expand to become global, or at least, as internationally diversified as possible.Agmon and Lessard

(1977) and Lessard (1976) provide some empirical evidence that financial markets show their appreciation to the reduction in business risk, through international diversification of operations.Clearly, firms with several markets around the world can move from a market in which operating exposure arises to another.Thus, one can say that a network of international markets denotes that the firm has 'naturally' hedged its operating exposure (although its accounting exposure may be significant).

The production management of operating exposure involves the development of an as efficient production technology as possible, to enable the firm to neutralise any competitive disadvantages, accruing from an unfavourable movement in the (real) exchange rate.This can be achieved by :

-developing production operations in different locations, to express the production costs in the major competitors' currency, and/or

-sourcing from markets from which major competitors source, so that, again, the currency to which production costs are determined, will be the same among international competitors.

These exposure management policies aim to give firms flexibility to overcome the exchange rate effects upon competitiveness.However, the following criticisms can be attached to them:

1.The development of a network of international markets does not always quarantee efficient hedging of operating exposure.For the case of the UK based firm with exports to the USA, analysed in chapter 2, this measure would imply that it should reduce its exports to the USA and target ,say, the German market (given a short term restriction on the production capacity).In the German market, it may face competition from German producers with DM-denominated costs, so that the portfolio of currencies for which the firm faces operating exposure is diversified. Where German competition exists. operating exposure will be reduced, only when the covariance of the \$/£ and DM/£ is close to -1. so that the competitive advantage (disadvantage) in the USA market will be offset by the competitive disadvantage (advantage) in the German market.Only in cases where the UK firm establishes marketing operations in markets where it has a monopolistic position, will exposure always be reduced. Clearly, the greater the network of international markets that the firm has (and thus, the more globalised it is), the more probable that the covariances of the exchange rates, in which operating exposure arises, will be closer to -1 (or at least negative), and thus, the more probable that operating exposure will be reduced.

However, if the UK firm competes in the German market with other USA firms with costs in dollars, then the operating exposure problem, analysed in chapter 2, is still relevant. Clearly,the USA firms can expand their selling operations in the same markets as the UK firm (possibly for the same reasons). George and Schroth (1991) argue that consolidation and mergers of international producers have effectively reduced the number of competitors in most markets.This indicates that the same players may be competing against each other in practically every market,reducing the importance of having a diversified network of selling operations in hedging against exposure.

2.The development of a network of production operations in different locations suffers from the following drawbacks:

a.Political instability may increase the riskiness of the project, which will,then, require a relatively higher rate of return.Trade Unions action may also impair the benefits expected to be derived from 'going abroad'.

b.There may be significant time lags between the time that production transfer is required and the time that the transfer is realised.These lags may attenuate the hedging effectiveness of this measure.If the production relocation is decided on the basis of expected exchange rates, the firm is exposed to the non-realisation of this expectation[3], as the re-establishment of production at home may take some time.As Adler and Dumas (1984) and Lessard and Lightstone (1986) argue, the exposure concept has a dynamic (i.e short term) feature (although it is a long term problem).As exposure levels may differ from one time period to another (as well as from one industry to another), any hedging measure should be flexible enough to allow for frequent hedging re-adjustments, to match these different exposures. Moving the production operations abroad, however, is similar to taking a long term (and thus inflexible in the short term) forecast of the future exchange rate and thus, exposure.This inflexibility may result in an increase in exposure, if the expected rate does not realise.For example, a UK firm relocates its production operations to the USA, on the basis of a forecasted appreciation of the pound.If the pound depreciates instead, the UK firm has an opportunity loss, due to having its costs in an appreciated dollar (implying competitive disadvantage) and not in a depreciating pound (implying competitive advantage).Therefore, since operating exposure requires short term considerations, and as production locations can not be shifted easily, one can conclude, that the latter measure may be incompatible with the concept of efficient hedging.

An example that highlights the importance of short term hedging against economic exposure is that of Caterpillar, the USA heavy machinery manufacturer.As reported by an article in the Euromoney magazine (September 1991), the company shopped the world for cheaper inputs, to eliminate the effects of an increasing dollar and maintain its competitiveness against its Japanese competitor, Komatsu.It expanded its sourcing offshore to Brazil, Mexico & South Korea.After that, the dollar started to go down, rendering the sourcing transfer redundant.The article concludes that had Caterpillar identified the short term nature of economic (operating) exposure, it could have hedged this exposure using financial instruments (such as forward or option contracts).

Further, and as mentioned above, building a factory or acquiring an already established business in the USA implies considering the operating exposure problem in the long-run. But as Lessard and Lightstone (1986) argue, the operating exposure problem may be irrelevant in the long term, since the real exchange rate movements (which trigger the creation of operating exposure) are relatively reduced.As a result, in the long term, the strategic hedges may be relatively irrelevant and in the short term inflexible, and thus, inefficient for hedging.Finally, another parameter that is linked with the strategic hedging is the high costs involved in setting up new production and marketing operations. In fact, these costs can be seen as the cost of hedging, when strategic hedges are used.

c.Significant economies of scale may emphasise a single giant production location.As reported in the International Automotive Review (1989), many Japanese automanufacturers believe that holding a single production operation helps improve quality controls.

3.Finally, and most importantly, all firms aim to develop a general network of marketing and/or production operations, to enable them to reduce overall business risks (risks from competition in markets in which the firm operates plus exchange rate risks), to cut domestic currency costs and thus improve competitiveness and future growth. Using this network of operations to hedge particularly exchange rate risks implies that, a compromise between the strategic policies for hedging overall business risk and the strategic policies for hedging specific exchange rate risk must be reached.

To illustrate this, consider the example of the UK firm,analysed in chapter 2.On the criterion of minimising exchange rate economic risk, it should move its production operations to the USA, in order to express its costs in the same currency as that in which its USA competitors' costs are expressed. [See section (1.6.1), in chapter 1].On the criterion of minimising overall business risk, however, it may be better off moving its production to, say, Brazil, to exploit the positive effects of the continuous devaluation of the Brazilian currency vsv the pound, upon the £ costs. In this case, the UK firm may gain an overall competitive advantage over both its USA competitors with costs in $s and its UK competitors in the UK market,with costs in £s.

In this example, hedging exchange rate risk requires a different strategic policy compared to the policy required for hedging overall business risk.This conflict may require a compromise in terms of how to allocate the assets (production) in establishing a 'high' profit margin and strong market presence, and at the same time,resolving the problem of exchange rate risk.Nestle, the Swiss confectionery producer, is an example of a firm, which over recent years, used strategic policies to reinforce its position in the European market.The company sought to purchase pan-European brands, to establish a stronger international position. This plan should not be explained as a means of reducing exchange rate risk, as exchange rates are fixed within the E.E.C.

Further, it does not follow that any production location plan that reduces the overall business risk, automatically reduces exchange rate risk as well.For the case of the UK firm, one can not argue, that moving production operations to Brazil definitely leads to the elimination of the latter risk. For example, we may have a situation where the pound appreciates vsv the cruseiro by 10% (and thus, the £-costs of production are going down by 10%), but against the dollar, it appreciates by 15%.This implies that, when expressed in a common currency, the pound costs are increased by 5%. compared to the dollar costs of USA producers. Thus, we have a case where, absolute £ costs decrease, but relative £

costs (£ costs/$-costs) increase.The latter result implies exchange rate operating exposure, even though the overall business risk appears to be decreased. due to the pound appreciation vsv the cruseiro.

In general, firms with well diversified networks of production will choose their production location on the economic principle of long term profit maximisation.The result in terms of locating production may not be the same as if the criterion of exchange rate risk hedging had been applied for choosing the best (more economically efficient) location.In other words, there must be a separation between the production decision (in terms of deciding on the allocation of assets) and the hedging decision.[Such a separation theorem can be established when financial hedging of exchange rate risk using futures is undertaken.See Broll and Zilcha (1992)].

Concluding this section, one can state that moving production locations around the world may fail to effectively hedge operating exposure (especially in the short-run). And although hedging is all about the possession by firms of 'alternative' (optional) courses of action, strategic hedging may force the firm to implement inflexible solutions, adopting a long term perspective on the operating exposure level.

4.2.3. Adler And Dumas (1984).

This approach can be seen as introducing the adoption of financial hedging against operating exposure.

For the purposes of financial analysis, Adler and Dumas define exposure as the amount of foreign currency that reflects the sensitivity of the future domestic currency value of this amount.Assuming that :

-probabilities of future outcomes are predetermined ,

-inflation rate in the domestic country is non-random,

-foreign inflation is random,

-forward contracts are available for hedging against exposure,

they argue that, exposure is a regression coefficient given by the following regression:

$$X = a_0 + a_1 * e + u \qquad (4.1)$$

where:

X :the pound value of the exposed asset,

a_1 :the exposure coefficient,

e :the exchange rate,

u :the random term, E (u) =0, $Cov(u_i, u_j) = 0$.

The authors analyse the measurement and hedging of two types of exposure:first, the exposure when the foreign currency value of the exposed asset is certain (which can be the case of transaction exposure) and second,when the foreign currency value of the asset is not certain (which ban be the case of operating exposure analysed in chapter 2, if we think of the commodity's price as the value of the exposed asset).

In the first case, the authors argue that the regression analysis gives an exposure measure equal to the (certain) foreign currency value of the exposed asset.Perfect hedging can be achieved using forward contracts. The amount of foreign currency to be sold forward should equal the foreign currency amount exposed.The latter equals $a\hat{}_1$.

When applied to operating exposure, (4.1) can be

$$EP = a_0 + a_1 * e + u \qquad (4.2).$$

where:

EP : the pound export price.

Again, the amount of foreign currency to be sold should equal a_1. In this case, however, the hedging is not perfect, implying that there is some residual unhedged exposure, which can not be eliminated by exchange rate hedging.

A first strand of criticism that can be attached to this approach is that running a regression line to estimate operating exposure imposes the assumption that this exposure is symmetric, and therefore, can be effectively hedged by a forward contract (the risk profile of which is symmetric as well)[4].The symmetric profile of exposure can be reasonable for the case of transaction exposure. As analysed in chapter 2, however, this may not be the case for operating exposure, the risk profile of which is affected by the choice between profit margins and market shares. Taking a regression line approach imposes the assumption that firms always prefer profit margins to market share expansion.This is not compatible with the evidence on export price behaviour outlined in chapter 2 [sections (2.2),(2.3.1) and (2.3.2)]. Therefore, as this approach does not allow for the trade off between profit margins and market shares, it may result in subordinate hedging decisions (involving forward contracts). What we need for hedging is,in fact, an 'option', and not a fixed (and inflexible) agreement, such as the forward contract.

Another strand of criticism that is attached to the Adler- Dumas approach is the fact that the measurement of exposure to be linked with the optimal level of forward contracts, depends heavily on the probabilities assigned to forecasts of future exchange rates. Different probabilities yield different exposure levels, and thus different 'optimal' hedging decisions[5]. Therefore, for different investors with different expectations on the future exchange rate, different hedging measures will be optimal.Eaker and Grant (1985), examining the hedging solution to the uncertain exposure using forwards, reach the same conclusion, regarding the significance of subjective probabilities for reaching a hedging decision.The above indicates that we need a hedging rule that is independent from subjective probabilities, so that the hedging decision will be widely accepted by all investors, regardless of different expectations over future rates.

Apart from the previous strands of criticism attached to the Adler-Dumas approach, their work establishes a rule of taking financial hedging against exposure.It is a step towards moving from strategic hedging to financial hedging.This step is based on the financial (rather than strategic) definition of exposure. This point is further analysed later in this chapter.

4.2.4. Hodder (1978, 1982).

In these papers, which can be seen as combining both strategic and financial hedging, a firm's exposure is a portfolio of 3 individual exposures to exchange rates:

a.exposure of domestic assets (operations),

b.exposure of foreign operations,

c.exposure to inflation.

Each of these individual exposures is measured by a regression coefficient, similar to that proposed by Adler and Dumas (1984).Hedging operating exposure can be achieved by changing the proportion of assets in different locations (strategic hedging). Any remaining exposure can be hedged using by forward contracts or foreign currency borrowing (financial hedging).Two strands of criticism can be attached to this approach.

First, the question of asymmetry, when measuring individual exposures, is relevant here as well.

Second, this approach seems to combine the hedging decision with the production location decision (with the latter being affected by the transfer of assets from one country to another, as a result of hedging exchange risk).Thus, the same criticism applies here.

regarding the short term inflexibilities in hedging, as for the case of strategic hedging.

To conclude this section, one can argue that strategic hedges are inflexible in the short run.Forward contracts seem to allow for short term variations in exposure measurement, but impose the assumption that operating exposure is symmetric.The probabilities assigned to scenarios on future exchange rates are critical for hedging rules using either strategic hedges or forward contracts. What we need is a hedging instrument that combines the short term flexibility of financial hedges with the insurance characteristic of strategic hedges (use the hedge when bad results come up, and ignore it when good results arise).This will be the basis for the analysis to follow.

No study has empirically examined the hedging effectiveness of either forward contracts or strategic hedges, in eliminating operating exposure. Further, no work has addressed empirical issues related to the actual implementation of a hedging policy (for example, hedge ratios and duration of the hedging period). A complete hedging proposition should allow for these topics.

4.3.Hedging Operating Exposure Using Real Options.

4.3.1.Real Options As Hedges Against Operating Exposure.

According to the analysis of chapter 2, the export business can be seen, under certain assumptions, as a real option 'written' by the UK exporting firm to foreign customers. Writing options always leads to exposure, which is, in this case, exchange rate operating exposure.

By real options, we mean alternative operational courses of action. that can be utilised when the firm desires.For example, many projects have embodied the shutdown option[6], or the abandonment option[7].As mentioned by Kunatilaka and Marcus (1988).

many capital budgeting and real market activities offer timing, production and technology choices.All these alternative courses of action are termed real options, since they are formally similar to hold-or-exercise choices, available to owners of put or call (financial) options.These real options have been named as 'operating options'[8], as well.Managers seem to refer to such options as 'intangibles'.

In fact, hedging operating exposure, which resulted from selling a real option, can be achieved by either buying back this real option which causes exposure or buying another similar real option, the value of which can offset cuts in export prices when the exchange rate appreciates.

One could perceive the strategic hedges against operating exposure as real options, that exporting firms want available (embodied) in their export business.One can see that strategic hedges are, in fact, real options that firms wish to have, if the theoretical framework of analysing real options, provided by Kunatilaka and Marcus (1988), is adopted.These authors recognise that there are overwhelming similarities in analysing real options, and offer a general approach which highlights these similarities.They argue that, when a firm possesses a real option, it has (at least) two operating modes to choose from.These modes can be interpreted generally.For the case of an exporting business with strategic options available, these modes can be two different markets available or two different production locations. Further, the firm has to decide 'today' the mode to be finally chosen.The optimal choice is determined by the value of a state variable (here, the exchange rate) that evolves stochastically.

With this as a background, an attempt will be made here to illustrate that the strategic hedges, previously outlined, can be seen as real options sought after by exporting firms. Having in mind that perfect hedging against asymmetric operating exposure can be achieved by instruments featuring risk profiles similar to call options, it is argued here that strategic hedges are real calls, and thus, can theoretically hedge this exposure. However, due to several practical problems attached to them, (which were analysed in the previous section), we will move to introducing financial options, in the next section.

Consider the UK firm analysed in chapter 2.It is assumed that it has a plant in the USA.In this case, the UK firm can be seen as possessing a real option in its export business, with the following modes:

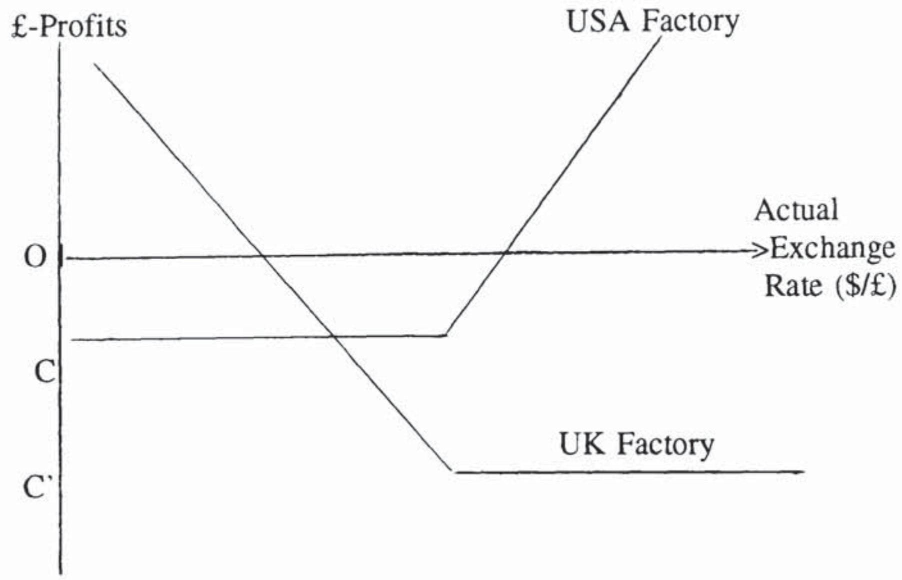
Mode A: Production in the UK when the pound depreciates or

Mode B:Production in the USA when the pound appreciates.

[This can be the case of Caterpillar, the USA heavy machinery manufacturer.As reported in Shapiro (1989), the firm has 'dual sources, domestic and foreign',allowing the firm to 'load the plant which offers the best economies of production, given exchange rates'].

The optimal decision (mode) will be based on the evolution of the actual exchange rate.

Diagram 4.1. Profit Profiles Of The UK And USA Factories.



When the pound appreciates vsv the dollar, the USA factory is relatively more efficient, and the production is transferred there.The UK factory remains idle, incurring a fixed cost that, together with the transportation costs of moving assets overseas, equals OC'.If the dollar appreciates, the UK factory is employed.The fixed cost of building up and maintaining the USA factory (possibly for future use) is CO. The possession of a production location in the USA makes the profit profile of the UK plant look like a real put option.Similarly, the possession of a production location in the UK makes the profile of the USA factory look like a real call option. Now, focusing on a UK firm with production operations in the UK, the acquisition of a USA plant is similar to 'buying' a real call option,incurring a hedging cost given by OC[9].

The development of an efficient production technology, enabling the firm to produce different versions of the product, can be also analysed in the same framework, indicating that this is also a real option.The firm's ability to diversify its product, as a means of hedging exposure, is a real option, as well as its ability to supply many different markets.

In theory, and since these strategic hedges are in fact real call options, one could argue that they do hedge (asymmetric) operating exposure. In practice, however, and as analysed in the previous section, several shortcomings are attached to managing exposure using real options. The question to which one is led, is whether financial (instead of real) options can be used. This issue is formally considered later in the chapter.

In the next section of this chapter, an attempt is made to quantify the use of real options for hedging operating exposure, in terms of determining hedge ratios.The same procedure will be followed later, to determine hedge ratios for the case of currency options hedging.

4.3.2.Determining Real Options Hedge Ratios[10].

As stated in chapter 2, the firm fixes its export price in pounds and translates this price into dollars, at the expected exchange rate.If the pound appreciates, the firm is obliged to cut its pound price, to compete with 'cheaper' USA products. Thus, the best that the UK firm can get at T_1, in terms of export price, is the pound export price expected to prevail at T_1 [see formula (2.3) in chapter 2].Diagram (4.2) depicts the firm's position at T_0.

Diagram 4.2.:The Export Price Scenarios at T_1.

$$\begin{array}{lll} T_0 & & T_1 \\ & & \\ EP_0 = & \begin{cases} \text{-> } EP_0 \text{ ,if the pound depreciates} \\ \text{-> } EP_1 \text{ ,if the pound appreciates.} \end{cases} \end{array}$$

where:

$EP_1 < EP_0$.

The asymmetry of operating exposure,outlined in chapter 2, is indicated in diagram (4.2), by the fact that the export price is reduced when the pound appreciates whereas it is not increased when the pound depreciates.Hedging exposure implies that the firm should possess a (real or financial) instrument to recover the loss of (EP_0-EP_1), if the pound appreciates.One way of achieving this is for the firm to have a (business) option to sell the product to another market (in which it does not face exposure in dollars), or another customer in the same market, which the USA firm can not supply.This is a real option.The question is how we can quantify this real option, that is, 'how many such options' are required per unit of commodity to be exported overseas.In practical terms, how big the alternative market should be to eliminate exposure.

Assuming that either of two possible export prices in diagram (4.2) will be actually realised, one can apply the Binomial method of option pricing[11], to calculate hedge ratios.

Letting m represent the hedge ratio, the value of the real (put) option depicted in diagram (4.2) at T_1 is given by diagram (4.3).

Diagram 4.3.:The Value of The Real Put at Time T_1

$$
\begin{array}{lll}
 & T_0 & T_1 \\
 & & \mid\!\!\to \quad 0 \quad \text{,if the pound depreciates} \\
m*P= & & \\
 & & \mid\!\!\to \quad m*(EP_0-EP_1)\text{,if the pound appreciates.}
\end{array}
$$

$(X = EP_0)$.

where:

X :the exercise price of the option,reflecting the price at which the firm wishes to sell its product, in order to avoid exposure,

P :the cost of acquiring 1 (put) option to sell one unit of commodity at the price of EP_0, which can be perceived as the cost of developing alternative markets,

m :the number of options required to hedge the price of one unit of output (hedge ratio),

m*P :the cost of acquiring the option to sell one unit of output at EP_0.

We determine the hedge ratio combining diagrams (4.2) and (4.3).This is done in diagram (4.4).

Diagram 4.4. Determining Hedge Ratios Of Real Hedges.

$$
\begin{array}{lll}
 & T_0 & T_1 \\
 & & \mid\!\!\to \quad EP_0 \\
EP_0 + m * P_0 = & & \\
 & & \mid\!\!\to \quad EP_1 + m * (EP_0 - EP_1)
\end{array}
$$

$$EP_0 + 0 = (EP_0 - EP_1) * m + EP_1 \quad \text{or} \quad m = 1.$$

This result, compatible with our a priori expectations, implies that,the firm should buy one option per unit of output to be exported. In practical terms, this indicates that the UK firm must have a second market as big as the first one.Only if the two markets are of identical size (and thus the firm can export all of its output to the second market). no exposure will arise.(Hedging implies that profit margins are protected without harming market shares).In fact, this result is based on the specification of the profile of the exposure along with the adoption of a real option, that has a risk profile that is exactly symmetric to the profile of the exposure[12].

4.4.Hedging Operating Exposure Using Currency Options.

4.4.1. Real Options Hedging vsv Currency Options Hedging.

A comparison between the real options and the financial options hedging can be carried out on the basis of diagrams (4.5) and (4.6).

Real options hedging focuses on production and marketing in-efficiencies that contribute to the creation of operating exposure and aims to 'correct' these in-efficiencies.In addition, it treats real exchange rate changes as given.

Diagram 4.5.:Strategic Hedging : Area Of Focus.

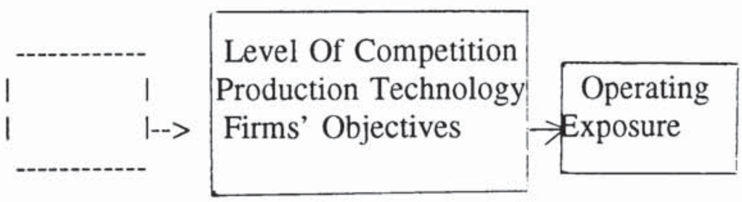


Diagram 4.6. Financial Hedging : Area Of Focus.

Currency options hedging treats market and production factors that lead to exposure as constant, and focuses on real exchange rates changes that trigger exposure.Therefore, currency options hedging treats the factors that contribute to exposure as a 'black box', and thus, avoids the difficult task of quantifying the effects of production technology and market structure upon export prices. Currency options hedging is based on a financial definition of exposure, which relates exchange rates and export prices.In this type of hedging, any excessive exchange rate risks,that the firm is not willing to bear. are transferred to financial markets which accept to bear this risk at the cost of a hedging premium.

4.4.2.The Central Idea.

Instead of establishing a production location overseas or developing different selling markets, the firm can hedge its (asymmetric) exposure by taking a long position in tailor-made call options on the pound, available in the Over-the-Counter (OTC) market[13].When the firm reconsiders its export pricing (at period T_0) and sets an expected export price, it can buy a call on the pound.The expiration time of the option can be set by the firm in the OTC market, reflecting the time at which the actual export price will be established (T_1).If the pound depreciates during this period (from T_0 and T_1) (and no hedging is effectively required), the call will end up being out-of-the-money (and its value will be zero).If the pound appreciates, the call has some (intrinsic) value that can be used to offset the loss in the export price.The firm sells the call to the issuing bank (or OTC market, in general),realises the gain on the call and covers the reduction in the price.The higher the pound appreciation, and thus the higher the export price decrease, the higher the profit on the call option that will offset the loss in the price.The adoption of a call option is a result of the risk profile of operating exposure. The whole case is highlighted by diagram (2.16) in chapter 2.

If the firm had used a forward contract, it would have been obliged to incur an opportunity loss on this contract. if the pound had depreciated.To cover this loss. the firm would have had to increase its export price and thus, would have lost customers. On the contrary, the use of a call option gives the firm scope for keeping prices down, when the pound depreciates, and possibly gaining customers in the USA market.To put it a different way, it is the objective of market expansion that is behind the proposition of hedging operating exposure using currency options.

The question in hand is, how we can theoretically determine hedge ratios, when currency options are used.To answer this question, we need to know two things:first,by how much the export price is affected, given a pound appreciation, and second, by how much the value of the currency option is increasing (reflecting the gain to cover the reduction in price).The first question has already been answered theoretically in chapter 2 and empirically in chapter 3.The exchange rate effect on the export price is given by b_1 in the regression:

$$EP = b_0 + b_1 * e + u$$

analysed in chapter 3. The second question requires some knowledge about currency option pricing.A brief overview on this issue is provided in section (5.3.2) in chapter 5..

4.4.3.Determining Currency Options Hedge Ratios.

As shown in Appendix A ,when the exchange rate increases the call option value goes up by delta.This reflects the profit on the call.However, as the time to expiration decreases, so does the time value embodied in it, measured by 'theta'.Thus, the option holder gains intrinsic value (the difference between the spot rate and the exercise rate of the option) given by delta (if the pound appreciates), and losses time value, given by theta.At expiration, the net profit from holding the call will be delta minus theta, if the option is in-the-money (that happens when the pound appreciates over the option's exercise rate).It is expected that delta minus theta will be positive (net profit), since the decrease in the option price, as time goes by, is relatively small compared to the increase in the intrinsic value after a pound appreciation[14].

Since the decrease in the export price, when the pound appreciates, is b_1 and, at the same time, the increase in the value of the call option is delta minus theta (d-Q). the hedge ratio,m,should be simply:

$$m = \frac{EP_0 - EP_1}{C_1 - C_0} \quad \text{or} \quad m = \frac{b}{d - Q} \qquad (4.3)$$

where:

b_1 :the exchange rate effect on export prices,

d :the option's delta,

Q :the option's theta.

If the firm enjoys a monopolistic position in the market [see diagram (2.7) in chapter 2], then b_1 will be quite close to zero, and thus,the hedge ratio will also be close to zero.This is compatible with the theoretical conclusions in chapter 2,that monopolistic firms are 'naturally' hedged against operating exposure.If the firm faces significant competition, it will tend to buy a relatively high number of options, and thus, incur a high hedging cost (that indicates the high level of operating exposure).

Note that the determination of this hedge ratio is independent of probabilities for the outcome of future exchange rates.Thus, this point overcomes the drawback of having to define probabilities when hedging is carried out using forward contracts.This hedge ratio will be optimal for all investors, regardless of their expectations on future exchange rates.

Finally. as d. Q and b_1 may change over time, the hedge ratio will also change.Thus. the currency options hedge ratio can be rebalanced periodically, to allow for the dynamic feature of operating exposure.Such hedge ratio readjustment is quite easy, when dealing with financial hedging (sometimes a telephone call to a bank which trades options is enough).This point overcomes the long term inflexibilities, attached to real options hedging.

The conclusion is that currency options hedging resolves the problems associated with real options and still quarantees efficient hedging. The monitoring and readjustment of the hedging policy does not affect production locations, to be decided on the basis of the criterion of minimising overall business risks.

4.4.4.Hedging Operating Exposure Using Currency Options Captures The Variability Of Real Exchange Rates.

Lessard and Lightstone (1986) argue that any financial instrument for hedging against operating exposure should be based on the behaviour of real exchange rates.Here, it is argued that this criterion is met by currency options.It is the parameter of exercise rate (that can be determined by the firm when negotiating an option contract), that enables the firm to take a position on the real exchange rate when hedging using a currency option.

Assuming that the hedging firm can successfully forecast the inflation rate differential (and not necessarily the individual inflation rates) of the countries concerned, it can determine the exercise rate on the basis of the 'current' spot rate and the inflation rate differential.In fact, the exercise rate can be calculated adopting the formula used to calculate real exchange rates (see footnote 6 in chapter 1), assuming that we know with certainty the inflation rate differential.To illustrate this, consider the following example.

We are at time $T_{0,}$ with the following information:£1=\$2, $E(i_{UK})=10\%$ and $E(i_{USA}) = 0\%$. We assume that the above expected inflation rates will be realised.At the end of the period, the nominal exchange rate should be £1 =\$1.81, so that the real exchange rate is unchanged (implying no competitive advantage or disadvantage transfer between producers).This rate should be the exercise rate.

If the actual nominal rate at the end of the period is £1=\$1.85. then there has been a real pound appreciation of 4 pence.In this case, the call (with an exercise rate of \$1.81) will be 4 pence in-the-money.This gain should be used to offset the loss of competitiveness, due the real appreciation of the pound.If the nominal rate is £1=\$1.75 (and we have a positive effect on competitiveness), the call will be worthless.

In essence, it is the fact that the exercise rate of the currency option contract can be established by the UK firm itself that makes currency options hedging capture real exchange rate changes. For the case of a forward contract (and as explained in Appendix A), the forward rate is a function of relative interest rates, and not open to the discretion of the firm.

The conclusion is that hedging exposure using currency options takes into account the inflation rate differential of the countries concerned.In fact, this inflation differential (along with the nominal exchange rate) influences operating exposure and the terms of the currency option contract to be used. This reinforces the argument of the relevance of currency options for hedging against operating exposure.

4.5.Scenarios Of Operating Exposure Which Require Hedging Using Advanced Currency Options Strategies.

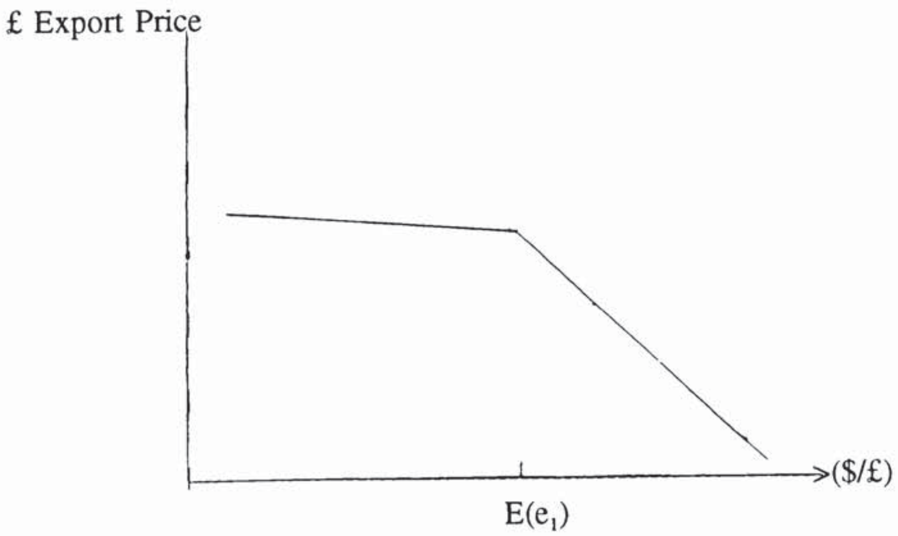
In chapter 2, it was argued that operating exposure can be strongly or weakly asymmetric (and in fact,can take many forms), depending upon the firm's corporate objectives, relative production efficiency amongst international producers and level of competition in the industry. The question here, is whether one can construct hedging strategies using currency options, to optimally hedge each of such exposures, taking into account hedging costs and effectiveness.

Below, some more complex scenarios are examined, concerning the level of competition, the firm's objectives and the relative cost efficiency. Examination is also made, of how some advanced currency option strategies can be used to hedge the exposures that these scenarios create.In essence, this section theoretically links the use of specific option strategies with specific scenarios regarding the parameters which affect operating exposure.

4.5.4.Scenario 1.

The UK firm fixes its price partially in pounds and partially in dollars.This case was analysed in chapter 2 [diagram (2.11)].It is reproduced here in diagram (4.7), in order to associate it with a currency option strategy in the next section.

Diagram 4.7. The Profile Of The Export Price Under Scenario 1.



4.5.2. Scenario 2.

The UK firm has fixed its export price in pounds, which, when translated into dollars at the actual exchange rate,follows a route along the 45-degree line in diagram (4.8).The USA firm, however, has fixed its dollar price, only up to a specific exchange rate.After this rate, the USA firm, following a behaviour towards higher profit margins, increases its export price, although at a lower rate than the UK firm, in order to obtain higher short term profit margins.In fact, after a specific rate (which reflects a 'significant' appreciation of the pound), the 'price-war' faced by the UK firm is rather impaired, due to the USA firm's attitude in favour of higher profits (and relatively lower market shares). Diagrammatically, this scenario is described by diagrams (4.8), (4.9) and (4.10).

Under this scenario, as depicted in diagram (4.10), the UK firm's operating exposure is relatively less severe than that depicted by diagram (2.6) in chapter 2.Taking a long position in a pound call, will result in overhedging for the exchange rate range on the right of e_1. To account for this and to save some hedging costs, a new hedging strategy is required here.

Diagram 4.8:The \$-Bid Prices Of UK and USA Firms Under Scenario 2.

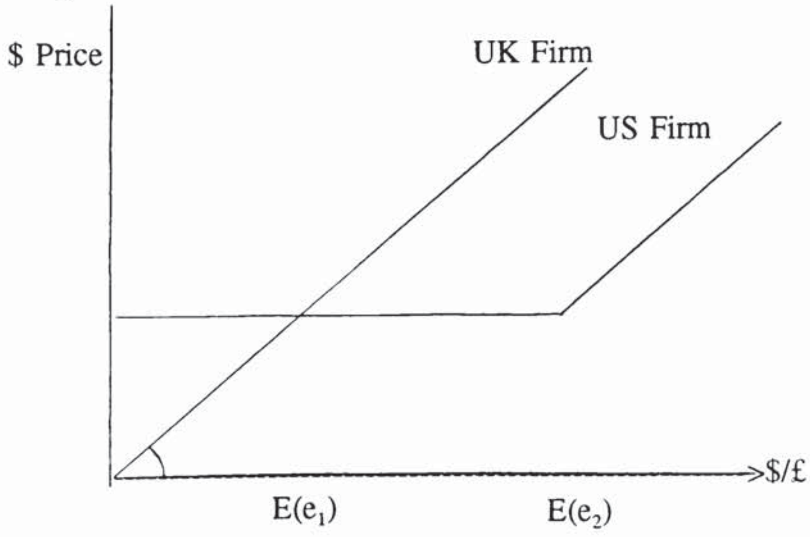


Diagram 4.9. The Profile Of The Dollar Price At Equilibrium Under Scenario 2.

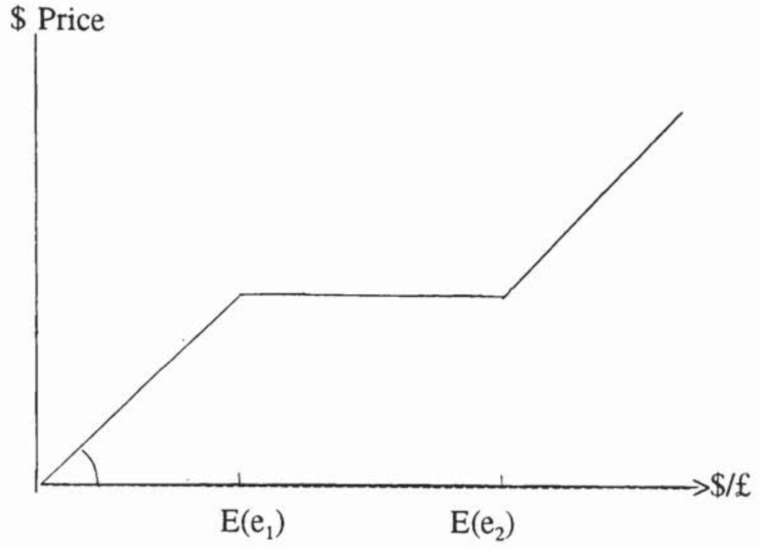
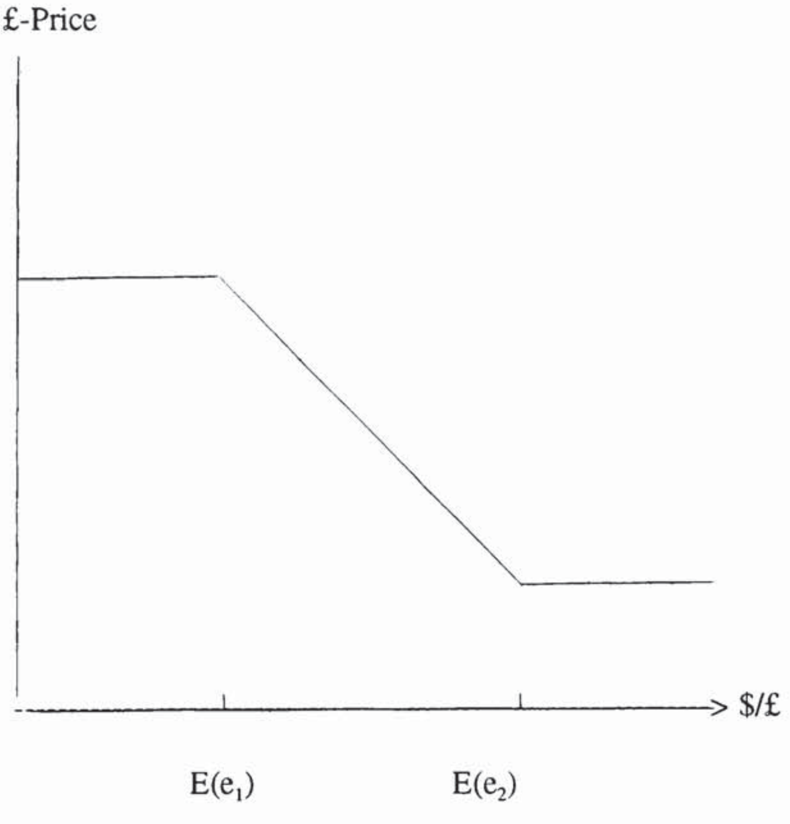


Diagram 4.10. The Profile Of The Pound Export Price Under Scenario 2.



This scenario implies that the type of operating exposure (and thus, the optimal hedging policy required) can be related to the competitors' behaviour regarding the trade off between profit margins and market shares.This behaviour (optimisation objectives) may be different at different levels of exchange rates affecting the risk profile of operating exposure faced by the UK firm.This point is in line with Luehrman (1990) who emphasises the consequences of exchange rate changes upon the competitor's dilemma between profit margins and market shares.To put it a different way, a firm's exposure may be a function of the structure of the price list offered by its competitors.

Adopting a slightly different perspective, one could argue that diagram (4.10) gives the operating exposure of the UK firm,if the two competitors adopt a collusive pricing strategy for exchange rates higher than [$E(e_2)$], that is, the two firms form a cartel.This strategy reduces the exposure faced by the UK firm.This reduction is depicted by the horizontal line for exchange rates on the right of $E(e_2)$.

4.5.3.Scenario 3.

Instead of assuming that the USA firm has a behaviour slightly in favour of relatively higher profit margins, one can assume this for the UK firm.In the range of exchange rates reflecting a pound depreciation, and assuming that the UK firm expects a large pound depreciation, the firm may fix its export price in pounds up to a specific exchange rate [$E(e_2)$], and for lower rates, may establish a fixed price in dollars. Alternatively, for exchange rates lower than $E(e_2)$, the firm may fix its export price partially in pounds and partially in dollars.These scenarios are possible responses to the previously outlined choice between profit margins and market shares.The first alternative of this scenario is depicted in diagrams (4.11),(4.12) and (4.13), and the second, in the same diagrams by the dotted line.

Diagram 4.11 : The Bid Prices Under Scenario 3.

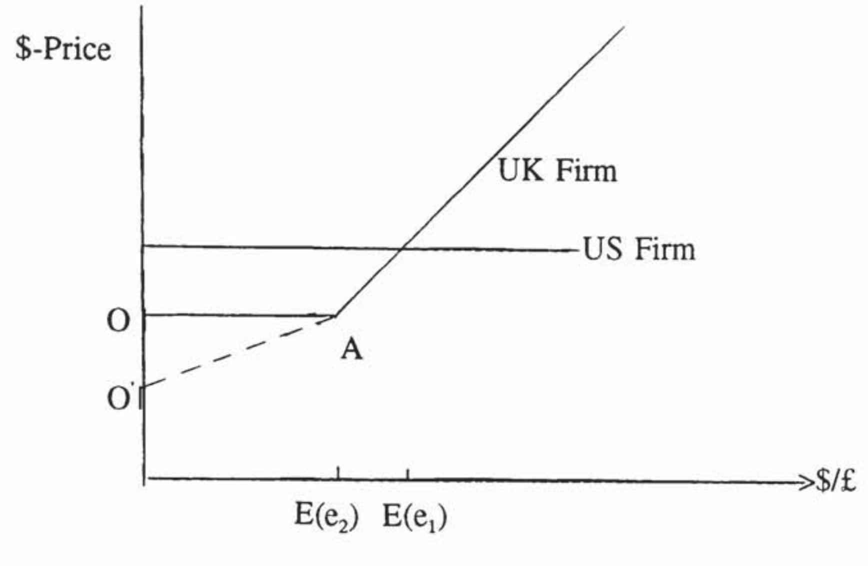


Diagram 4.12.The Profile of The Dollar Equilibrium Price, Under Scenario 3.

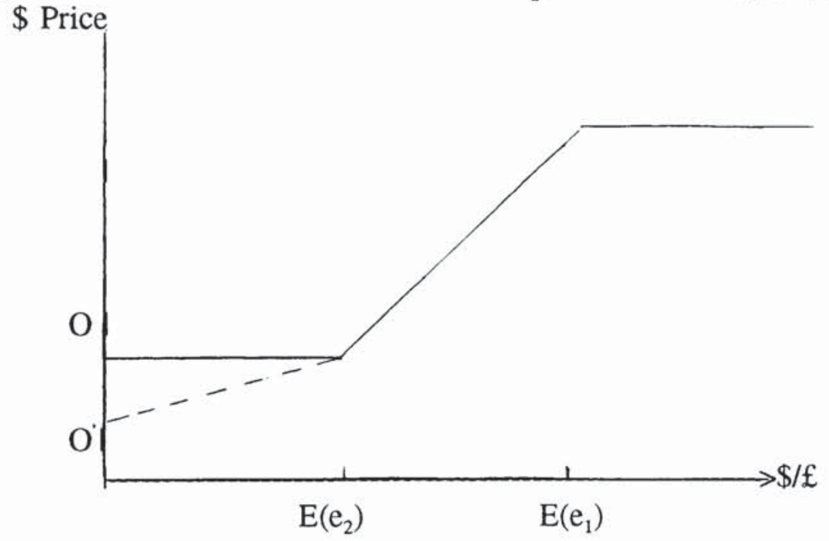


Diagram 4.13.The Profile Of The £ Export Price, Under Scenario 3.

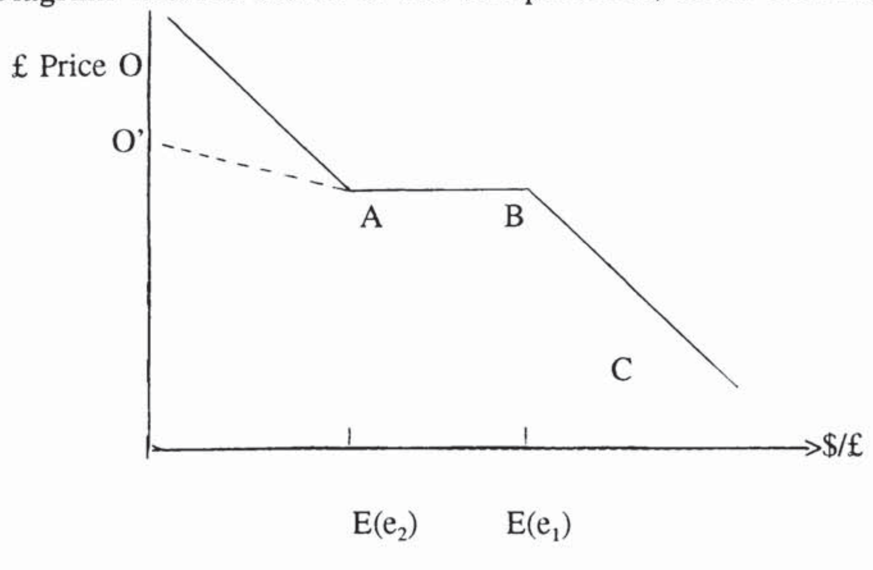


Diagram (4.13) depicts another type of operating exposure that can not be optimally hedged by a simple call option.When the firm fixes its export price partially in pounds and partially in dollars, the operating exposure profile is given by O'ABC in diagram (4.13).This differs from OABC, to the extent that the part O'A is less vertical than the part OA (reflecting the degree of the partial price fixing in dollars).

As the pound fixing of the export price for exchange rates on the left of $E(e_1)$ can be seen as a concession to foreign customers, the fixing of the price in dollars, for exchange rates on the left of $E(e_2)$ can be seen as a partial removal of this concession. A reason that may lead the firm to behave like this, is either a low level of competition in the industry or its own preference towards the market share expansion objective.Clearly, as the price-lists scenarios followed by firms may be based on the degree of industry competition, many such scenarios (and thus, exposures) may exist for different levels of competition.The latter indicates that the industry structure may have an effect on the choice of currency option hedging against operating exposure.

4.5.4.Scenario 4.

Another way of balancing the market expansion objective with the profit margin objective is for the UK firm to offer an export price partially fixed in pounds and partially fixed in dollars, for a specific range of exchange rates, given by $[E(e_2),E(e_1)]$. For exchange rates on the left of $E(e_2)$, the export price is fixed in pounds.This scenario can be adopted, if the firm anticipates a relatively low pound depreciation.This is depicted in diagrams (4.14), (4.15) and (4.16).

In general, depending upon the expectations of the UK firm on the magnitude of a possible pound depreciation, its attitude over the market expansion target and the market structure, the area OB (reflecting the area of concessions given by the firm to foreign customers), in diagrams (4.13) and (4.16), can take very different forms, with each one depicting an individual type of exposure.It is, therefore, obvious that we need flexible currency option strategies,to match any exposure profile that can arise from different combinations of the previous factors. The flexibility that this strategy should carry. will give 'freedom' to the firm to submit competitive export price lists and have them hedged, in case when adverse exchange rates arise.

Diagram 4.14:The Bid Prices Under Scenario 4.

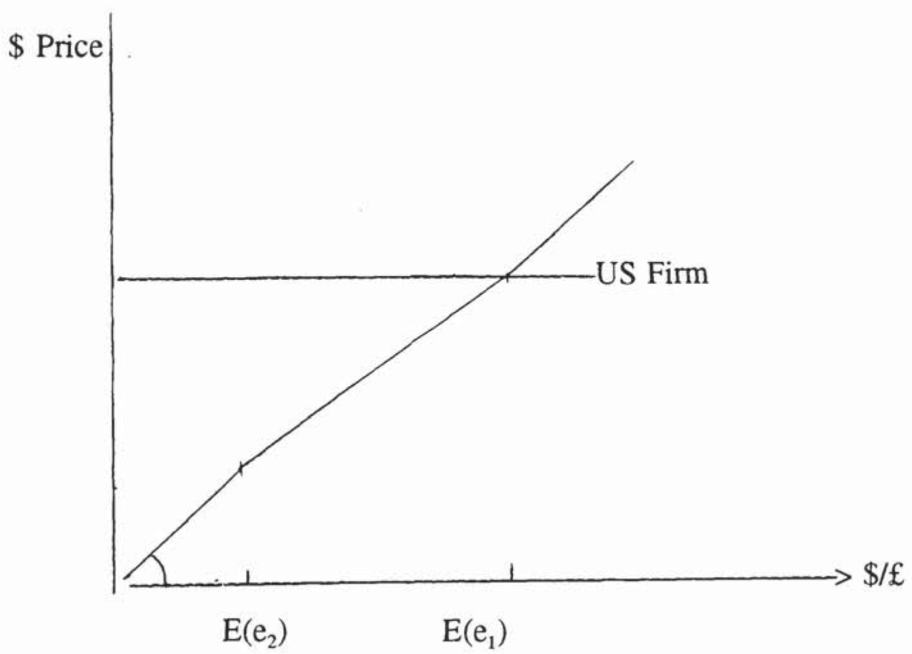


Diagram 4.15:The Profile Of The \$ Price at Equilibrium,Under Scenario 4.

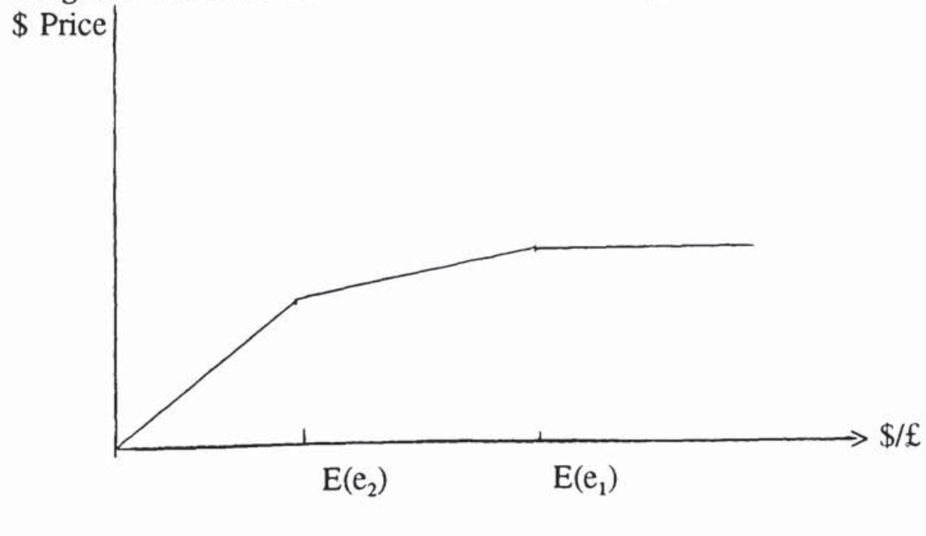
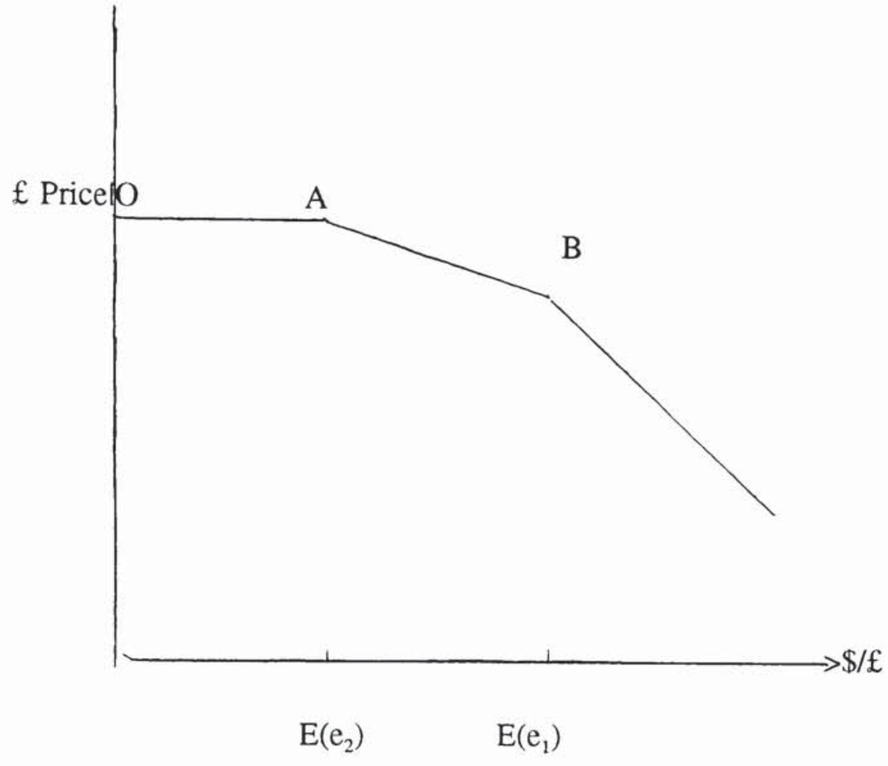


Diagram 4.16:The Profile Of The £ Export Price Under Scenario 4.



4.5.5. Scenario 5.

As analysed in chapter 2, the USA firm may be technologically advanced, and thus, capable of cutting prices (and possibly costs) even when the dollar appreciates.This policy can be justified, if the USA firm finds that a 'price-war' is the solution to eliminating import competition from the UK firm.The relevant operating exposure is given in diagram (2.10) in chapter 2, and is reproduced here for convenience, in diagram (4.17).In fact, the scenario depicted in diagram (4.17) can be reasonable, when the USA firm expects a rather small pound depreciation [in the vicinity of $E(e_1)$].If the firm expects a relatively larger pound depreciation, then one may get diagram (4.18), which indicates that the USA firm cuts its price, for exchange rates lower than $E(e_2)$] [diagram (4.18)].

Diagram 4.17:The Exposure Profile Of The UK Firm, When Its Competitor Is Very Efficient.

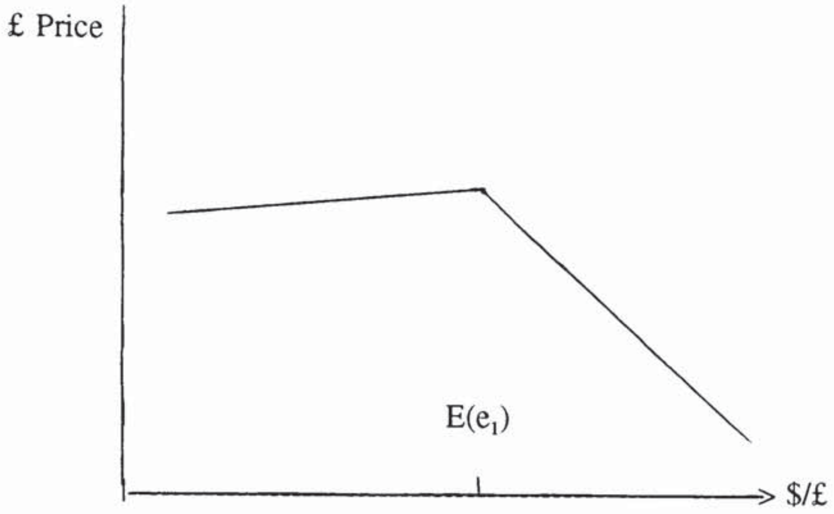
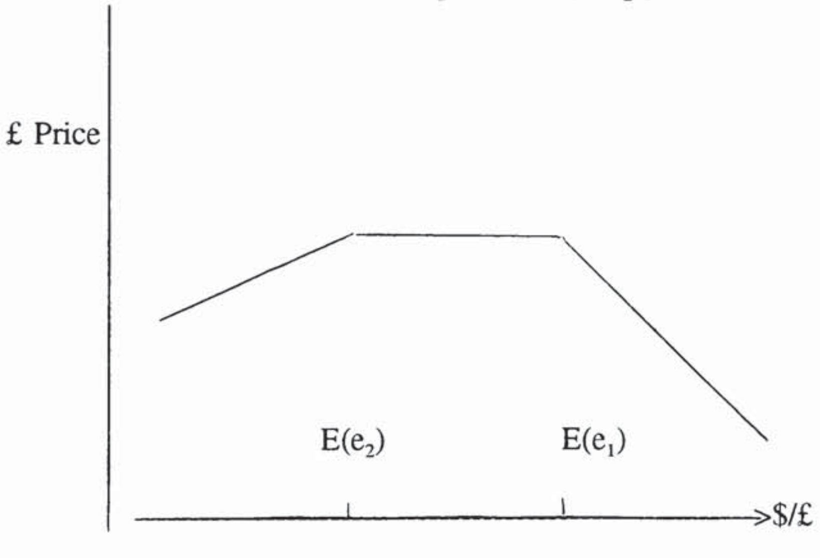


Diagram 4.18.The Exposure Profile Of The UK Firm, When the USA Firm Cuts Its Price After A 'Low' Exchange Rate [$E(e_2)$].

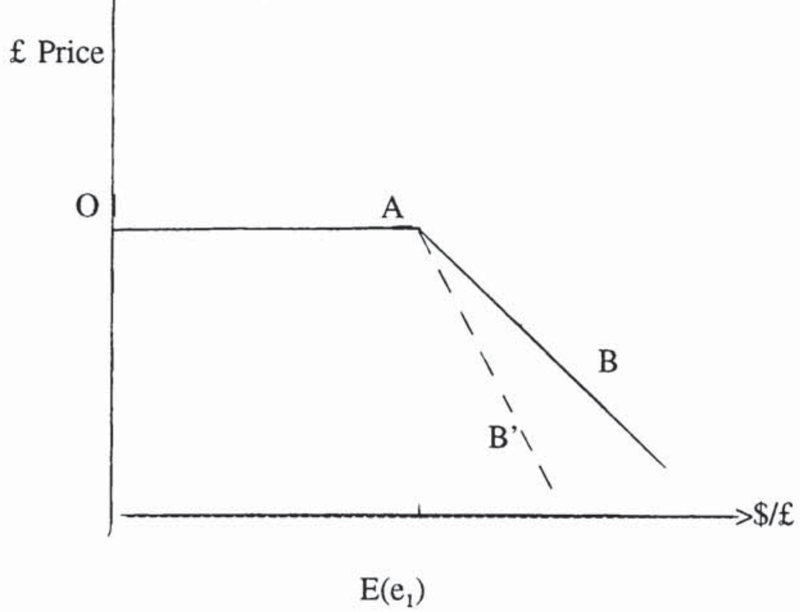


4.5.6.Scenario 6.

If the UK firm is more technologically efficient than its USA competitor, then, as analysed in chapter 2, it can partially offset pound price cuts when the pound appreciates, by cutting costs.This implies that, depending upon the degree of its technological advancement, its downward sloping line in diagram (2.6) of chapter 2, can take many positions, ranging from close to horizontal to very precipitous.Diagram (4.19) depicts the case.

If exposure is given by OAB, one can see that the firm is relatively hedged (due to its efficient production technology).In this case, the financial hedging required will be different from the hedging required for the exposure given by OAB'.This scenario, along with the previous one, highlights the characteristics that relative production technologies bring to choosing the right currency options hedging strategy.

Diagram 4.19.:Different Exposures For Different Levels Of Relative Production Efficiency.



This section indicates that an efficient hedging strategy against operating exposure is determined by such factors as the level of competition, relative production technologies and firms' objectives.Different assumptions about these factors result in different exposure profiles.The hedging policy to be finally chosen should reflect these factors.An efficient hedging policy should lead to a perfectly horizontal position. when combined with the exposure profile, at the minimum cost.

In the next section, a brief outline of different currency option strategies traded in the Over The Counter Market will be given ,together with an illustration of how these strategies can combine with the previously outlined exposure profiles, to yield perfectly hedged positions.

4.6.An Overview Of Currency Options Strategies And Hedging Different Scenarios Of Exposure.

4.6.1.The Concept Of Financial Engineering.

In the 1980's, there has been a remarkable growth in the industry of derivative instruments.As Citicorp's Leslie Lynn Rahl, in Keller (1989), says, 'what was once a state of the art product is now just another item in the shopping list'.The building up of different and sometimes complex option strategies is known as financial engineering[15], and is related to the Over- The-Counter derivatives market.

Below, some options strategies, that represent the most popular combinations utilised by professional option traders, are outlined. These strategies are:spreads, straddles, straps, cylinders, hybrids and strangles.Many more exist, as trading banks produce their own products and assign their own brand names.It is not intended here to exhaustively detail all possible strategies, but rather, to illustrate how different exposures can be hedged by different currency option strategies.

The risk profiles of the option strategies outlined below are not expected to be distorted by transaction costs, as in the OTC market, there are no such costs. After a brief exposition of these strategies, focus will be placed on how they can be used for hedging the types of exposure previously outlined.

4.6.2.Hybrid Put Options And Hedging Against Scenario 1.

Hybrid currency options are widely traded in the OTC market[16]. Briys and Croughy (1988) mention that, hybrid options bring a delicate compromise between flexibility. protection and costs into currency risk management. These options are of European style (exercisable at maturity), making them less expensive than American options (exercisable at any time prior to maturity).

There are many types of hybrid options.Here, the hybrid with proportional coverage is considered.At maturity, if the option is in the money, its payoff is a proportion of the payoff of the ordinary option.Consequently, its premium is less than that of an ordinary option (with the same valuation parameters). Below, a hybrid put with proportional coverage is utilised for hedging against scenario 1.

A long hybrid put is depicted in diagram (4.20) and a short hybrid put in diagram (4.21).

Diagram 4.20.:A Long Hybrid Put With Proportional Coverage.

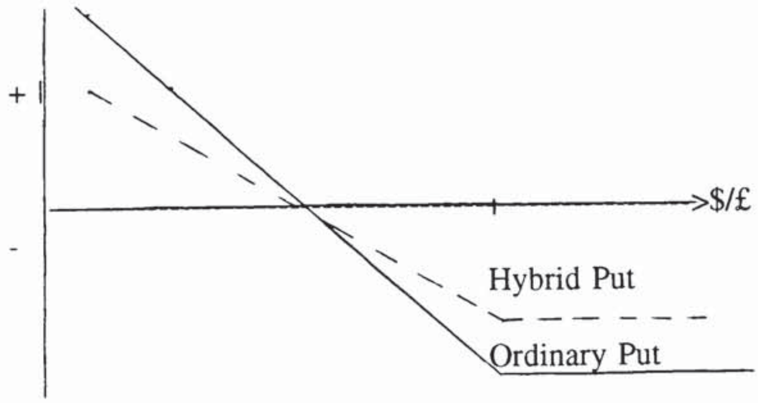
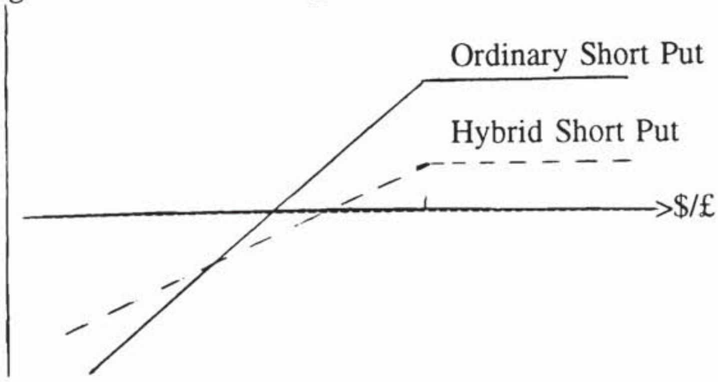


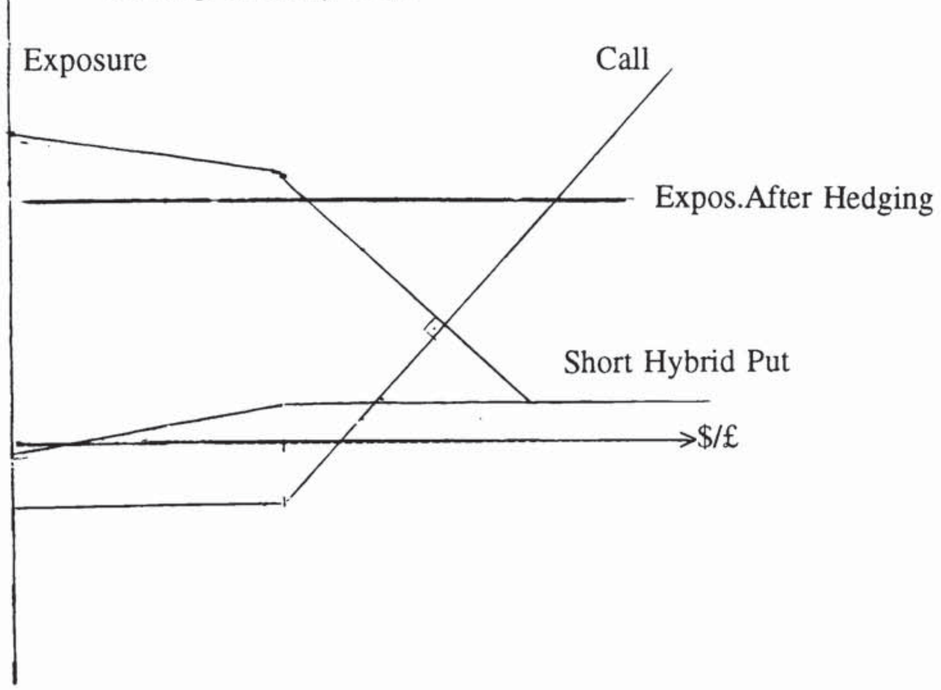
Diagram 4.21: A Short Hybrid Put With Proportional Coverage.



In both diagrams, the dotted line depicts the hybrid option, and the solid line the ordinary option.

A short hybrid put can be combined with a long ordinary call to hedge exposure which reflects the weak form of the asymmetry hypothesis, given by scenario 1.Diagram (4.22) depicts this case.

Diagram 4.22. Hedging Weakly Asymmetric Exposure Using A Short Hybrid Put And A Long Ordinary Call.



In this case, the hedging firm sells a hybrid put with a proportional coverage, determined by the slope of the upward line depicting exposure.This upward line is offset by the downward line of the short put, for as long as the slopes of these lines are the same.Assuming that the firm knows the effect of a pound depreciation on export prices (given by the slope of the upward line which depicts exposure), it can sell a put, with a proportional coverage which equals this effect.The premium it receives reduces the overall cost of hedging compared to the case when only a long call is used.This reduced hedging cost, however, stems from the fact that when the pound depreciates, the firm relatively increases its pound export price, not investing in future market expansion.Thus, we have lower hedging costs as well as lower prospects for future growth.

4.6.3. Spreads And Hedging Against Scenario 2.

Generally speaking, there are three types of spreads:money spreads, butterfly spreads and calendar spreads.Of these,the focus here will be only on money spreads, as the more relevant for hedging the previously outlined operating exposures. A money spread can be a call spread or a put spread.To obtain the former, you buy a call with exercise price A and sell another call with exercise price B.If B>A, we have a bull call spread.If B<A, we have a bear call spread.In these calls, time to expiration (and the other of the valuation parameters) is (are) exactly the same.A put spread involves the purchase and sale of a put with different exercise prices.For purposes of hedging operating exposure, the focus will be on the bull call spread, that has a risk profile depicted in diagram (4.23).

Diagram 4.23.:A Bull Call Spread.

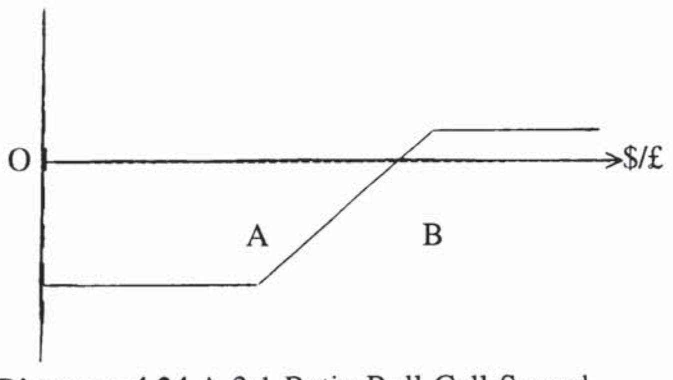
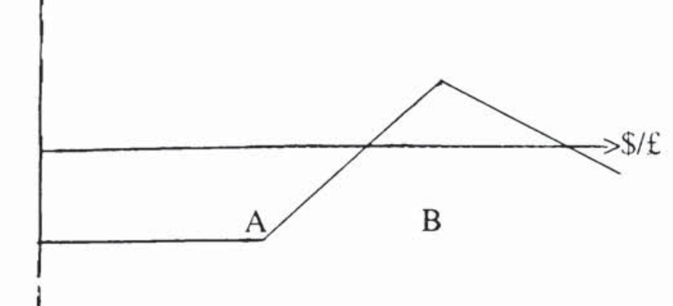


Diagram 4.24.A 2:1 Ratio Bull Call Spread.



In fact, the risk profile of a bull call spread depends on the ratio of the number of calls sold over the number of calls bought.If this ratio is 2:1, the strategy is called a 2:1 ratio bull call spread, and is depicted in diagram (4.24)

When this ratio becomes 0 (i.e. 0:1), we simply get the simple call option profile.The cost of a 1:1 bull call spread (diagram 4.23) is less than the cost of a 0:1 call spread (simple call), because the selling of a B-call (i.e. a call with exercise price B) reduces the cost of buying the initial call at exercise price A.Similarly, the cost of a 2:1 call spread is lower than the cost of a 1:1 spread.The profit potential of a 1:1 call spread is restricted (compared to the profit potential of an ordinary call), for exchange rates on the right of B.Similarly, for a 2:1 call spread, there are losses for exchange rates on the right of B.The conclusion is that the higher the ratio in a call bull spread, the lower the overall cost. but the less the potential for profits.

A ratio call bull spread should be used in cases in which a negative exposure arises in a restricted area of exchange rates, in order to give the best matching between costs and hedging effectiveness.Consider the operating exposure in diagram (4.10). Using a 0:1 bull call spread (simple call) would result in the profile given by diagram (4.25).

On the basis of this diagram,one could say that a call (being more expensive than a 1:1 bull spread) yields a position, which, for rates on the right of B, involves an upward sloping line implying overhedging.The firm can reduce the cost of hedging, and remove this overhedging part (and thus achieve an efficient hedging strategy) by selling a B call, that is buying a 1:1 Bull Call Spread.This strategy helps the firm save some hedging cost and still have a perfect hedge.Diagram (4.26) portrays this case.The fact that the hedging cost is reduced, under this strategy. reflects the relatively lower operating exposure that the UK firm now faces under this scenario. since the price-war by its USA competitor is halved somehow.

Diagram 4.25.:Hedging Exposure Under Scenario 2, Using A Simple Call.

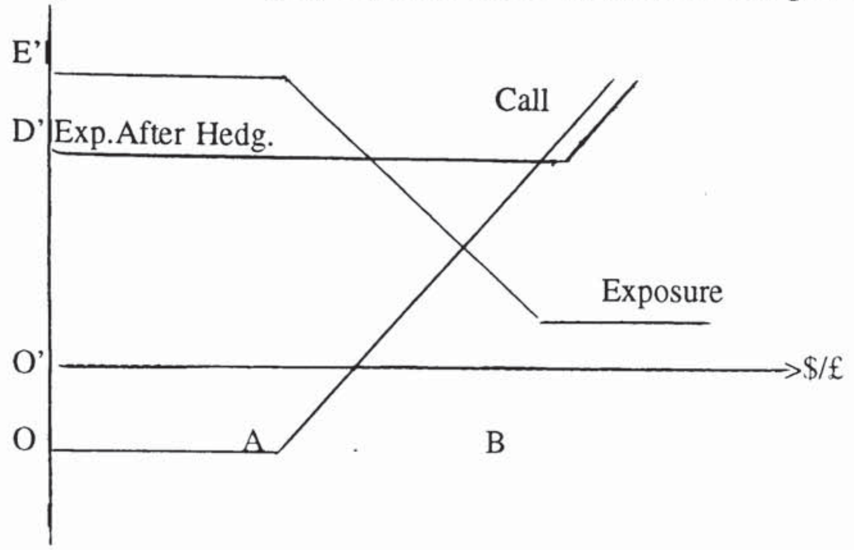
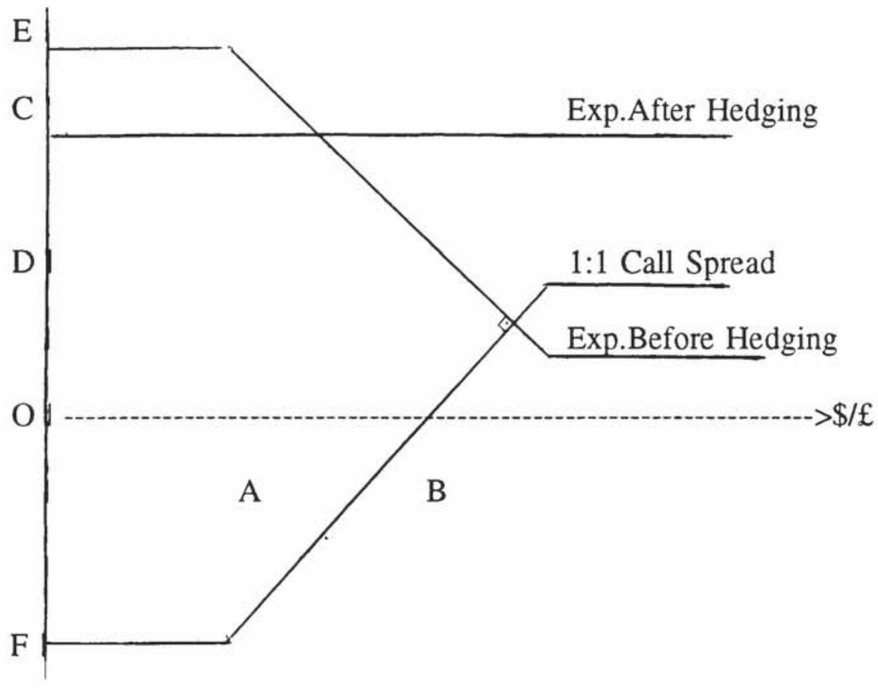


Diagram 4.26.:Hedging Exposure Under Scenario 2,Using A 1:1 Bull Call Spread.



(Note that: EC = OF - OD.Further, OF>OD, because the premium of a B call is lower than the premium of an A call, with B > A).

With respect to the question of the theoretical determination of the hedge ratio, the answer follows from the conclusion in section (4.3.2), in this chapter. When, in fact, the hedging instrument has a profile that is exactly symmetric to the profile of the exposure to be hedged, then the theoretical hedge ratio is 1 (that is, 1 option contract per unit of exported commodity). Thus, one 1:1 bull call spread should be used for hedging the exposure depicted in diagram (4.10).

4.6.4. Straps, Straddles, Strangles And Hedging Against Scenario 5.

A straddle [diagram (4.27)] consists of 1 long put and 1 long call, with the same exercise rate. A strap [diagram (4.28)] consists of 1 put and 2 calls, with the same exercise rate.

Diagram 4.27:A Straddle

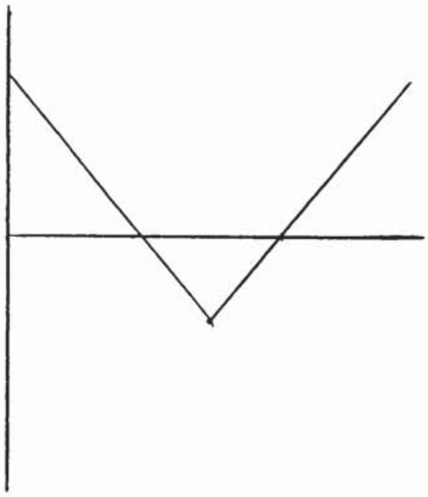
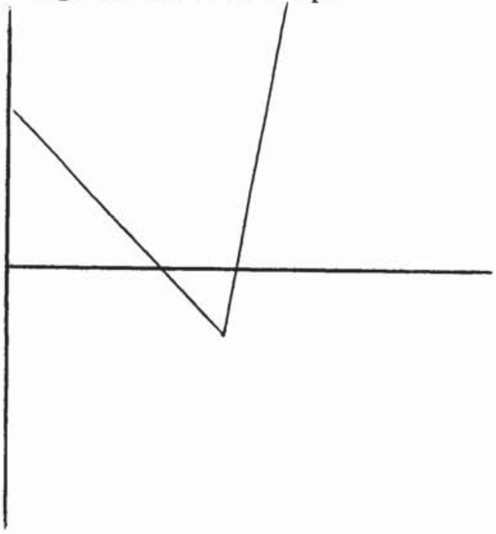


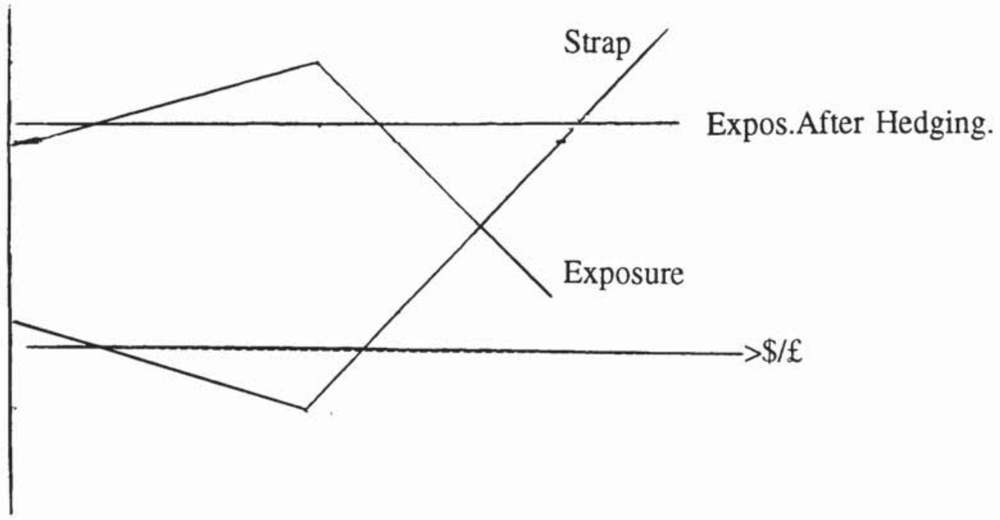
Diagram 4,28.: A Strap.



The cost of a straddle (and a strap) is definitely higher than the cost of a simple call strategy,as we now buy two options (three options, for the case of a strap).However, a straddle (and a strap) yields a profit in any state of nature.A straddle should be used when the firm faces a two-sided negative exposure like that depicted in diagram (4.17).

A strap is better in the case where, as in diagram (4.17), the slope of the profile for exchange rates on the right of $E(e_1)$ is higher than the slope of the profile for exchange rates on the left of $E(e_1)$.

Diagram 4.29.Hedging Exposure Under Scenario 5 Using A Strap.



As a strap consists of long positions in 1 put and 2 calls,its cost is higher than the cost of a straddle.Its profit potential is, however, higher. The case of hedging the exposure under scenario 5 using a strap is depicted in diagram (4.29).The relatively higher cost of hedging, in this case, reflects the higher level of exposure faced by the UK firm, and is due to the fact that its USA competitors possess a very efficient production technology enabling them to cut prices.

Generally speaking, when the exporting firm is relatively inefficient, it will tend to hedge its exposure using straps or straddles.

In line with the previous arguments on the theoretical determination of hedge ratios,1 strap per unit of exported commodity should be used when the relevant exposure is given by diagram (4.17).

An alternative, and yet quite similar, strategy to the strap is the strangle.A strangle consists of a long position in a B- call and a long position in an A-put, where B>A.Another version of a strangle can consist of 1 put and 2 calls.The hedge ratio for hedging the exposure depicted in diagram (4.18) using a strangle is,again, 1.The profile of a strangle is depicted by diagram (4.30).Diagram (4.31) depicts the case of hedging the exposure depicted in diagram (4.18), using a strangle.

Diagram 4.30: A Strangle.

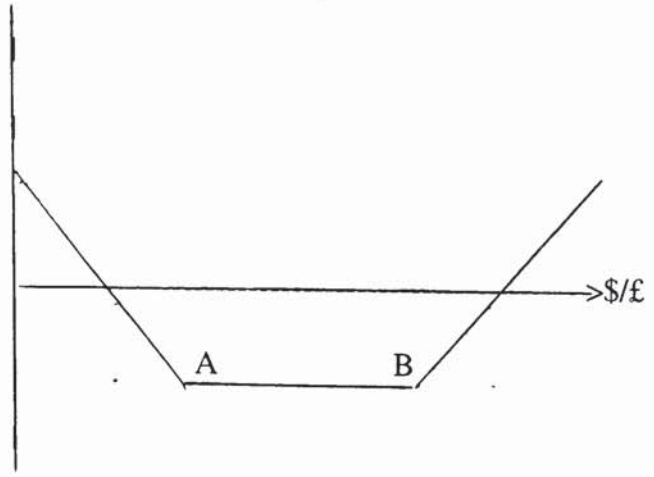
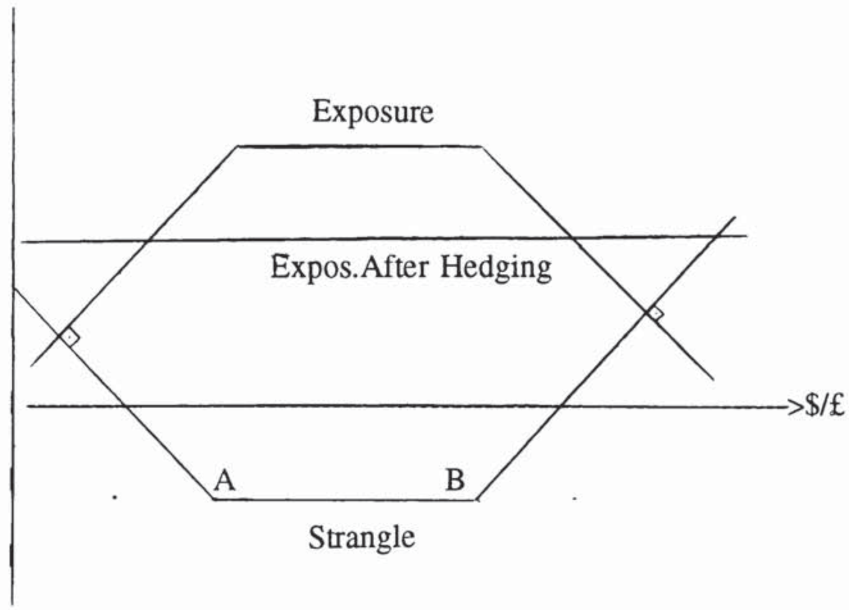


Diagram 4.31:Hedging The Exposure Under Scenario 5 (Diagram 4.18), Using A Strangle.

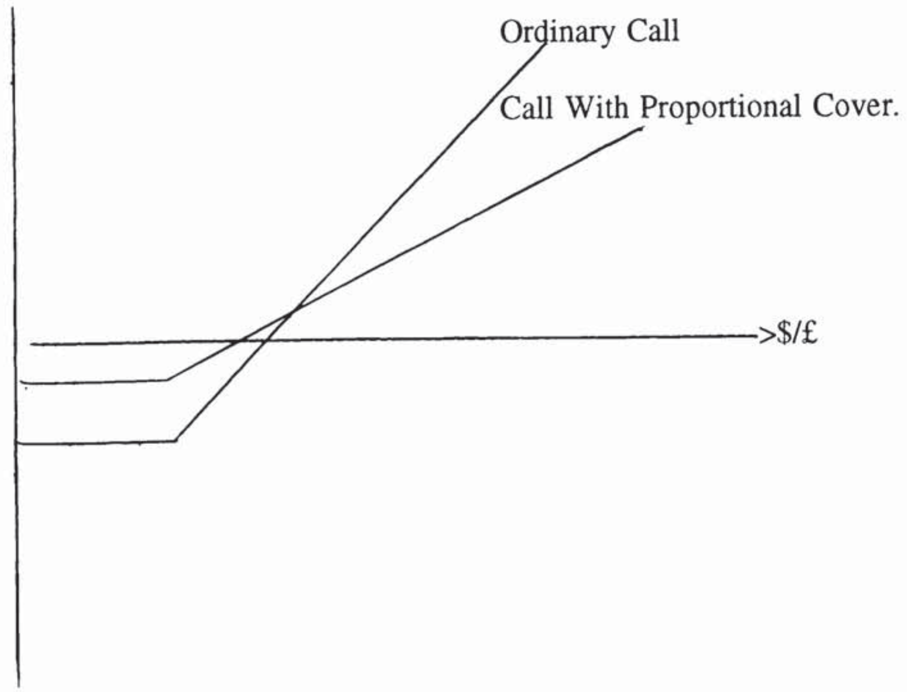


4.6.5.Hybrid Calls And Cylinders And Hedging Against Scenarios 3,4 and 6.

As mentioned earlier, hybrid options ensure a compromise between costs and hedging effectiveness.In this section, the focus is on a hybrid call with proportional coverage. Like a hybrid put, it involves a reduction in the level of protection along with a reduction in the up front premium. Diagram (4.32) depicts the case of a long proportional call.

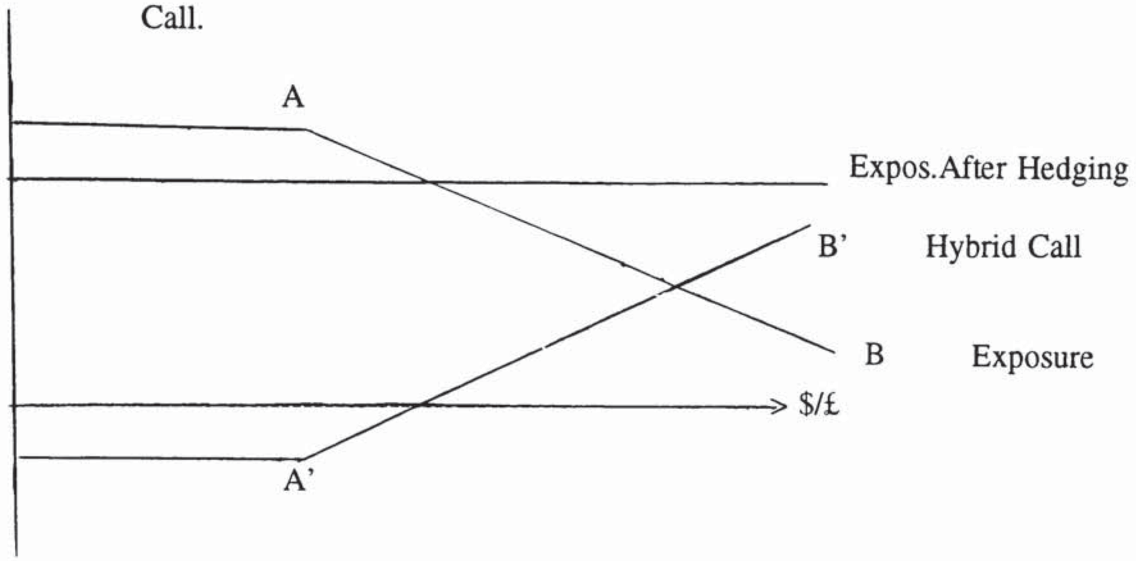
If the contract expires in the money, the payoff is limited to a percentage of the payoff of the ordinary call.Such an option can be used for hedging exposure, when its downward sloping line has a slope lower than -1.This can be the case depicted in diagram (4.19), where the UK firm is capable of partially absorbing a reduction in the profit margins due to a pound appreciation.This is the case of a technologically advanced firm, that can be perceived as being partially 'naturally' hedged, and thus, seeking only partial financial hedging.The partial (proportional) coverage call fulfils this target and ensures a good compromise between hedging effectiveness and costs.Should the firm have used an ordinary call, it would have ended up paying a higher premium and facing the overhedging result, depicted in diagram (4.25).Again, with regards to the hedge ratio, it should be 1, if the slope of line AB is the same as the slope of A'B'. Diagram (4.33) depicts the whole case.

Diagram 4.32.A Call With Proportional Coverage Compared With An Ordinary Call.



Note that,in diagram (4.33), the slope of AB equals the slope of A'B' (with the opposite sign), and both are less than 1.

Diagram 4.33 :Hedging Against Exposure Under Scenario 6 Using A Partial Coverage Call.



By buying a partial coverage call with exercise price A and selling the same partial coverage call with different exercise price (B), one obtains a partial coverage 1:1 bull call spread.This strategy is depicted in diagram (4.34).

Diagram 4.34:A Partial Coverage 1:1 Bull Call Spread Compared With An Ordinary Bull Call Spread.

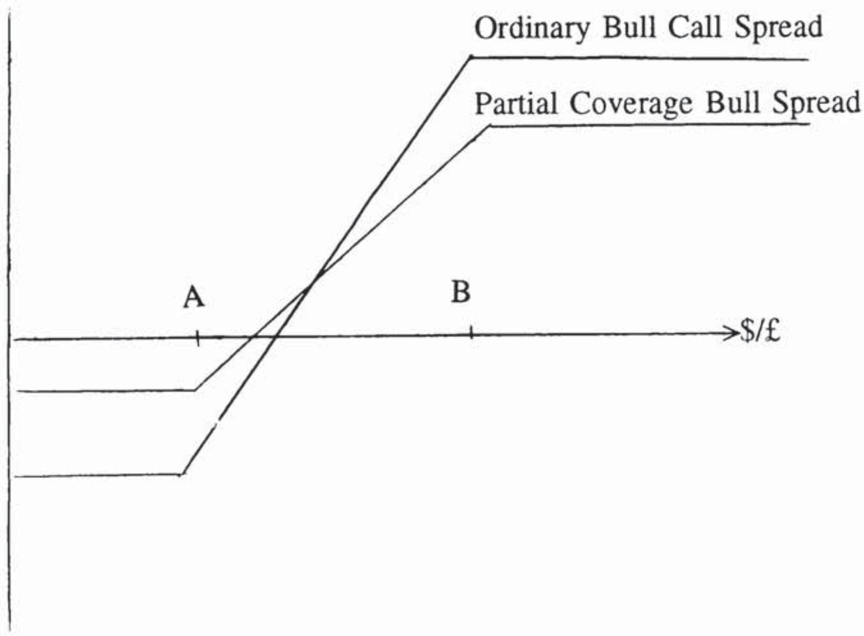
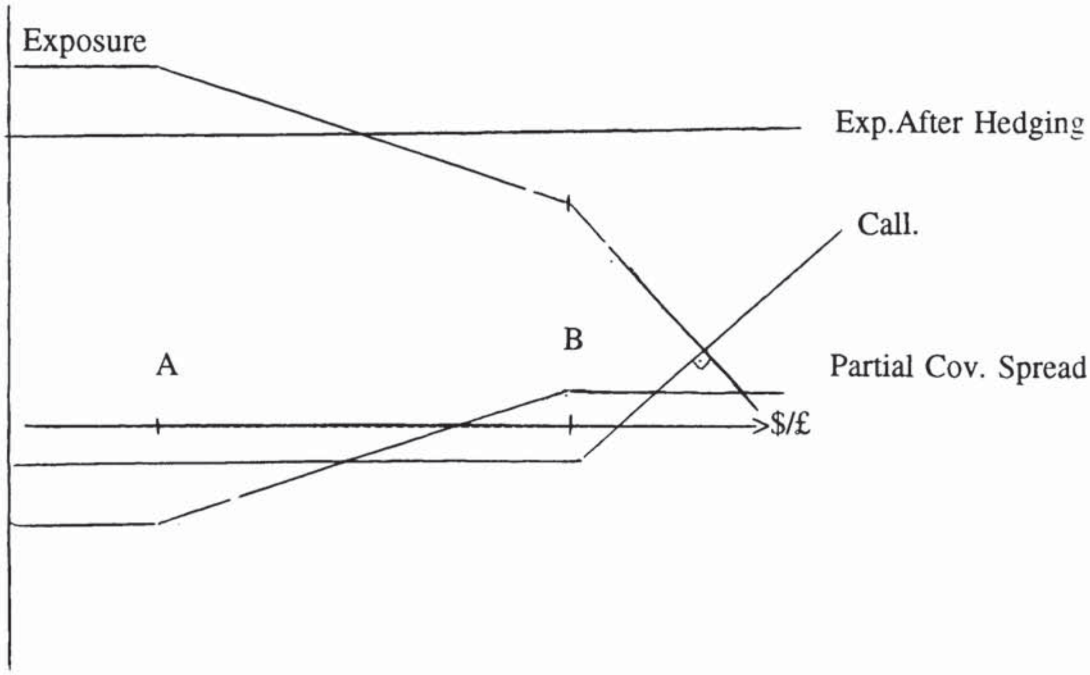


Diagram (4.35) depicts the hedging of exposure under scenario 4, using a 1:1 partial coverage bull call spread.

Another type of hybrid options is the cylinder option, a specific case of which is the Range Forward Contract, widely traded by Salomon Brothers.

Diagram 4.35.Hedging Against Exposure Under Scenario 4, Using A 1:1 Partial Coverage Bull Call Spread.



Generally, a cylinder option consists of a long position in a A-call and a short position in a B-put. The exercise prices can be properly arranged, so that the net up-front premium is according to the firm's requirements. This implies that, for two particular exercise prices the up front premium is zero (i.e. the premium of call bought is the same as the premium of the put sold).This cylinder is called a Range Forward contract.

A cylinder option's profile is given in diagram (4.36).

Diagram 4.36: A Cylinder Option.

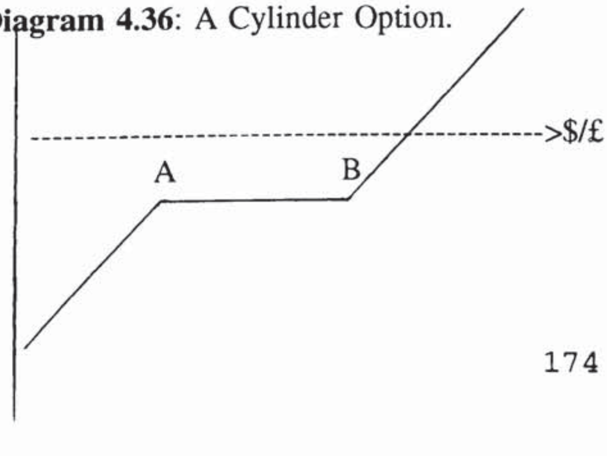
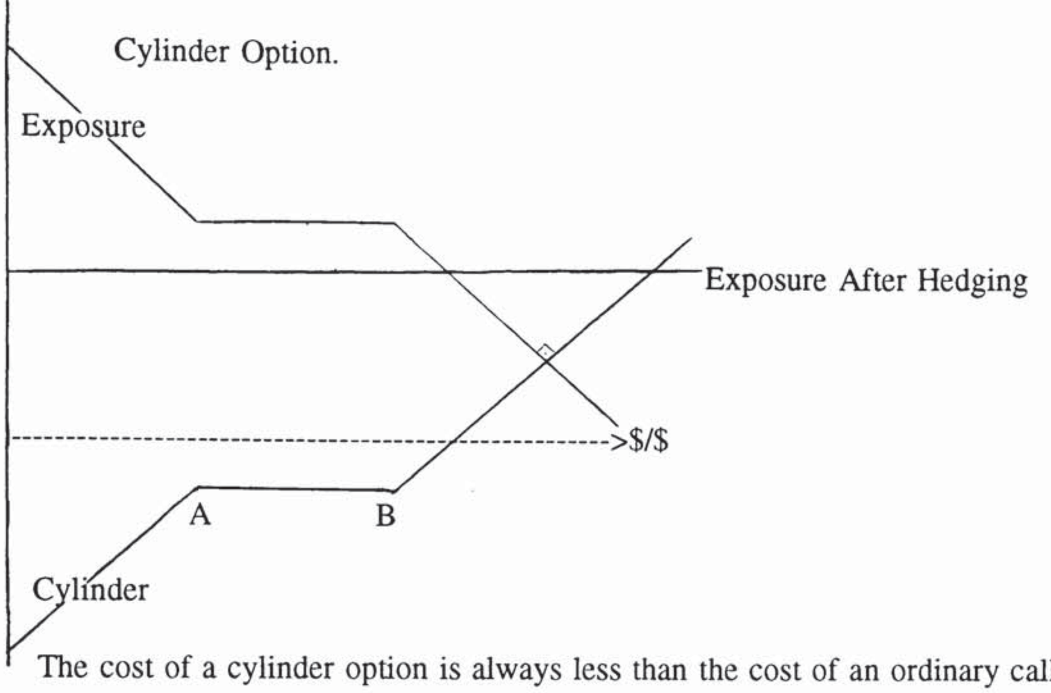


Diagram 4.37:Hedging Against Exposure Under Scenario 3, Using A Cylinder Option.



The cost of a cylinder option is always less than the cost of an ordinary call, but it may lead to unlimited losses, for exchange rates on the left of A [diagram (4.36)]. A cylinder option can be used to hedge the exposure depicted in diagram (4.13).Diagram (4.37) depicts this case.

In general, a firm that has an efficient production technology (and thus, is partially hedged) will tend to use a partial coverage hybrid option to hedge its operating exposure.If a firm prefers higher profit margins to market expansion, it will tend to hedge exposure using a Range Forward contract.

The overall conclusion of this section is that, one can combine the very many option profiles to obtain complex hedging scenarios, that optimally fit different types of market structures, relative production efficiency and firm's preferences over the choice between higher short term profit margins and long term market expansion.These hedging scenarios can not be achieved by real options.Thus, this section provides another reason why financial (currency) options should be preferred to real options, when it comes to hedging operating exposure.

4.7. Hedging Operating Exposure Using An Opposite Transaction Exposure. Is It Possible?

As an alternative way to real or currency options hedging against operating exposure, one could raise the question whether, operating exposure can be combined with an opposite transaction exposure, so that the overall result will be a simultaneous hedging against both exposures. The argument is based on diagram (1.3) of chapter 1, reproduced here in diagram (4.38). As transaction exposure (that refers to the credit award period) comes after the time in which operating exposure (that refers to the period from the beginning of the production process until the selling agreement) arises, one could ask if a negative operating exposure (over the period, say T_2) can be offset by a potentially positive transaction exposure at this period (that follows the operating exposure that was relevant in time T_1). One assumption on which the consideration of this argument can be based, is that the credit award period should equal the period that the firm takes, from the time it starts its production operations to the time it sells its output.

Diagram 4.38: The Time Pattern of Transaction And Operating Exposures.

```
T0          T1            T2              T3          T4 ...
|-------------|---------------|---------------|----------| ...
 Operating  | Transaction  |
 Exposure   | Exposure     |
-----------------------------------------------------------
              | Operating    | Transaction  | .....
              | Exposure     | Exposure     | .....
```

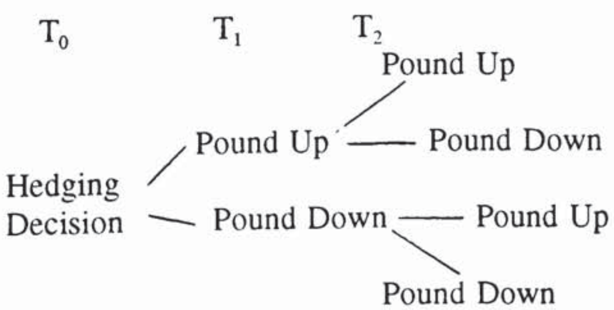
One initial problem that impairs the plausibility of constructing a portfolio of offsetting transaction and operating exposures, is that the former is due to nominal exchange rates changes, whereas the latter is due to real exchange rates changes.This problem is overcome when the inflation rates in the countries concerned are the same.

The next question is the covariance of transaction exposure, with regards to operating exposure. A portfolio consisting of both exposures can lead to a simultaneous reduction of both, if their covariance is close to -1.But this does not seem to be the case for an exporting firm with foreign currency receivables. Let's focus on the period from T_1 to T_2.The firm has a foreign currency receivable to be collected at T_2.At the same time. it undertakes production for the next period, and thus, has an operating exposure at T_2.If the pound appreciates at T_2, the domestic currency value of the foreign currency receivable is reduced (negative transaction exposure), and at the same time, the export price is also reduced (negative operating exposure). Therefore, it appears that the two exposures have the same sign (and thus, their covariance is rather positive).Consequently, one should rule out the possibility of constructing such a portfolio.

One final question is whether one can obtain a hedging instrument, to hedge both transaction and operating exposures, implying that there is no need to consider operating exposure hedging separately.With regards to diagram (4.38), the question is whether one can take a hedging instrument at T_0, to hedge both exposures up to time T_2.

The answer to this question is based on diagram (4.39).

Diagram 4.39.Exchange Rate Projections For A Unique Hedging Decision Against Both Transaction And Operating Exposures.



Any hedging decision should be made at T_0. At T_1 (when the operating exposure period ends), the pound could be either appreciated or depreciated. This also applies for the end of period T_2.

The different hedging instruments which can be used at T_0 (to cover the period up to T_1) are:

- a forward contract,

-a currency option contract,

- an option on a future contract[17],

-a compound option[18].

If we use a forward contract, we effectively assume that operating exposure (period T_0 - T_1) is symmetric.On the basis of the analysis of chapter 2, this may not be the case, and thus, the use of a forward contract is ruled out.

Using a currency option for the whole period implies that transaction exposure is hedged by an option.Due to the symmetric profile of this exposure, however, forward contracts should be preferred.Thus, a unique (single) currency option contract is again ruled out.

The same applies to the use of a compound option.

The case of an option on futures is,initially, more promising. If the pound appreciates at T_1, the option will be exercised, and the futures contracts will be delivered.Some of them will be sold to offset the possible export price losses, and the remainder will be held until T_2 to hedge transaction exposure.But problems arise if the pound depreciates.In this case, the option will expire worthless and no futures will be delivered.This implies that the transaction exposure that may potentially arise at T_2 due to a subsequent pound appreciation, will be completely unhedged.

The conclusion of this section is that, each type of exposure should be 'isolated' from each other and optimally hedged separately. With regards to hedging operating exposure, this section reinforces the role of currency options, as the latter appear to be the most efficient of all the alternatives considered here.

4.8. Conclusion

This chapter discussed several alternatives for hedging operating exposure.It showed that operating exposure for an exporting firm with costs in its domestic currency, can not be hedged by an offsetting transaction exposure, and any hedging instrument should target operating exposure, on an individual basis.To meet this aim, firms have two different types of hedging instruments:real options and currency options.Real options may be efficient in the long term, but rather inflexible in the short term.Further, they do not provide any flexibility to hedge different types of exposure, due to different market structures, relative production efficiencies and preferences over corporate goals.Finally, the choice of real options may affect the overall strategic policy of the firm, targeting to minimise overall business risks and not only exchange rate risks.It is expected that, when one (strategic) hedging tool is used to serve two goals (minimisation of both exchange rate and business risk), several complexities may arise over the decision making process.

Currency options seem to overcome most of the shortcomings of real options.They offer both time flexibility (implying easy short term manipulation and monitoring of the hedging strategy) and marketing flexibility, in terms of constructing different packages of bid offers in the overseas market.

The recent boost in the use of currency options in hedging exchange rate risks is associated with a general growth of the financial engineering industry, producing financial instruments for hedging against interest rate, exchange rate or even business risks.According to Keller (1989), recently, there has been a tendency for corporate treasurers to use financial hedging against economic recession.Prior to the development of such instruments, the only way of hedging such risk was to develop an efficient strategic expansion in various industries (or countries).The idea in this chapter is that the benefits of the growing financial engineering industry should be recognised for the case of hedging against exchange rate operating risks.

NOTES

1.Kester (1984) mentions that, the DCF model provides an underestimate of the real market value of real options.Hayes and Abbenarthy (1988) state that, the adoption of this valuation model by USA firms has led them to misjudge investment projects with significant growth opportunities, implying that the DCF model misses future expansion , and thus, takes a rather short term view in project's profitability.

2.This approach for hedging operating exposure is based on the argument that, since operating exposure is a real (production or market based) problem, real (production or market based) hedges should be used for eliminating this exposure.

3.Over the period from 1973 to 1990, there have been two periods (1978-1980 and 1985-1988) over which UK exporters to the USA have faced operating exposure, due to the pound appreciation vsv the dollar.If some of those exporters had established production operations in the USA, they could have found themselves at a competitive disadvantage during the period from 1980-1984, when the pound steadily depreciated vsv the dollar.

4.See Appendix A, section (A.2).

5.In exhibit 4, in Adler and Dumas's 1984 paper, if we assign different probabilities to the future exchange rate outcomes, we will end up with different exposure measures.

6.See McDonald and Siegel (1985), who analysed and valued the option of manufacturers to shut down a plant, when output price falls below variable costs.

7.Myers and Majd (1983).

8.See McDonald and Siegel (1985, 1986), Myers and Pindyck (1987).

9.In this case, the plant in the UK can be seen as a real option, and can be valued using option valuation techniques in line with McDonald and Siegel (1985).This can be an area for future research on real options.

10.In the financial literature, a hedge ratio is the ratio of units of the hedging instrument per unit of the underlying security to be hedged.Here, by hedge ratios, we mean the number of options per unit of commodity to be exported overseas.

11.See Copeland and Weston (1988).

12.This result is compatible with the traditional theory of hedging, that contends that hedge ratios should always be 1. See Ederington (1979).

13.For the OTC market , see Appendix A.

14.We deal only with 'large' (significant) exchange rate movements, that result in high intrinsic value increases in the call prices.

15.The concept of financial engineering is compatible for interest rate, exchange rate and stock derivatives.Some examples of such derivatives are:caps, floors, swapoptions. Asian options, collars, index options, limit options,lookback options, etc. For definitions, see:'The Mitsubishi Finance Risk Directory', 1990/91, Mitsubishi Finance International,plc, Mitsubishi bank.

16.Citibank and Salomon Brothers are reported by Croughy and Briys (1988) to trade various versions of hybrid options. Further, many French banks are reported to have been actively competing themselves to market various types of hybrid options, such as the Participating Forward and the Conditional Forward.For an analysis of these instruments, see Croughy and Briys (1988).

17.An option on a currency future gives the holder the right but not the obligation to obtain a currency future at a predetermined exercise rate, at a predetermined expiration date.In fact, an option on a future is the same as an option on currency, with the only exception that, under the former contract, we have futures contract exchange, whereas in the latter, we have currency exchange.For options on currency futures, see Tucker (1991).

18.A compound option is an option on another option.It is similar to an option on currency, with the only exception, that under the former contract, an option is exchanged (if the initial option is exercised), whereas under the latter contract, physical currency is exercised. For more on compound options, see Tucker (1991).

CHAPTER 5.

FORECASTING EXCHANGE RATE VOLATILITY FOR PRICING OTC CURRENCY OPTIONS.

5.1.Introduction

As proposed in chapter 4, firms may hedge their exchange rate operating exposure utilising the Over The Counter (OTC) currency options market.Currency options prices are not publicly available for this market.As will be illustrated later in the chapter, (ordinary) currency options in this market are priced on the basis of the Garman-Kohlhagen European call option formula.The problem that arises here, is that one of the parameters appearing in this formula is not directly observed.This parameter is the future exchange rate volatility (risk).If we do not have a forecast on this parameter, we can not calculate option prices, gains on options and thus hedge ratios (see chapter 4).Further, we can not proceed towards an empirical evaluation of the hedging performance of currency options, which is to appear in chapter 6. It is obvious that a good method of estimating future volatility is essential for both option traders and hedging firms.

This chapter deals with two methods for estimating future exchange rate risk.First, it deals with historical volatilities, and second, with volatilities implied by option prices in organised markets.After comparing the two approaches, some conclusions are drawn, upon which measure should be used by currency option traders in the OTC market and by firms, when negotiating the price of an option.

The chapter addresses the question of how to forecast future quarterly (as opposed to daily or monthly) average exchange rate volatility. It focuses on quarterly data, in order to be consistent with the empirical work in chapter 3 (which addressed the issue of the effects of quarterly average exchange rates on export prices), and chapter 6 which will focus on the effectiveness of an empirical hedging scenario assumed to be taken every three months.

5.2. Historical Volatilities.

5.2.1.Methodological Issues.

One simple (and rather naive) way of estimating future exchange rate volatility is to calculate the past variability on the basis of actual (realised) exchange rates, and take this measure as a forecast of the future volatility. This approach is termed 'historical' volatility, and implicitly assumes that the volatility of exchange rates is stable over time, and thus, past evidence describes well future expectations.

Several researchers [see Pattell and Wolfson, (1982)] contend, however, that important informational events (such as inflation rate announcements, interest rate announcements or political events) can alter the stability feature of exchange rate volatility.

Furthermore, Tucker (1988) argues that volatility can be heteroscedastic (i.e. dependent on the level of exchange rate itself), and thus, non-constant.For example,it is true that for a country with high national debt, a currency depreciation may increase the future exchange rate variability, on the grounds that the burden of paying back debt is increasing.An example where the volatility can be heteroscedastic is provided by Fitzgerald (1987).Over the period from January 1985 to January 1986, when the pound fell to $1.05, its lowest level ever against the dollar, the exchange rate variability moved from 14% at the beginning of the period to as high as 22% ,and back to around 12% in December 1985. This indicates that historical volatility needs to be adjusted to new information.In general, any exchange rate change caused by new information related to Balance of Trade effects may alter future volatility.News about the economic prospects (income, growth, unemployment) may also affect exchange rate volatility.Finally, government action (such as the pegging period of the £ vsv the DM, followed by the then Chancellor Nigel Lawson over the second half of the 1980's) may also affect volatility.

Moving towards some practical issues in calculating historical volatilities, one may face the following questions:

a.Should historical volatilities be measured over long-term or short-term periods?

b.Should we calculate historical volatilities of exchange rate levels or exchange rate changes?

c.Can we adopt the standard deviation measure for calculating historical volatilities?

The first question addresses the issue of how far back one should go for measuring historical volatilities.Shastri and Tandon (1986) and Fung,Lie and Moreno (1990) take a 40-day historical volatility measure.Based on daily data, Glassman (1987) argues that both 5-day and 65-day volatilities are important for traders.

The question, as to whether exchange rate levels or exchange rate changes should be used, has to do with the statistical distribution of exchange rates.Meese and Singleton (1982) and Boothe and Glassman (1987) find that time series of exchange rate levels are non stationary, but that the first differences are. On the basis of this evidence, the volatility measures should be calculated from exchange rate changes.

The final question is which measure of exchange rate volatility should be adopted.If the exchange rate distribution is normal, then a reasonable measure of volatility can be the standard deviation.However, past evidence supports the view that the distribution is not normal.Mussa (1979) uses weekly data and finds skewness in exchange rates, attributable to periods of quiescence followed by periods of turbulence.Using daily and weekly data, Cosset and Rianderie (1985) find skewness in the distribution.Skewness was also observed by Domowitz and Hakkio (1985).Westerfield (1978) finds significant kurtosis in the exchange rate distribution.This evidence imposes some restrictions in using the standard deviation as a measure of volatility.If the distribution is not normal, further moments are required to describe it[1].

As the question of the exchange rate distribution is an empirical issue, we turn to testing whether quarterly average exchange rates follow the normal 'law'.If the answer is yes, then the adoption of the standard deviation for measuring volatility can be justified. Before that, some comments should be made on how we choose the periods for calculating historical volatilities.To estimate the historical volatility for the first quarter (1980/III), we focus on the period from 1975/I to 1980/II.[This period was chosen to start in 1975, and not earlier, in order to allow for a relatively sufficient time gap after the collapse of the Bretton Woods System].This time span includes 22 quarters.To estimate the historical volatility for the second quarter (1980/IV), we focus on the 22-quarter period from 1975/II to 1980/III. The same procedure is followed for subsequent quarters.

5.2.2.Testing The Normality Hypothesis Of The Distribution Of The Quarterly Average Exchange Rate Between The £ And The \$.

In general,there are two types of tests for the normality hypothesis of a sample of observations:

a.The x^2-test of goodness of fit.This test can be used when the sample size is relatively large [Snedecor and Cochran, (1980)].

b.Certain functions of the moments of the sample are calculated and the significance of their departure from the normality conditions is examined.

As each of the periods, over which we want to test the normality hypothesis, consists of 22 quarterly observations,we focus on the second type of test.

To carry out this test, we need to compute two statistics and test their statistical significance, as to if they are compatible with the normality conditions.

The statistic for skewness is

$$b = \frac{m_3}{m_2 * (m_2)^{1/2}} \qquad (5.1)$$

where

b :the statistic for skewness

m_3: the third moment around the mean

m_2:the second moment around the mean

For small sample sizes (25-200), we can test whether the calculated value of b is compatible with the assumption that there is no skewness in the distribution, by comparing this value with the critical value of the distribution of b, that can be found in Table A 20 (i), in Snedecor and Cochran (1980).

In this table, the critical values of the distribution of b are provided for sample sizes higher than 25.Interpolating backwards for a sample size of 22, an approximate critical value of b is obtained,with which we compare the calculated value of b.The 5% percentage point of the distribution of b is about .775 and the 1% point is about 1.15.If the calculated value of b is higher than these critical values, then we reject the normality assumption, and accept that some degree of skewness exists.

The results of the calculated b are reported for each period in table (5.1).Of the 45 cases tested, only 7 appear to be subject to skewness, on the basis of the 5% percentage point.At the 1% point, there was no period for which skewness was traced.For those cases for which skewness was apparent (at the 5% point), the value of b was not very different from the approximate critical value (.775), with the exception of three periods: 1976/IV-1982/I (b=1.14), 1976/III-1981/IV (b=1.0) and 1977/I-1982/III (b=.95).

Overall, we can accept that there is not much skewness in the exchange rate distribution,over the periods depicted in table (5.1).

We now turn to testing the normality hypothesis, with regards to kurtosis.

The statistic for kurtosis, used in this work, is the one proposed by Geary and reproduced by Snedecor and Cochran (1980).This test is suitable for small samples.It involves the computation of the following statistic:

$$a=\frac{\sum |X_i-X|}{n^*\ m_2} \qquad (5.2)$$

where
a :the statistic for kurtosis

Xi :$\log(E_t/E_{t-1})$

X :average of X_i

m_2 :second moment around the mean

n :the sample size (n=21)[3]

The Table with the critical values of the distribution of a, at 5% and 1% points, is found in Snedecor and Cochran (1980).As the distribution of 'a' is not symmetric, both lower and upper critical values are provided.For n=21, and at 5% upper and lower points, the critical values are .8768 and .7304 respectively.

The normality hypothesis for kurtosis can not be rejected,if the calculated value of 'a' is lower than .8768 and greater than .7304.

TABLE 5.1

TESTING THE NORMALITY HYPOTHESIS OF THE EXCHANGE RATE DISTRIBUTION.

Period	b	a	Period	b	a
1975/I- 80/II	-.42	.86	1981/I-86/II	.54	.77
1975/II-80/III	-.57	.85	1981/II-86/III	.56	.77
1975/III-80/IV	-.66	.82	1981/III-86/IV	.91*	.78
1975/IV-81/I	-.67	.82	1981/IV-87/I	.83*	.80
1976/I-81/II	-.75	.82	1982/I-87/II	.63	.84
1976/II-81/III	-.87*	.81	1982/II-87/III	.60	.83
1976/III-81/IV	-1.0*	.80	1982/III-87/IV	.40	.86
1976/IV-82/I	-1.1*	.78	1982/IV-88/I	.27	.85
1977/I-82/II	-.95*	.79	1983/I-88/II	.20	.85
1977/II-82/III	-.84*	.82	1983/II-88/III	.23	.86
1977/III-82/IV	-.86*	.85	1983/III-88/IV	.06	.87
1977/IV-83/I	-.47	.86	1983/IV-89/I	.06	.87
1978/I-83/II	-.52	.85	1984/I-89/II	.06	.87
1978/II-83/III	-.57	.84	1984/II-89/III	.05	.87
1978/III-83/IV	-.51	.83	1984/III-89/IV	.01	.86
1978/IV-84/I	-.41	.80	1984/IV-90/I	-.1	.86
1979/I-84/II	-.31	.78	1985/I-90/II	-.01	.84
1979/II-84/III	-.12	.76	1985/II-90/III	-.2	.84
1979/III-84/IV	-.25	.75	1985/III-90/IV	-.24	.84
1979/IV-85/I	-.16	.77	1985/IV-91/I	-.01	.84
1980/I-85/II	.68	.71+	1986/I-91/II	-.32	.83
1980/II-85/III	.71	.73			
1980/III-85/IV	.72	.73			
1980/IV-86/I	.72	.73			

+ : Leptokurtic distribution   * :Skewed distribution.

From an inspection of table (5.1), which also reports the calculated values for 'a',one can see that there is only one case (period 1980/I-1985/II), for which the value of this statistic was not compatible with the normality hypothesis (in fact, the distribution appeared to be leptokurtic over that period.

Overall, there is no evidence to suggest non normality.This result is in contradiction to the findings of previous researchers mentioned earlier, according to which, the distribution of exchange rates, on the basis of daily or weekly data, appears to be far from normal.

One possible explanation of this discrepancy may be the time dimension of the data.The data employed here is quarterly average observations.It may be possible, that the averaging process in this data may eliminate any effects of extreme values upon the shape of the distribution.Focusing on (end-of-period) daily or weekly data, one can expect to face more extreme values than focusing on average quarterly data.It may be these extreme values that cause skewness and/or kurtosis. Using quarterly average observations, the absence of many extreme values may make the shape of the distribution look closer to the shape of the normal distribution.

Finally, the results of this section overwhelmingly support the use of the standard deviation for measuring historical volatilities.

5.2.3. Calculating Historical Volatilities.

With our objective being the estimation of the actual volatility at the i-th quarter using the historical volatility approach, the actual past quarterly exchange rates are considered and the annualised standard deviation is calculated,using the formula:

$$HSD_i = (4)^{1/2} * [S_{t=1}^{21}(R_t - R)^2 * (1/20)]^{1/2} \qquad (5.3)$$

where:

HSD_i :the historical volatility for quarter - i.

R_t :$\log(E_t/E_{t-1})$

$E_{t,t-1}$:the exchange rates at t, t-1

R :the average of R_t

$4^{1/2}$:to express HSD at an annualised basis.

Take,for example, the first quarter in the sample:1980/III.The expected annualised volatility for this quarter can be set equal to the actual volatility of exchange rates, that prevailed over the period from 1975/I through to 1980/II.For the next quarter (1980/IV), the annualised volatility can be set equal to the volatility of actual exchange rates, that prevailed over the period from 1975/II through to 1980/III, and so on.Thus, for each quarter from the period 1980/III up to 1991/IV, the historical standard deviation can be calculated, on a roll-over basis.

5.3.Implied Volatilities

5.3.1. The Central Idea.

The approach for estimating future volatility is based on the market value of currency options traded in organised markets, along with the assumption that these markets are efficient,and thus,the market option prices can be exactly replicated by a theoretical pricing model. Also embodied, is the assumption that the other parameters involved in the valuation formula are measured with accuracy. Therefore, if the market value of a currency option is available, the option valuation model (see below) can be solved, with respect to the (market assigned) exchange rate volatility (standard deviation).To estimate the exchange rate volatility for a specific quarter, the price of a currency option with an expiration time in three months must be considered, at the end of the previous quarter.

Although this approach is more reasonable than the historical method, there are some critical issues on which the accuracy of the volatilities, implied by the option prices, is dependant.These issues will be discussed in a following section of this chapter.

If implied volatilities turn out to be more accurate than historical volatilities, examination should be made, as to which type of options (i.e.out-of the money,at-the-money or in-the-money) gives the best (more accurate) forecast of the actual volatility.

Before proceeding towards a formal discussion on these issues, a brief outline of the basics of the currency options pricing is in order.

5.3.2. The Pricing Of Currency Options.

In the option pricing literature,the breakthrough came in 1973, when Black and Scholes published their seminal work on pricing European stock options[4].One of the assumptions embodied in their model is that the stock pays no dividends.Merton (1973) relaxed this assumption and derived an option valuation formula for an option that pays a fixed dividend.This formula is the basis of (and in fact, the same as) the formula used for pricing currency options.In fact, one may view a foreign currency as a stock that pays a constant dividend.The latter corresponds to the interest rate that can be earned on the foreign currency, if deposited in an interest bearing account.

The basic idea, on which the derivation of the valuation model was based, is that one can form a riskless portfolio (which earns the riskless rate of interest), if one has a long position in a foreign bond, a short position in a domestic bond and sells the proper amount of calls (known as delta)[5] on the foreign currency. The importance of this insight is that, it is not necessary to make any assumptions about the expectations on the exchange rate movements.What is required only, is the assumption that the option value is a function of the underlying asset (exchange rate).

Thus, focusing on the case of a European currency option (that can be exercised only at the expiration day), and assuming that:

-the foreign exchange rate follows a Geometric Brownian Motion, implying that the exchange rate distribution is lognormal[6],

-the foreign market operates continuously,

-there are no transaction costs and/or taxes (and no bid-ask spreads),

-the risk free interest rates are constant, both abroad and in the home country, over the life of the option,

-there are no penalties for short-sales,

Biger and Hull(1983), Garman and Kohlhagen (1983) and Grabbe (1983) developed the following option valuation model for European calls on foreign currency[7] :

$$C = \exp(-r_f * T) * S * N(d_1) - \exp(-r_d * T) * X * N(d_2) \qquad (5.4)$$

$$d_1 = \frac{\ln (S/X) + [(r_d - r_f) + (c^2/2)*T]}{c * (T)^{1/2}}$$

$$d_2 = d_1 - c * (T)^{1/2}$$

where:

C :the European call option price

exp (a) = e^a,

r_f:the foreign (£) interest rate,

S :the spot exchange rate,

r_d:the domestic ($), risk free interest rate,

X :the exercise price

c^2:the volatility of the proportional change of the exchange rate.

T :time until the option's volatility expressed as a percentage of the year.

N(.):the normal cumulative probability evaluated at d_1 and d_2.

In the above model, there are six valuation parameters involved:S, X, t, r_f, r_d and c^2.Of these, only the last is not observable.Having the first five parameters and the option price available, one can solve the model with respect to c^2 and obtain a market estimate of the future exchange rate volatility, which refers to the period until the expiration of the option.This volatility is the implied volatility.

Having obtained the value of the European call, one can obtain the value of the European put, with the same valuation parameters as the call,through the Put-Call Parity[8].

The European Put valuation model is given by (5.5).

$$P = X * \exp(-r_d * T) * N(-d_2) - S * \exp(-r_f * T) * N(-d_1) \qquad (5.5)$$

where

P :the value of the European put .

5.3.3. Problems Associated With The Use Of Currency Options Formulae For Deriving Implied Volatilities.

Is the formula correct? The derivation of the currency option model is critical on the assumption that exchange rates follow the lognormal distribution. As pointed out earlier in this chapter, previous work on the exchange rate distribution rejects the hypothesis that exchange rates follow the normal 'law'. Tucker, Peterson and Scott (1988) question the accuracy of the models (5.4) and (5.5).They argue that, the exchange rates do not follow a Geometric Brownian motion, and propose an alternative currency option model that is based on the assumption of a constant elasticity of variance. This model is expected to account for the mispricings of currency options, that are due to the adoption of the models (5.4) and (5.5) which have been indicated by previous research.The implication of this observation is that, if the true exchange rate distribution is not that assumed by (5.4) and (5.5), then the implied volatilities derived by equating actual prices with model prices will be wrong, and thus, relatively poor estimates of actual volatilities.

Another assumption, on which the models (5.4) and (5.5) are based, is the stability of interest rates over the life of the option.Clearly, if either the foreign interest rate or the domestic interest rate changes, the option price will be affected.The interest rate driven option price effect will be depicted on the implied volatility, which will then differ from the actual one.

Accuracy Of Inputs To Enter Into The Formula. As stated above, the formulae given by (5.4) and (5.5) were developed under the assumption of no transaction costs and bid ask spreads.As bid ask spreads are a real issue for both exchange rates and interest rates, one should choose which part of the spread to enter into the valuation model.

As stated earlier, the construction of the riskless portfolio, consisted of a short position in a domestic bond (foreign bond), a long position in a foreign bond (domestic bond) and a short (long) position in delta calls, is the basis for developing the valuation model in (5.4).The relevant part of the spreads to enter into the valuation model is related to which of these two strategies one assumes underlines the option pricing determination. If one assumes that the option pricing is based on borrowing domestic currency($), selling delta calls in £, buying foreign currency(£) and lending the balance , then the relevant set of spreads is:

-offer interest rate on $,

-offer exchange rate,

-bid price of currency option,

-bid interest rate on £.

If one assumes that the call option price is determined by borrowing foreign currency (£), selling this currency for dollars, buying delta calls on £ and lending the balance, then the relevant spreads are:

-offer interest rate on £,

-bid exchange rate,

-offer price of the currency option,

-bid interest rate on $.

In equilibrium, both sets of bid-ask quotations should lead to the same implied volatility.The critical point is the consistent use of either the first or the second group of spreads,and not mixing the two groups together.

When either of the three categories of bid-ask spreads (on exchange rates, interest rates and currency options) is not available, an approximate solution would be to take mid-points in each spread quote.

Market Efficiency. The most significant assumption, behind using implied volatilities as proxies for actual volatilities, is the market efficiency, that is the assumption that market prices can exactly be replicated by the theoretical pricing model (given that this model is correct).If the market is not efficient, then it would not be legitimate to equate market prices with model prices for deriving implied volatilities.By doing so, the implied volatilities obtained, will be poor forecasts of the actual volatilities.

Tests of the currency options market efficiency can be classified into two categories:boundary tests[9] and exact pricing tests. Boundary tests examine whether the actual market prices fall within two boundaries, between which, arbitrage opportunities do not exist (rational option pricing).These tests avoid the requirement of specifying a stochastic process for the exchange rates, and thus, escape from the criticism that exchange rates do not follow the outlined distribution.

Exact pricing tests examine the point accuracy of the theoretical model. after specifying an exchange rate distribution.

Many studies have examined the issue of the efficiency of the currency options market.The critical point in this issue is the use of simultaneously determined data on exchange rates, interest rates and currency option prices.In an extensive study on boundary conditions, Bodurtha and Courtandon (1986) contend that the currency option market in the Philadelphia Stock Exchange is efficient, if simultaneous data is used and there is an allowance for transaction costs.When end of day data is used, then there is some indication of arbitrage opportunities.Shastri and Tandon (1985) conduct a boundary test and reach the same conclusion using, end of day data and no transaction costs.Tucker (1984) uses intraday data and conducts both a boundary test and a test of exact pricing.He finds no evidence of arbitrage profits. Shastri and Tandon (1986), using end of day data, find that mispricings exist, implying that either arbitrage profits can be realised in the currency options market or the pricing model in (5.4) is incorrect.

For this study, intraday data was not available.Instead, end of day data is used.This imposes the problem of non-simultaneous data on exchange rates, interest rates and currency options prices.

The exchange rates used here are last trade quotes obtained from the Financial Times, and reflect the position of the London exchange market at 5.00 p.m.for every trading day.The currency options prices are also last trades quotes obtained from the Wall Street Journal, and reflect the market at 2.30 p.m. Eastern Time.Thus, taking into account the time difference between London and New York, there is an approximate 2-hour gap between the time that the exchange rate was recorded, and the time that the currency option price was recorded.Any exchange rate changes, that may occur in the New York exchange market over this two hour period, may affect the currency option market, but, will not be captured by our data.

To account for the findings of previous work, that market efficiency is reinforced when transaction costs are taken into account, these costs have been allowed for, prior to calculating the implied volatilities.An estimate of the transaction costs of the market maker in the Philadelphia Stock Exchange was obtained from Bodurtha and Courtandon (1986):

Options Clearing Corporation Initial Fee :\$0.05

Philadelphia Stock Exchange Broker Fee :\$2.00

Philadelphia Stock Exchange Fee :\$0.05

Philadelphia Stock Exchange Proportional Value Charge:0.12%

These costs are added to the quoted option price, and the total is then used as the market price for deriving implied volatilities.

Early Exercise Premium. The currency option valuation formula, previously outlined, was meant only for European options.In this study, the data on option prices refers to options traded in the Philadelphia Stock Exchange.These are American options (they can be exercised at any time until the option expiration).Clearly, as the American options carry the advantage of early exercise, they should be more valuable than their European counterparts. In fact, the American options price should be equal to the European option price plus a premium of early exercise.The latter is an increasing function of the probability of early exercise. For an American option with a low (high) early exercise probability, its price should be close to (different from) the price of a European option, with the same valuation parameters.Therefore, if the early exercise probability (and thus. the early exercise premium) of an American option is high, one can not use the European model to estimate the volatility implied by the premium of this option, as the relatively high option price will be (falsely) reflected as a higher volatility.This will make the implied volatility a poor forecast of the actual volatility.Consequently, the use of the European models given by formulae (5.4) and (5.5) is justified only for American options with low early exercise probability, and thus,early exercise premium.

Roll (1977) contends that calls on stocks feature low probability of early exercise, if the stock pays low dividend. Since a currency option can be seen as an option on an asset (foreign currency) that yields a fixed interest rate that corresponds to the dividend paid by a stock,one could extend Roll's conclusion to currency options: early exercise in call options is possible, if the foreign interest rate is relatively low.This argument was stated by Shastri and Tandon (1986), Adams and Wyatt(1987) and Jorion (1989).In fact, the early exercise probability (premium) is a function of the ratio of the two interest rates.The holder of the foreign currency should be seen as possessing a foreign bond (since he/she can always deposit it, to earn interest).A call holder may be induced to give up the time value of the option, if there is the potential to earn a relatively higher interest rate on the foreign currency.Thus, the higher the foreign currency (£) interest rate relative to the domestic interest rate, the higher the probability of (and the premium for) early exercise.Therefore, the higher the foreign interest rate compared with the domestic rate, the less accurate the implied volatilities obtained from American options premiums using the European pricing model.

If we now glance at diagrams (5.1) and (5.2), depicting the Eurocurrency interest

DIAGRAM 5.1

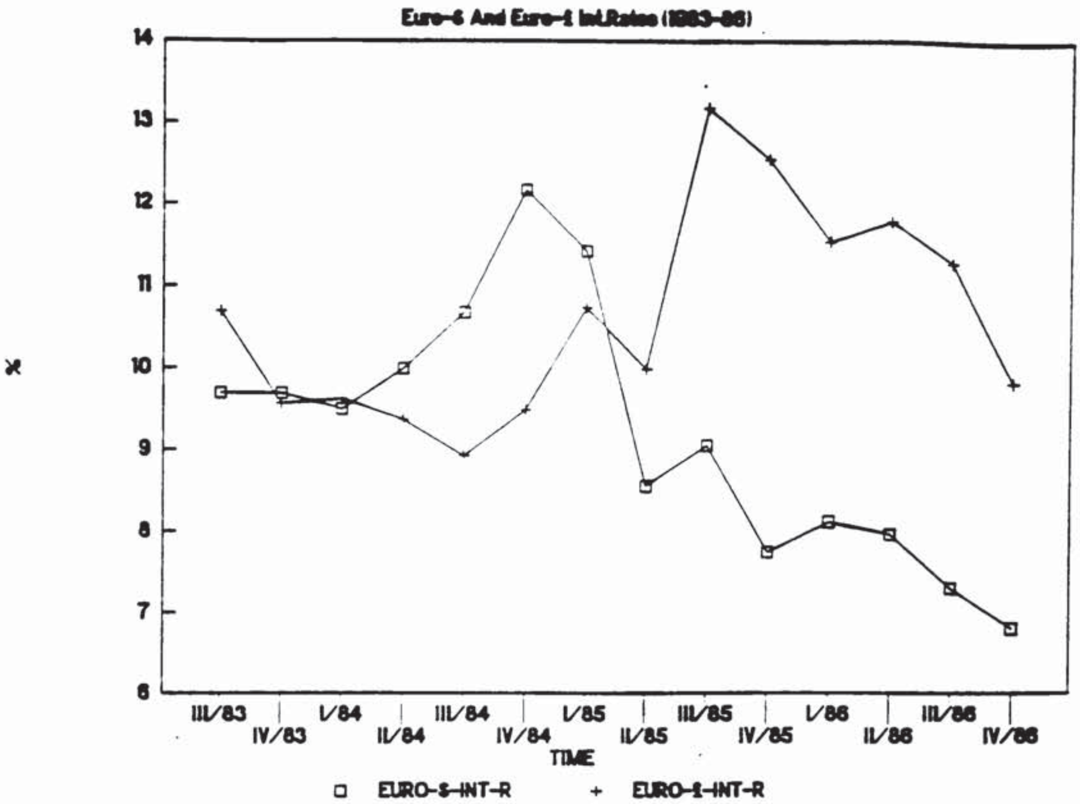
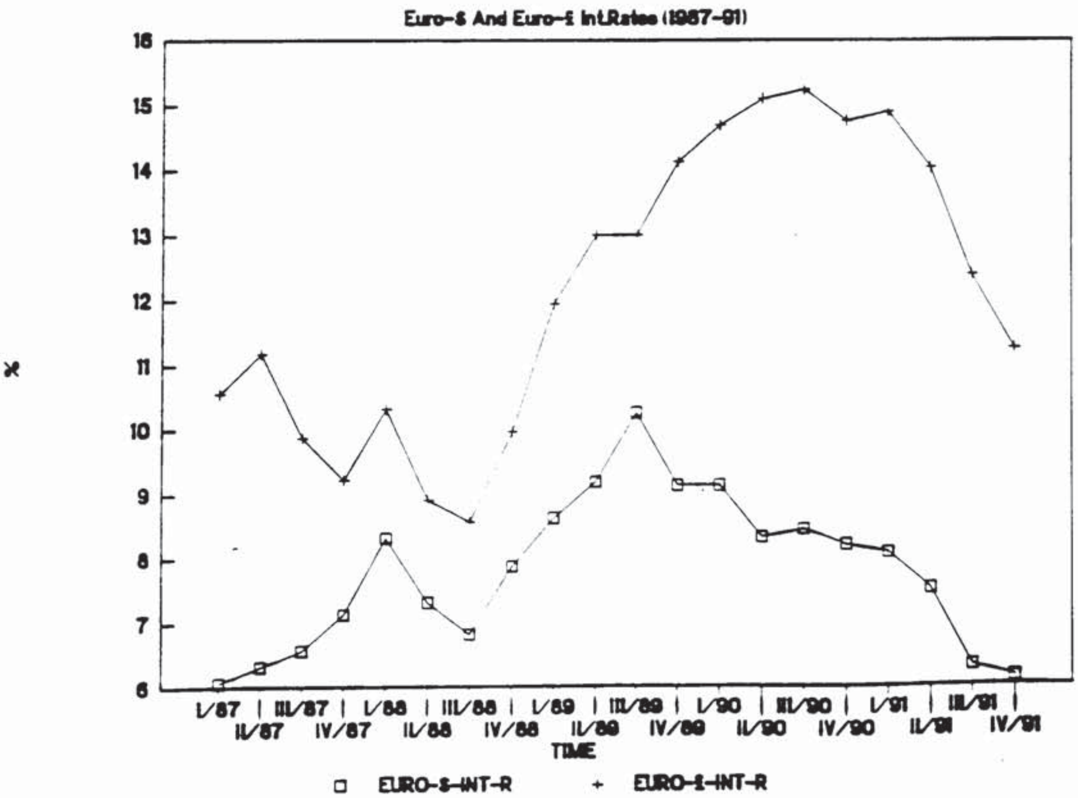


DIAGRAM 5.2



rates for the £ and \$, we can see that the £-interest rates were higher than the \$-interest rates, during the period from 1983 to 1991, with the exception of the period from 30/3/84 through to 28/9/1984.This imposes a real problem in using the European model to estimate volatilities implied by American options prices.Evidence by Adams and Wyatt (1987) and Shastri and Tandon (1986) indicates that the problem is significant when the calls are at- or in-the-money.The American feature premium is reduced when the call moves out-of-the money, and in fact, becomes zero for well (more than 15%) out-of-the money call options. The previous authors, as well as Jorion (1989) argue that, given the interest rate differential between the two currencies, the volatility and time to maturity,the more out-of-the money the call, the less its early exercise premium.

This insight can be used in this chapter, to avoid spurious misjudgments of the implied volatilities using the European model on American options data.Thus, the focus here will be given on well out-of-the-money calls.For the sake of comparison, at-the-money calls will be also considered.

Another way of neutralising the effects of the early exercise premium upon implied volatilities is to consider an American option pricing model, like the one reported by Tucker (1991).The disadvantage of this alternative is that the numerical manipulation of this model is very complicated.Further, there is some evidence by Adams and Wyatt (1987) and Bodurtha and Courtandon (1987) that for well out-of-the-money American calls, the use of an American model is not justified.In this case, the European model may lead to more accurate implied volatilities, in terms of forecasting actual volatilities. This piece of evidence, reinforces the use of the European model to estimate volatilities, implied by well out-of-the-money calls.

Although the use of the European model to estimate volatilities implied by calls is.

in general, problematic when the foreign interest rate is higher than the domestic rate, the use of this model on American puts is quite reasonable.When the foreign interest rate is higher than the domestic one, the early exercise probability of an American put is relatively low, and thus, the use of the European model is more justified.As the American put holder has the option to change at any time £s for dollars, he will never do so if the interest on the pound (foreign currency) is higher than the interest on the dollar. Thus, the probability of early exercise of the American put is relatively lower than that of the American call.On the basis of this, the European put option valuation model, depicted in (5.5), can be used to estimate volatilities implied by American puts.

Further, given the interest rate differentials, volatility and time to expiration , the degree that a put is out-of or in-the money may affect the early exercise premium,and thus, the accuracy of the volatility derived from model (5.5).The probability of early exercise increases as the put moves in the money, and decreases as it moves out of the money [Jorion, (1989)].The latter implies that one should expect more accurate (with regards to the minimisation of the early exercise premium) volatilities implied by out-of-the money puts.

The conclusion of this section is that, the adoption of the European currency option models, given in (5.4) and (5.5),can be acceptable for estimating volatilities implied by out-of-the money calls, out-of -, at- and in-the money puts.In the next section, volatilities implied by such options will be calculated. For comparison purposes, volatilities implied by at-the money calls will be also estimated.Each of these volatilities will be compared with the actual volatilities, and the one with the lower error will be chosen as the best predictor of the quarterly exchange rate volatility.

5.4.Actual Volatilities.

As stated earlier, the comparison between the different measures of volatilities is on a quarterly basis.Therefore, actual volatilities should refer to quarters and should give the annualised standard deviation of the actual daily or weekly exchange rates, over a specific quarter.The formula for calculating the actual volatility for each quarter is:

$$AV = [\ S_{i=1}^{k} (R_i - R) * \frac{1}{k}]^{1/2} * [54]^{1/2} \qquad (5.6)$$

where:

AV_i :the annualised actual volatility for the i-th quarter,

R_i :$\log(E_t/E_{t-1})$,

R :the average of R_i

$E_{t,t-1}$:the actual exchange rate at t, t-1.

k :the number of (weekly) exchange rate observations in the quarter.

54 :to express weekly actual volatilities at an annual basis.

The adoption of this formula for calculating actual volatilities makes the actual volatilities comparable with implied volatilities, as well as with historical volatilities. This is because all three measures of volatility refer to the standard deviation of the proportional exchange rate change, and not to the standard deviation of exchange rate levels.

5.5.Data Description.

Currency option prices were collected from the Financial Times and cover the period from the first quarter of 1983 through to the last quarter of 1991.Since the objective is to test the accuracy of implied volatilities on a quarterly basis, the focus is placed on the last trading day of each quarter, and a record is made of the market value of an option with maturity in three months.For example, to obtain an estimate of the implied volatility for the first quarter of 1988, we took the market value of a 3-month option that prevailed on 31 December 1987.As the expiration day of the options traded in the Philadelphia Stock Exchange is the Saturday before the third Wednesday of the expiration month, the implied volatility does nor refer to the whole quarter (until the 31st of March 1988), but omits the days between the option's expiration and the end of the quarter.For some options, for which prices were not available at the last trading day of the quarter, other dates close to the end of the quarter were chosen.This, however, may affect the implied volatility which is a function of changes to the time to maturity [Fung and Hsieh, (1991)].

Options prices were collected for both calls and puts, on the basis of the analysis of the previous section. With regards to out-of-the money calls and in-the-money puts, an attempt was made to avoid extreme exercise prices, as it is expected that a relatively low number of trades has occurred at those prices, rendering the market relatively 'thin', and thus, not reflecting market based volatilities.

Actual volatilities were calculated using weekly data, derived from the Datastream.

Interest rates on risk free bonds were approximated by Eurocurrency rates obtained from the Financial Times.

5.6. A priori Expectations and Tests.

Our objective is to choose the volatility measure which, when compared with the actual volatility,yields, on average, the minimum forecast error .The testing period spans 9 years (1983-1991),giving 36 quarterly observations.There are six series of different measures of future volatilities (historical volatility, and volatility implied by out-of- and at- the money calls, out-of-, at-, and in-the money puts), each to be compared with the series of actual volatility.

According to the theory outlined in the previous section,the a priori expectations about the choice of the best volatility measure, are:

-on average, implied volatilities are expected to give better forecasts than historical volatilities,

-out-of- and at- the money puts and out-of-the money calls are expected to give the best forecasts amongst the different measures of implied volatilities.

The next question is which test one should adopt for measuring the predictive ability of the above predictive measures of actual volatility.In the literature, two different approaches have been used.First, a regression approach was adopted by Beckers (1981), Heaton (1986) and Shastri and Tandon (1986). The type of the regression line is:

$$\text{Act.Volat.} = b_0 + b_1 * X + u \qquad (5.7)$$

where

X :either of the six different predictive measures of actual volatility.

The R^2 gives a measure of the predictive performance of each different measure.

There are, however, two strands of criticism against regression analysis:

1.As Beckers (1981) argues, variances may move together, so that the usual Gauss-Markov assumptions about the independence of the error term are violated.

2.According to Heaton (1986), the estimated coefficients may be unstable over the period of examination.

Alternatively, two other measures can be used:the Mean Absolute Error (MAE) and the Root Mean Squared Error (RMSE).The measure with the lowest MAE (or RMSE) is the best.

The formulae for MAE and RMSE are:

$$MAE = \frac{1}{k} * S \, |Act.vol. - Pred.Meas.| \qquad (5.8)$$

$$RMSE = \frac{1}{k} * S \, (Act.Vol. - Pred.Meas)^2 \qquad (5.9)$$

where

k :the number of observations used to calculate MAE or RMSE.

Both MAE and RMSE measure the average prediction error (difference between actual volatility and predicted volatility). They differ in that, the latter is more sensitive to a few large errors.As Beckers (1981) and Bodurtha and Courtandon (1987) use the MAE, this measure will be adopted, for drawing conclusions on the predictive performance of each volatility candidate.For the sake of comparison, the RMSE will be also calculated.

5.7.Previous Work and Results.

Latane and Rendleman (1976), Chiras (1977) and Chiras and Manaster(1978) were among the first who used implied volatilities as proxies for actual volatilities[10].More recently, Beckers (1981) examines the performance of volatilities implied by stock options and concludes that, volatilities implied by at-the money options give better forecasts.He focuses on daily data from the NYSE and the CBOE.Gemmill (1986), in testing the London stock options market, shows that, volatilities implied by in the money options give better forecasts than out-of- or at- the money options.Using monthly data, Heaton (1986) tests the predictive performance of the volatilities implied by at-the money calls and concludes that they outperform historical volatilities.

For volatilities implied by currency options prices. Shastri and Tandon (1986) contend that implied volatilities outperform historical ones, with the best forecasts being given by at-the money options.Their analysis was based on daily data from the Philadelphia Stock Exchange.They use both calls and puts, but do not provide a detailed analysis of the predictive performance of each of these types of options.Fung ,Lie and Moreno (1990) use closing daily data from the Philadelphia Stock Exchange, and conclude that at-the-money or out-of-the money calls give the more accurate forecasts of the actual volatility.

This work adds to that previously mentioned, in the following ways:

1.All measures of the implied volatilities refer to quarters.The previous studies examine the predictive performance of different types of volatility, with no reference to the time dimension of this predictive performance.In this work ,it is the quarterly future exchange rate risk that we seek to forecast, and not the future exchange risk in general.

2.The use of the standard deviation to measure historical volatility is statistically justified.Previous studies used standard deviation to measure the actual volatility of daily exchange rates.This can be dangerous, however, as there has been some evidence that daily exchange rates do not follow the normal distribution, and thus, standard deviation may not be a sufficient measure of dispersion.The evidence presented here makes one more confident that the standard deviation sufficiently measures (historical) risk.

3.The volatilities implied by puts and calls are isolated, and their predictive performance is examined separately.

4.There is an allowance for transaction costs, along with an examination of their effects upon estimating implied volatilities.

The results are presented in table (5.2), which reports both MAE and RMSE.The following comments apply on the results reported in this table:

1.In any case, the volatilities implied by option prices outperform historical volatilities.This result is compatible with the findings of previous studies.

2.On the basis of MAE, at-the-money puts seem to give the best forecast of the future actual volatility.Thus, it is the at-the money puts, which are the source of estimating future volatilities.However, out-of-the money calls and out-of-the money puts seem to yield relatively accurate implied volatilities as well, quite close to the ones implied by at-the-money puts.

3.On the basis of the RMSE, out-of-the money calls give slightly better forecasts than out-of-the money puts and-at-the money calls.

In general ,the results in table (5.2) support the use of out-of-the money or at-the-money puts for estimating future exchange rate risk.Out-of-the money calls could also be considered.

Finally,transaction costs do not appear to make much difference to the choice of options type, for deriving implied volatilities.

The previous table indicates that, on average, there is a difference (forecasting error) of .03 between actual volatilities and implied volatilities.This difference can be seen as an indication that arbitrage opportunities exist in the Philadelphia Stock Exchange currency options market (no arbitrage opportunities require zero forecast error).This result is in line with Shastri and Tandon (1986).However, one should be cautious in inferring that the currency options market is in-efficient.

The following arguments prevent us from being confident that the market efficiency hypothesis is violated:

1.Proper currency options tests on market efficiency should be carried out on simultaneous data, concerning exchange rates, interest rates and option prices.Here,the data is not simultaneous.

TABLE 5.2.

MEAN ABSOLUTE ERROR (MAE) AND ROOT MEAN SQUARE ERROR (RMSE) OF DIFFERENT PREDICTIVE MEASURES OF ACTUAL VOLATILITY.

Measure	MAE	RMSE
Historical Volatility	.0334	.045
Out-Of-The Money Calls: No Transact.Costs	.03	.0357*
Out-Of-The Money Calls: Transaction Costs	.03	.0358*
At-The-Money Calls: No Transaction Costs	.03	.036
At-The-Money Calls: Transaction Costs	.03	.0362
Out-Of-The-Money Puts: No Transaction Costs	.028	.0359*
Out-Of-The-Money Puts: Transaction Costs	.0289	.036*
At-The-Money Puts: No Transaction Costs	.0282*	.037
At-The-Money Puts: Transaction Costs	.0282*	.0372
In-The-Money Puts: No Transaction Costs	.0315	.038
In-The-Money Puts: Transaction Costs	.0317	.0381

* : Best (More Accurate) Measure Of Actual Volatility.

2.Actual volatility is measured by weekly exchange rates, derived from Datastream.These exchange rates may not be exactly the same as those by which the currency options market is affected.

5.8. Conclusion.

The empirical findings of this chapter will be used in the following empirical chapter, which deals with the empirical evaluation of the hedging performance of currency options.As stated in chapter 4, any hedging scenario consists of a number of currency options, known as the hedge ratio.The latter is a function, amongst others,of the currency option price.Since option prices are not available for the OTC market, one needs to simulate these prices on the basis of a given model, and statistical data on the parameters which enter this model.This chapter dealt with how one can forecast the major parameter of future exchange rate volatility, which enters option pricing models.

It turns out that, volatilities implied by currency option prices traded in organised markets outperformed volatilities based on historical exchange rate data.In fact, out-of-the money calls, and out-of-the money and at-the money puts appear to yield the more accurate forecasts of the actual volatility.These volatilities will be used in the next chapter to yield prices and hedge ratios of average rate currency options, when considering these options in an empirical model of hedging against operating exposure.

Finally, the practical implications of this chapter is that, when hedging firms and options traders negotiate a (three-month) currency option contract, the premium should be calculated on the basis of the future volatility implied by either out-of-the money calls or out-of-the money puts, traded in organised markets (Philadelphia Stock Exchange).

NOTES

1.If the distribution of exchange rates is not normal, then the validity of the currency options pricing model [equation (5.4) in the next section in the chapter] is questioned.

2.For a full analysis of this test , see Snedecor and Cochran (1980)

3.Since we take the first differences in logs, we lose one observation.

4.See Black and Scholes (1973).

5.For a detailed analysis of the fundamentals of the options pricing, see Copeland and Weston (1988).

6.See Biger and Hull (1983).

7.Another version of this model can be derived directly from (5.4), if we assume that the Interest Rate Parity holds.This parity establishes a relationship between the spot exchange rate, the forward rate and the interest rates of the currencies concerned.
Define F, as the forward exchange rate on a foreign currency for a contract with delivery date T.The Interest Rate Parity, expressed in continuous time, is:

$$\ln(F/S) = (r - r_f) * T.$$

If we plug the Interest Rate Parity into (5.4), we get

$$c = \exp(-r_d*T)*F*N(d_1) - \exp(-r_d*T)*X*N(d_2)$$

$$d_1 = \frac{\ln(F/X) + (c^2/2)*T}{c*(T)^{1/2}}, \quad d_2 = d_1 - c*(T)^{1/2}$$

This version of the currency options model indicates the association between call options prices, forward exchange rates and domestic interest rates.

8.The Put-Call parity, originally developed by Stoll (1969), connects the value of a European call with the value of a European put.It is given by the formula:

$$P = C + X * \exp(^{-rd*T}) - S * \exp(^{-rf*T})$$

where
P is the price of the European put.The other parameters are the same as in (5.4).

9.This method of testing market efficiency is based on the work by Merton (1973), on rational option pricing.

10.See Fung, Lie and Moreno (1990) for a brief overview of these studies.

CHAPTER 6

EMPIRICAL EXAMINATION OF THE EFFECTIVENESS OF CURRENCY OPTIONS IN HEDGING AGAINST OPERATING EXPOSURE.

6.1.Introduction

In chapter 2, the problem of operating exposure was theoretically analysed within the context of the theory of the firm (i.e.considering such factors as corporate objectives, industry structure and production cost efficiency).Chapter 4 provided a theoretical analysis of how one can hedge against the type of operating exposure analysed in chapter 2.In the former chapter, it was argued that a currency call option should be adopted to hedge against asymmetric exposure (which arises under specific assumptions about the three previous parameters that affect exposure).This argument was highly theoretical.It did not consider how a currency option hedging strategy can be implemented, nor did it empirically examine its hedging effectiveness.

Previous work on hedging against operating exposure does not address the issue of how a theoretical hedging proposition can be applied in practice. This chapter focuses on issues related to the empirical implementation of a currency options hedging strategy. It aims to identify critical points which may arise, when a firm is contemplating to undertake such hedging strategy.These points are related to the type of currency options to be used, the determination of the exercise rate of the options, the timing of placing and removing the hedge and the empirical determination of hedge ratios.The chapter also deals with the empirical examination of the hedging effectiveness of currency options.It focuses on the export prices of five commodities (cars, wool, petroleum, chocolate confectionery and copying machines) which appear to be subject to operating exposure in chapter 3, and examines whether options provide sufficient coverage, in terms of eliminating exposure.In fact, this chapter attempts to provide an empirical simulation of the currency options strategies assumed to be undertaken by a firm which exports either of the previous commodities, and to statistically examine their hedging effectiveness.

6.2.The Type[1] Of Currency Options To Be Used For Hedging Against Operating Exposure:Ordinary Options vsv Average Rate Options.

In the theoretical analysis of economic exposure,provided in chapter 2, it was argued that export prices are determined by 'significant' exchange rate changes,ignoring daily exchange rate 'noise'. Clearly,export prices do not change every day, but rather every quarter or six months, possibly even every year.This leaves us with the task of having to define these 'significant' exchange rates, over a specific period.In chapters 2 and 3, this rate was taken to be the period average rate[2], assuming that export pricing is a function of (and thus,economic exposure is caused by) average exchange rate movements.End of period exchange rates were ignored in terms of export pricing, and thus, economic exposure.In fact, in many studies which examine the variability of real exchange rates (that cause economic exposure), it is the average exchange rates (as opposed to end of period rates) which are used, along with inflation rates, to examine real exchange rate changes[3]. These considerations carry significant implications about the type of options to be used in the hedging scenario against economic exposure.

Consider an exporting firm that wishes to place a hedge at T_0 against a pound appreciation over the next quarter.It is assumed that the actual export price will be determined at T_1, on the basis of the actual average exchange rate to prevail over that quarter.If the actual average rate appreciates, the actual export price will decrease (chapter

2).Hedging using a currency option will be efficient if, at T_1, the option yields a net profit that (at least partially) offsets the decrease in the export price.If the firm buys a conventional (ordinary) call on the pound (that its expiration value depends on the end of period exchange rate),it (the firm) may find itself in the following situation:the exchange raw may be steadily appreciating from T_0 through to just prior to T_1, causing the average exchange rate to appreciate (and thus the export price to decrease).At T_1,the daily, end of period exchange rate may suddenly depreciate, impairing the profit on the call at expiration, and thus, its hedging effectiveness[4]. Clearly, we need an option whose expiration value is unaffected by the daily, end of period exchange rate.In fact, we are looking for an option whose value depends on the period average exchange rate.(This is a result of the argument that operating exposure is caused by average exchange rate appreciations).Such an option has been developed in the Over-The-Counter currency options market and is named 'average rate currency option' or 'Asian' option[5].

The hedging scenarios outlined in chapters 2 and 4 should involve average rate options.These options also will be the basis of the empirical hedging scenario, to be exposed later.The next section describes the fundamentals of these options, in terms of pricing and uses.

6.3.Average Rate Options.

6.3.1.General Characteristics.

The value of a conventional option depends on the end of period exchange rate, that prevails at the expiration of the option (or generally, on the spot exchange rate of the day when the option is exercised,sold or bought). As Boyle (1991) states, the basic option contract has been extended in several ways in recent years.One of these extensions is to consider options with payoffs dependent on the price path, instead of the daily price, of the underlying asset (here, the exchange rate).In such options, what really matters is the historical trajectory of the underlying asset and not its 'current' daily value.Within this category of options, one can classify Asian options or average rate options[6].

An average rate call will be exercised, at maturity, if the average exchange rate over its life is higher than the exercise rate.An average rate put will be exercised, at maturity. if the average exchange rate, over the option's life, is lower than its exercise rate.Similarly to a conventional option, an Asian option can be either of European type (exercisable only at expiration time) or of American type (exercisable at any time prior to or at expiration time).

Average rate options can be 'fixed-strike' options or 'floating-strike' options.For fixed strike options, the exercise rate is known at the time when the option is taken.For floating-strike options, the exercise rate is the spot rate that prevails at maturity.The commonest type of Asian options are the fixed strike ones.The empirical hedging scenario, to be detailed later, involves fixed strike average options.

Letting K represent the fixed exercise rate of an Asian option, the payoff of a call, at expiration, is:

$$\text{Max}\ (S'-K,0) \qquad (6.1)$$

The payoff of the put, at expiration, will be given by :

$$\text{Max}\ (K-S',0) \qquad (6.2)$$

where:

S' :the average exchange rate.

From these relationships, one can see that the risk profile of an Asian option is the same as the risk profile of a conventional option.Diagram (6.1) gives the risk profile of an Asian call and diagram (6.2) repeats the risk profile of a conventional call.

Diagram 6.1:The Risk Profile Of An Asian Call.

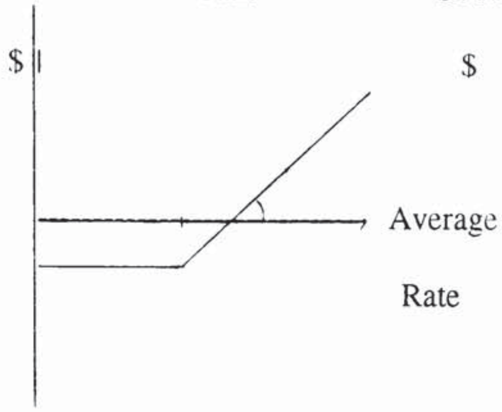
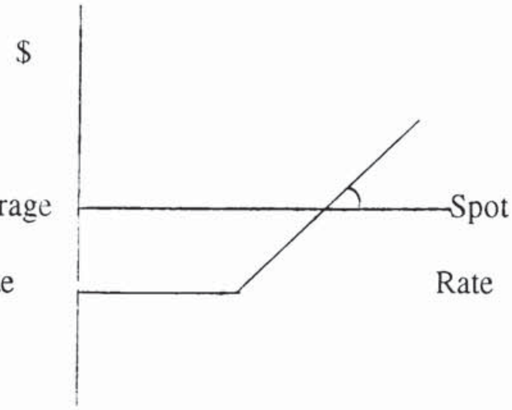


Diagram 6.2 The Risk Profile Of A Conventional Call.



As can be seen from the previous diagrams,one difference between these two risk profiles is that, the horizontal axis in diagram (6.1) measures average exchange rates, whereas in diagram (6.2), it measures spot end of period rates.Another difference is the price of these two options.It is expected that the price of an Asian call (put) will be significantly lower than the price of a conventional call (put).The pricing of Asian options is discussed later.

Since what matters for an Asian option is the period average rate, one has to determine how this rate is calculated.In fact, the calculation of the average rate is based on an agreement between the seller and the buyer of the option, with regards to:

-the source of the daily exchange rate (for example, Bank of England Pound index)

-the time and the date over which nominal exchange rates will be considered, and

-the frequency of the fixing intervals (daily, monthly, or any other regularly sized time interval).

One can calculate the average rate using either the geometric average formula (in which case, one focuses on a geometric average option) or the arithmetic average formula (in which case,one focuses on an arithmetic average option).

The Asian option is cash settled at maturity.There is no exchange of foreign currency (which occurs for conventional options).If the Asian option is exercised, the buyer will receive a net payment that equals the value of the Asian option at expiration.

6.3.2.Pricing Asian Options And Their Hedging Properties (Delta, Theta).

One initial observation, with regards to the pricing of Asian options compared with the pricing of conventional options, is that, for a given spot exchange rate, interest rate differential and expiration time, the Asian option will be cheaper than the conventional option.As Sullivan (1991) argues, the Asian option can be 40% cheaper than the perfectly identical conventional option.This is because the averaging involved in Asian options reduces the volatility of exchange rates. The lower the volatility of average exchange rates compared to the volatility of daily rates, the cheaper an Asian option compared to an identical conventional option.

Another parameter, involved in pricing Asian options, is the relationship between the averaging period and the life of the option as well as the frequency of fixings within the averaging period[7].

Focusing on the relationship between the averaging period and the life of the option, one could argue that the longer (shorter) the averaging period in relation to the life of the option, the cheaper (more expensive) an Asian option compared to an identical conventional option.In the limiting case where the averaging period is delayed until the expiration day, the price of the Asian option will be exactly equal to the price of an identical conventional option.In this case, the beneficial effects of averaging in reducing volatility are abated (as the averaging period is reduced).However, Turnbull and Wakeman (1991) argue, in contradiction to Kemna and Vorst (1990), that if the averaging period is longer than the maturity time, the Asian option can be more expensive than the conventional option.

Now, within the averaging period, the price and hedging properties (delta, theta, etc) of an Asian option will be affected by the frequency of fixings taken to compute the average rate, provided that a sufficiently large number of fixings are taken[8].For a typical option with a maturity period of one year, a sufficient condition would be for the number of fixings to be around 20 and at least 12[9].

The key task is the derivation of a pricing formula for Asian options.As there are arithmetic average options and geometric average options, we focus on each of these types separately.

First, we examine the pricing of geometric Asian options.

For such options, a closed form equation can be derived. Assuming that daily exchange rates follow a lognormal distribution, and since the geometric average is given by the formula:

$$G(T)=(S_{T+1} * S_{T+2} * \ldots * S_{T+n})^{1/n} \qquad (6.3)$$

the product of n-lognormally distributed variables is a lognormal distribution itself.[See Boyle (1991)].This observation enables the derivation of an exact pricing formula for geometric average options.Boyle (1991), Fitzgerald (1991) and Turnbull and Wakeman (1991) report the following formula for geometric average call

$$C = \exp(-r_f * T) * S' * N(d_1) - \exp(-r_d * T) * N(d_2) * X \qquad (6.4)$$

$$S' = S * \exp\{-[(r_d - r_f)/2 + (c^2/12)] * T\} \qquad (6.4.a)$$

$$d_1 = \frac{\ln(S'/X) + [(r_d - r_f) + (c'^2/2) * T]}{c' * (T)^{1/2}} \qquad (6.4.b)$$

$$d_2 = d_1 - c' * (T)^{1/2} \qquad (6.4.c)$$

$$c'^2 = (c^2)/3 \qquad (6.4.d)$$

where:

C :the price of an Asian call

$\exp(a)=e^{a}$, e:the base of natural logs,

S :the actual spot price when the option is taken

c :the volatility (variance) of future exchange rate changes

X :the exercise rate of the option

r_d,r_f:the riskless domestic ($) and foreign (£) interest rate respectively.

T :time to maturity

N(.):cumulative normal distribution function.

In fact, the above formula is the same as the Garman-Kohlhagen model for valuing conventional currency calls [equation (5.4) in chapter 5].The difference is the transformation of the spot rate and the volatility before using them in the Garman-Kohlhagen model. These transformations are given by (6.4.a) and (6.4.d).

Finally, as these options are of European style, the put/call parity holds, and can be used to value Asian puts on geometric average, if the value of Asian calls is available.

Focusing on arithmetic average options, a closed form pricing formula can not be derived.The reason is that the distribution of the sum of lognormally distributed variables is not lognormal.To overcome this problem,several approximations have been developed.One of these, is the Levy's arithmetic average approximation, reported by Fitzgerald (1991).This formula is:

$$C_A=S_A*N(d_1)-\exp(-r_d*w)*K*N(d_2) \qquad (6.5)$$

$$S_A=\exp(-r_d*w)*(t/T)*S_{AV}+(S/g)*[\exp(-r_f*w)-\exp(-r_d*w)] \qquad (6.5.a)$$

$$d_1=[1/(v)^{1/2}]*(0.5*\log D-\log K) \qquad (6.5.b)$$

$d_2=d_1-(v)^{1/2}$ (6.5.c)

$v=\log D-2(r_d*w+\log S_A)$ (6.5.d)

$D=[1/(T^2)]*\{M+(t*S_{AV})^2+[(2*t*S*S_{AV})/g]*[\exp(g*r-1)]\}$ (6.5.e)

$M=[(2*S^2)/(g+c^2)]*\{[\exp(2g+c^2)w-1]/(2g+c^2)-[\exp(gw-1)/g]\}$ (6.5.f)

where:

C_A :the approximate value of an arithmetic Asian call.

$\exp(a)=e^a$

$g = r_d - r_f$

$w = T - t$ is the remaining maturity

T is the original maturity

t is the evaluation time

S_{AV} is the average rate at t.

and the other parameters as in (6.4).

Another solution to the problem of pricing arithmetic average options is the adoption of the geometric formula,under the condition of having low volatilities.This conclusion is due to Turnbull and Wakeman (1991).According to the results of chapter 5, the volatilities of the 33 quarters, over the period from 1983 through to 1991, were about 10-15%, with only two quarters featuring volatilities about 20%.Turnbull and Wakeman (1991) use a 20% volatility as a yardstick to compare the geometric formula with an approximation of the arithmetic formula and conclude that the difference was low.Thus, for volatilities of about 10-15%, one would expect that the adoption of the geometric average pricing formula can well approximate arithmetic average option prices.

For the purposes of this work, the decision was made to use the geometric formula for pricing arithmetic average options, on the grounds that, Levy's approximation involves an enormous amount of calculations.

With regards to the delta and theta of an average rate call, diagrams (6.3), (6.4) and (6.5) give a pictorial presentation of how those compare with the delta and theta of an identical conventional call.The delta of out-of-the money average calls is greater than the delta of conventional out-of-the money calls.For at-the money calls, the delta of an Asian option is almost the same as that of an identical conventional option.

The theta is lower for Asian options than for conventional options.

We are especially interested in these two derivatives, as they enter into the theoretical formula for determining hedge ratios, outlined in chapter 4, that is:

$$m = \frac{b}{d - Q} \qquad (6.6)$$

where:

m : the hedge ratio,

d :the option's delta

Q :the option's theta

b :the effect of exchange rate change on the export price (chapter 3).

How do hedge ratios, using Asian options, compare with hedge ratios using conventional options?

As delta and theta are lower for average options, it is unclear whether the difference is higher for Asian options than for conventional options.It is probable that, the difference (d-Q) for average rate options is not much different from (d-Q) for conventional options, implying that the hedge ratios using Asian options may be similar to ratios using conventional options.If, however, one considers the argument by Sullivan (1991), that an Asian option is cheaper than a conventional option, one could conclude that hedging economic exposure using Asian options is cheaper than hedging this exposure using

DIAGRAM 6.3

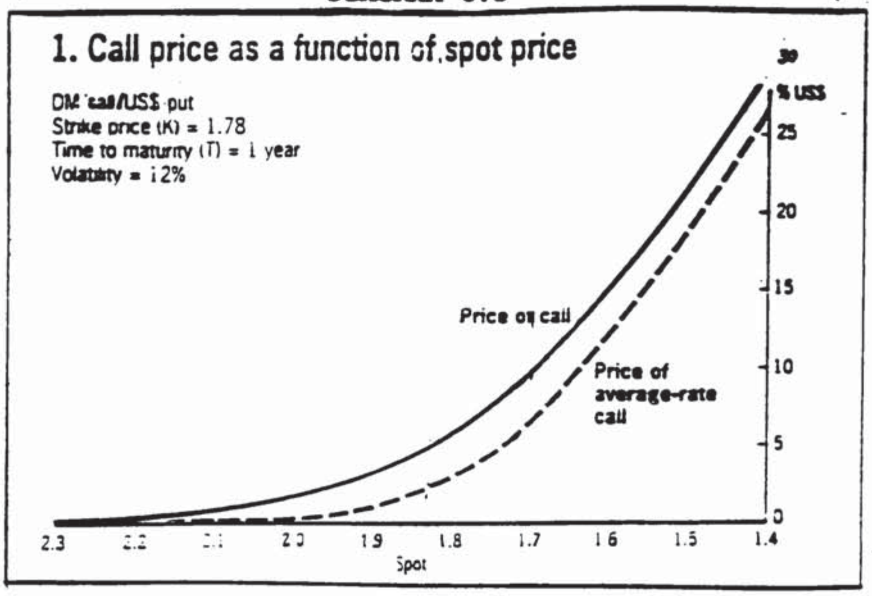


DIAGRAM 6.4

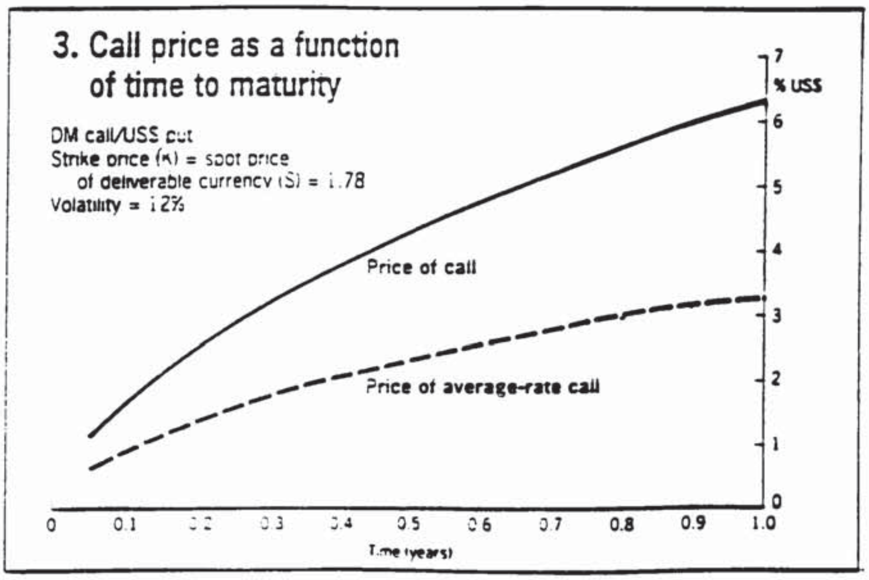
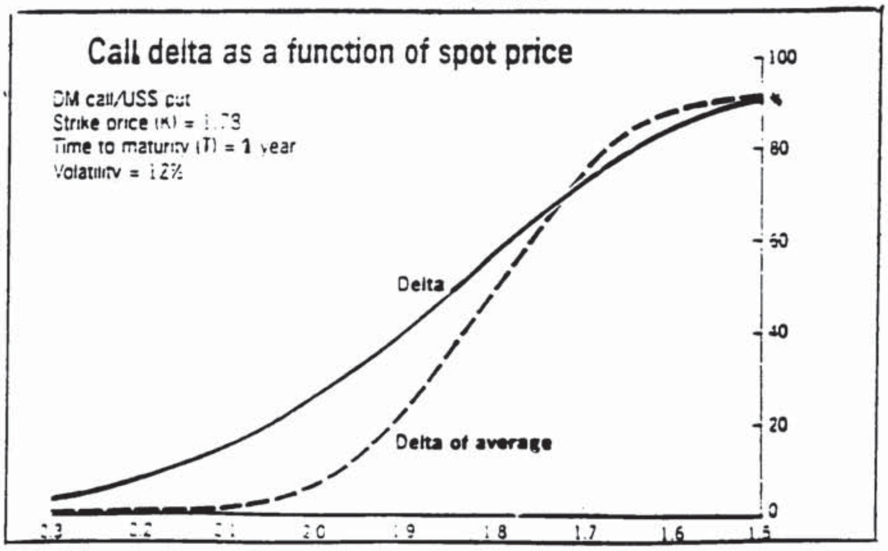


DIAGRAM 6.5



SOURCE : Fitzgerald (1991).

conventional options.

This result supports the use of average options for hedging against economic exposure, in terms of reducing hedging costs.

6.3.3.Other Uses Of Asian Options.

In this work, it is proposed that Asian options can be used for hedging against economic exposure.Other uses of Asian options involve hedging against transaction and/or translation exposure.

With regards to translation exposure,Asian options are used to hedge the translation of overseas profits at the average period rate over the year rather than at the end of-period rate.

With regards to transaction exposure, an Asian option can be used when a firm has a series of foreign currency receivables and/or payables. Suppose that a UK firm has signed a contract that will pay the firm \$1000 in the next two quarters.These two receivables indicate the existence of two transaction exposures and the need for taking two (conventional) options (one for each quarter).This may create complexities in administering and/or monitoring the hedges, if conventional options are employed.Let's assume that the firm expects payments at T_1 and T_2.It can buy an Asian option and define these two dates as fixing dates for the calculation of the average rate over the period up to T_2.The expiration of the option should be at T_2.At T_1, the firm receives the first \$1000 and uses the then spot rate (e_1) to translate the dollars into pounds.It receives the second payment at T_2,and again, uses the then spot rate (e_2) to translate dollars into pounds.At T_2, the arithmetic average rate is calculated as:

$$S^{`}=(e_1+e_2)/2. \qquad (6.7)$$

Setting the current exchange rate equal to the exercise rate (K), at expiration of the Asian option, we have either of the following cases:

If K > S', then the firm has a negative transaction exposure (indicating that it enjoys a transaction gain due to favourable exchange rates), and the Asian call will expire worthless.

If K < S', then the firm has a positive exposure to be offset by the difference (S' - K), which is the value of the Asian call at expiration.

Asian options give the firm the opportunity to buy only one option which is cheaper and more easily manageable than the conventional option, in order to hedge multiple transaction exposures.

6.4.The Hedging Scenario Using Currency Options :Other Empirical Issues.

Having outlined the reasons that support the use of Asian options for hedging against economic exposure, and the fundamentals of Asian option pricing (which determine the cost of hedging), we can now focus on some additional issues related to the empirical hedging scenario, assumed to be taken by exporting firms.By 'hedging scenario', it is meant the determination of the exercise rate of the option, the time when the hedge should be placed, the maturity of the hedge and its quantity (i.e.hedge ratio).

As assumed in chapters 2 and 3, the time horizon is divided into quarters.(This is very much an academic assumption,though. Export prices may be revised every six months or every year, instead of every quarter as assumed here, depending on the industry).

The hedging scenario to be outlined here, is based on the timetable given in diagram (6.6).

The UK firm undertakes production between T_0 and T_1.It determines an expected export price at T_1, on the basis of the expected average exchange rate that is to prevail over the next period (over which operating exposure arises).Thus, the expected export price is determined one period in advance[10] of the actual export price, that is determined after the commodity has been marketed in the overseas market.It is the fact that the selling of the commodity takes place one period after the production period that causes economic exposure.

Diagram 6.6:The Timetable Of Determining Expected And Actual Export Prices:Production Period Predates Marketing Period.

Operating

T_0 T_1 Exposure T_2

|----------------------------|------------------------|------

Expected Price Actual Price

Production Period Marketing Period

Further, it is the difference between the expected exchange rate and the actual exchange rate that prevailed over the marketing period that causes the divergence between the expected export price and the actual export price.Equivalently, we could assume that both production and marketing periods coincide, according to diagram (6.7).

Diagram 6.7:The Timetable Of Determining Expected and Actual Export Prices:The Production Period Coincides With the Marketing Period.

$(\text{Exp.Price})_2$ $(\text{Act.Price})_2$

T_0 T_1 T_2

|----------------------------|---------------------------|------

$(\text{Exp.Price})_1$ $(\text{Act.Price})_1$

$(\text{Production Period})_1$ $(\text{Production Period})_2$

$(\text{Marketing Period})_1$ $(\text{Marketing Period})_2$

Again, the expected price is determined at the beginning of each quarter and on the basis of the expected exchange rate for this period.

The only difference between the two previous timetables is that in the first one, the £ costs of the firm are known when the expected price is determined (T_1), whereas in the second, the £ costs are expected. However, assuming that the UK firm can successfully forecast the inflation rate of the next period (which can be the case for short term periods), the two diagrams are equivalent, and either can be used for the determination of the exercise rate, the timing of placing the hedge and the timing of removing it. This equivalence gives the flexibility of applying this scenario to many firms according to their own timing of production and marketing periods.

We first deal with how we can simulate the determination of the exercise rate for an option. As explained in chapter 4, the exercise rate should be that particular rate that entails no competitive advantage or disadvantage to any firm. The hedging firm will adjust the 'current' exchange rate by the inflation rate differential, to end up with a nominal exchange rate which leaves the real exchange rate unaffected. This nominal rate should be the exercise rate of the option.

Let's assume that, according to diagram (6.6), we are at T_1 and the firm wants to place a hedge (about the exact timing of placing the hedge, see below). It wants to hedge against exchange rate changes over the marketing (i.e. operating exposure) period. At T_1, it obtains a forecast of the inflation rate differential between the UK and the USA, expected to prevail over that period. This forecast is assumed to be correct. For the case of the UK/USA , according to diagram (1.2) in chapter 1, this differential is assumed to be close to zero. This implies that the 'current' average exchange rate (that prevailed over the period from T_0 to T_1) should not be adjusted (or adjusted by 0%). to give the exercise rate that leaves the real exchange rate unchanged (which entails no exposure). Consequently, the exercise rate should be set at the same level as the exchange rate which prevailed at the quarter prior to the marketing period.(This rate is known at T_1). Adopting diagram (6.7), one is led to the same conclusion.

Now, the next question is how to determine exactly when to place the hedge. We continue to refer to diagram (6.6) and in parentheses, to diagram (6.7). Can we place the hedge at T_1 (T_0 for the first period and T_1 for the second period)? To answer this question, we have to see how the cost of an Asian option (which affects its hedging effectiveness) is determined. According to formula (6.4), the (geometric) Asian option price is, amongst others, a function of the spot daily exchange rate that prevails at the time when the hedge is to be placed. This brings important implications to the above question.

An initial approach would be to place the hedge at T1 [T_0 and T_1, in terms of diagram (6.7)].This is not always correct, however, for the following reason:the daily exchange rate which prevails at T_1 (T_0 and T_1) may be much higher than the average exchange rate of the production period (production and marketing period) to be used as an exercise rate of the option.This will increase the (intrinsic) value of the Asian call and therefore, the cost of hedging. Consequently, the net gain on the call, when the actual exchange rate is realised at T_2 (T_1 and T_2), will decrease and the hedging effectiveness of the option will be impaired. Thus, the timing of placing the hedge is very important with regards to the effectiveness of the hedging exercise.

In fact, we can place the hedge some day prior to T_1 (T_0 and T_1), when the daily rate is close to the average rate of the period.This requires that the hedging firm keeps an eye on the daily exchange rates before T_1 (T_0 and T_1), and decides to place a hedge before this period, when there is a trend for the exchange rate to increase.

The inability of having a clear rule of when to place the hedge can be seen as a drawback of this hedging exercise.However, this drawback is relevant only for cases when the pound appreciates as we approach T_1 (T_0 and T_1), compared to the average rate.If the pound depreciates compared to (or stays about the same level as) the average rate, instead, we can argue that the hedge should be placed exactly at T_1 (T_0 and T_1).Further, if the pound depreciates as we approach T_1 (T_0 and T_1), placing the hedge at T_1 (T_0 and T_1) will result in reducing the cost of hedging, and thus, increasing the hedging effectiveness of the hedge.

Consequently, to decide when to place an options hedge, one should compare the daily spot rate, close to the end of each quarter with the quarter average.If the two rates are about the same or if the daily spot rate is lower than the period average, then the hedge should be placed exactly at the end of the period.Otherwise, the hedge should be placed prior to the end of the period, when the spot rate is still about the average rate[11].

In this case, the maturity life of the Asian option will be higher than the averaging period.The latter point has some implications about the correct valuation formula to be adopted for valuing such an option.Diagram (6.8) depicts the relationship between the maturity period and the averaging period for Asian options taken prior to T_1[12].

Diagram 6.8:The Averaging Period Of An Asian Option vsv Its

Maturity Life.

```
T0                T1            T2
|--------------|-----------|-------------------------|---
               Hedge        Averaging Period
               Placed
```

With regards to the hedge's expiration, and since actual export prices are assumed to be determined at the end of each quarter (after the realisation of the marketing period average rate), the hedge should expire at the end of the quarter, in order to capture the whole course of the average exchange rate over the relevant period.

After having outlined what the firm should consider about the time of placing the hedge, we have to comment on how to determine hedge ratios and to empirically examine their hedging effectiveness.

Before that, we should comment on the source of exchange rates to be used in the calculation of average rates, as well as the frequency of exchange rate fixings.To secure coherence with the data on exchange rates used in chapter 3, we assume that the source of exchange rates is the Telerate, available in the publication 'Economic Trends'.The fixings are on a daily basis[13].

The next question is the determination of the number of options required to hedge one unit of exports, namely the hedge ratio.As for every ratio, the hedge ratio consists of a numerator and a denominator.In the numerator, we have the expected export price cut at the next quarter, should the pound appreciate.In the denominator, we have the expected profit on the Asian option, should, again, the pound appreciate.(If the pound depreciates, we will have neither any export price cut, nor any gain on the Asian option).Both the numerator and the denominator of the hedge ratio are determined on an expected basis.These hedge ratios are assumed to be taken a-priori, that is before the realisation of the actual exchange rate, actual export price and the actual gain on the hedge.It must be noted, however, that these expectations do not refer to deciding whether to take the hedge or not.They refer to estimating the hedge ratios, given that a pound appreciation will arise.Thus, the hedge ratio can be formally written as follows:

$$m = \frac{\text{Expected export price} - \text{Target export price}}{\text{Expected profit on Asian call} - \text{cost of Asian call.}} \qquad (6.8)$$

We have to comment on how we can determine (simulate) each of these four parameters involved in the determination of hedge ratios.

First, we deal with how we can determine the cost of an Asian call.This is the premium that the buyer of the call (the firm) should pay the seller (the bank).It is the cost of hedging, incurred when the firm places the hedge at (or just prior to) the end of production period [diagram (6.6)].To determine the premium of an Asian call, we need a valuation formula and data on the parameters which enter the formula.

The formula to be used here, to simulate Asian option prices, is the geometric average call pricing model given in (6.4). Although the average rates we are dealing with are arithmetic ones, the adoption of the geometric average call pricing model was justified in the previous section.The parameters, which are readily observable at the time when the hedge is placed, include the spot exchange rate and the interest rate for the pound and the dollar for a period equal to the life of the option (three months).We also have to enter the time expressed as a fraction of the year and the exercise rate.The determination of these two parameters was analysed above.Finally, we must enter a measure for the future exchange rate variability (volatility). This parameter is not observed and should be estimated.Chapter 5 dealt with this issue.According to the conclusion of this chapter, one should use the volatility implied by at- (or, out-of-) the money put options traded in organised markets.Table (6.2), in the next section, provides a simulation of Asian call premiums from the OTC currency options market.These premiums are assumed to have been faced by all UK exporting firms, from 1985/II to 1988/IV,had they wished to have their exposure hedged,over this period, using Asian options.

We now turn to the determination of the expected profit on Asian options, expected to have also been faced by all hedging firms.As it is assumed that the call will be held until expiration (T_2), when the export price is assumed to be determined,the value of the Asian call at T_2 will be simply the difference between the then actual average exchange rate (on which the actual export price will be determined) and the fixed exercise rate.(A positive actual difference indicates that the average rate had increased, causing, probably, an export price decrease).But, since when we place the hedge, we can not know the actual exchange rate and actual export price at T_2, we can only estimate these two parameters, taking for granted that the pound will appreciate. We should make clear, here, that we do not want to forecast whether the future exchange rate will appreciate or not.All we want is to obtain an estimate of a probable future pound appreciation (upper exchange rate), if we take for granted that the pound will actually appreciate.(The pound appreciation is taken for granted, since we want to place a hedge against an actual pound appreciation).

This problem can be handled using the estimates of future volatilities of exchange rates, implied by options with maturity in 3 months from the initiation of the option.According to chapter 5, it is the volatilities implied by at- or out-of-the money put options which should be used in forecasting future exchange rate volatilities. Now, we can transform these volatilities into upper and lower expected exchange rates, using the well known formulae of Cox-Ross-Rubinstein (1979).These formulae transform volatilities of the underlying asset into an upper and lower value, assuming the binomial distribution.The formula for the upper expected value (in which ,we are interested here) is:

$$u = e^{c * T/n} \qquad (6.9)$$

where:

u :the percentage of the upper change in the exchange rate

c :the volatility of future exchange rate

T :time, expressed as a fraction of the year

e :the base of natural logs

n :the parameter of Binomial distribution, set equal to 1[14]

Table (6.1) gives the forecast upper and lower levels of exchange rates, and the actual quarterly average exchange rates over the period from 1985/II to 1988/IV.These upper and lower exchange rates are assumed to be the 'best' forecasts of either an appreciation or a depreciation of the pound respectively, without forecasting towards which direction the actual rate will move. And they are the best forecasts on the assumption that they are obtained from expected (implied) volatilities assigned by a market which is efficient.(Efficient markets imply that expected volatilities equal actual volatilities).If the actual rate turns out to be lower (higher) than the forecast rate, then the actual volatility turns out to be higher (lower) than the traded implied volatility.This discrepancy between actual and implied volatilities indicates the existence of arbitrage opportunities in the market. Empirical studies on this issue, however, suggest that markets are efficient (see chapter 5, section (5.3.2)].

The upper expected exchange rate will be used to determine the expected value of the Asian option at the expiration of the hedge.The latter will be equal to the difference between the upper expected rate and the exercise rate.Now, in order to derive the net gain expected to be realised on the Asian option hedges, we deduct the cost of hedging [table (6.2)] from the expected revenue on the option at expiration.For the cases that the expected revenue on the Asian call is lower than the premium of the option at its initiation, we set the hedge ratio equal to zero (that is, we do not take any option hedge).This can be the case when the upper exchange rate is expected to be only marginally higher than the 'current' average rate, resulting in only marginal (and thus, negligible) export price cuts.The firm will place a hedge only when it (the firm) expects to obtain a positive profit on the Asian option (that is, the expected revenue to be higher than the cost of hedge).

This positive profit is likely to arise after a relatively 'significant' expected exchange rate appreciation that will cause an expected export price cut.

TABLE 6.1

FORECASTS OF UPPER AND LOWER EXCHANGE RATES

Quarter	Implied Volatilities	Upper Exch.Rates	Lower Exch.Rates	Actual Exch.Rate
1985 II	.213	1.2724	1.0151	1.2580
III	.195	1.4062	1.1372	1.3760
IV	.210	1.5310	1.2260	1.4360
1986 I	.132	1.5360	1.3482	1.4390
II	.118	1.5563	1.3687	1.5090
III	.122	1.6150	1.4250	1.4890
IV	.132	1.5465	1.3539	1.4300
1987 I	.107	1.5150	1.3555	1.5430
II	.113	1.6838	1.4900	1.6410
III	.096	1.6932	1.5375	1.6180
IV	.078	1.6905	1.5630	1.7540
1988 I	.133	1.9600	1.7077	1.7912
II	.133	1.9582	1.6877	1.8390
III	.110	1.8047	1.6165	1.6954
IV	.10	1.7767	1.6100	1.7972

NOTES:The forecasts of upper and lower exchange rate changes are from the second quarter of 1985 through to the fourth quarter of 1988 (period of pound appreciation when the call is in-the- money).Implied volatilities are estimated from at- and out of- the money puts (chapter 5).
The formula for upper exchange rates is: $u = e^{c^* T/n}$ and for lower rates is: $l = e^{c^* T/n}$ where e, c, T, n are as explained in the text.For the above formulae, see Cox, Ross, Rubinstein (1979).

This cut will be offset by the expected net profit on the Asian option.(If the expected pound appreciation is relatively low,the expected profit on the call may be relatively lower than the cost.In this case, no option will be bought, and the effectiveness of the hedging strategy is mitigated).

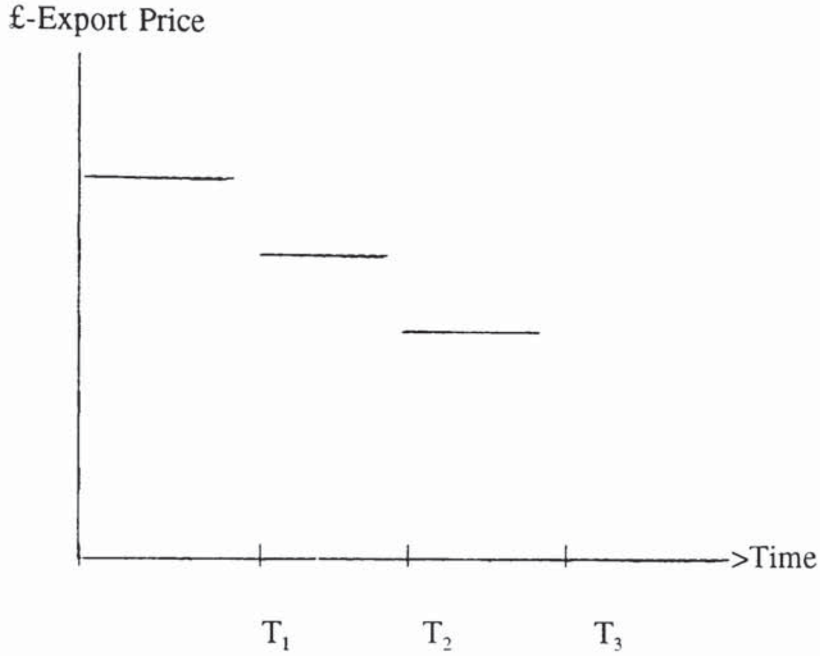
The target export price is the price at which the firm enjoys a 'normal' profit margin. and does not face economic exposure. This can be the market export price in periods of a pound depreciation, when the firm is expected to enjoy a competitive advantage, and thus, a 'normal 'profit margin.How can we determine this target price? There are possibly two candidates that can be considered as target prices: Firstly, we can set as target price for period t, the actual export price of the previous period, t-1.This means that the export price will fluctuate from period to period.Secondly, we can set a unique target export price for the whole hedging period (from 1985/II to 1988/IV). In my opinion, the second definition of the target export price is the correct one.To explain this, consider diagram (6.9).

As depicted in this diagram, there may be cases where we consider as a target price for period t, the actual export price at t-1, that is reduced as a result of a pound appreciation at t-1.Assuming that the pound appreciated from T_1 to T_3, and the export price followed a downwards course as a result of this pound appreciation,we can not set as target price for the third quarter, the actual export price of the second quarter, since the latter, having come up after a pound appreciation, is not a 'normal' (exposure-free) export price.

In the analysis to follow, we set a fixed target price over the whole hedging period.

Empirically, such a price can be the best export price achieved over the period of the pound long term depreciation. or the price that prevailed just prior to the period of the long term pound appreciation.

Diagram 6.9.:Considering The Actual Export Price Of The Past Quarter As The Target Price For The Next Quarter.



Next, we have to discuss how we can determine expected export price cuts, if a pound appreciation is taken for granted.To answer this question, we can use the regression equations in chapter 3 along with the forecasts of future upper expected exchange rate, in order to predict the expected export prices for the new upper exchange rates.The underlying assumption, here, is that when the hedge is placed, the regression equation is known by the firm.Thus, at the beginning of each hedging period,the firm has a forecast of the probable export price if the pound appreciates,knows its target export price, and thus, obtains a forecast of the probable export price cut.This expected price cut is the numerator in the empirical hedge ratios.

Thus, having obtained a forecast of the future expected export price cut and a forecast of the future expected profit on the Asian option hedge, we can work out the expected hedge ratios.For example, if the export price is expected to fall by 1 pound, after an expected pound appreciation, and the expected gain on one option is 10 pence, then the expected hedge ratio is 10 contracts of Asian options.This is the ex-ante hedge ratio.

In practice, firms use sophisticated computer models to work out complicated hedging scenarios and ratios.For example, as reported in the 'Institutional Investor', (September 1990), Merck, the USA pharmaceuticals firm,has a computer model to predict the results of various option hedging strategies to hedge its exposure. Further and according to an article in Euromoney (17 April 1989), when Enterprise Oil purchased an option to protect itself against exchange rate fluctuations, 'they calculated carefully the option premium and the strengthening of the pound vsv the dollar'.

The previous discussion can be seen as addressing the issues on which an empirical options hedging model should be focused, and computerised hedging models should be based.

6.5.Average Rate Options: Cost Of Hedging

Having outlined the fundamentals of average rate options and how the parameters involved (exercise price, spot rate, time to maturity, volatility and interest rate differential) can be measured, we simulated the premium of Asian calls that any UK firm would face over the period of the pound appreciation (1985/II to 1988/IV)[15].This call premium reflects the cost of hedging economic exposure, using Asian options.Table (6.2) provides details on the valuation parameters and premiums for Asian options, using the geometric average option pricing formula.Although the options relevant here are arithmetic average options,the geometric average pricing formula was considered a good approximation to pricing arithmetic average options, according to what was outlined earlier.

Also, in the same table, the premiums for conventional calls appear, using identical valuation parameters and the Garman-Kohlhagen pricing model.These are included in order to compare the cost of Asian options with the cost of conventional options, and examine the effects of averaging on option prices.The second column of this table gives details of the valuation parameters used to derive the values of Asian (and conventional) options.The time to expiration (T) used, is expressed as a percentage of the year.If T > .252, then the hedge is assumed to have been placed prior to the end of the production period due to the trends of a pound appreciation, as we approach the end of the period.S is the spot rate that prevailed when the hedge is assumed to have been placed.The volatility measure is given by c.The exercise price is X, reflecting the average exchange rate that prevailed over the production period.The riskless interest rates on the pound and the dollar are given by r_f and r_d respectively, and are approximated by the Eurocurrency interest rates.

In the third column, we derive the value of Asian options (and for some quarters, the value of conventional options).We can see that the averaging effects have led to Asian option premiums which are significantly reduced compared to the premiums of conventional options.

In the fourth column, we have the expected value (based on expected upper exchange rates) and the actual value (based on actual exchange rates) of Asian options.Both are expressed in dollar terms and are values at expiration [T_2, in diagram (6.6)]. For some periods (e.x.1986/IV), the actual profit on Asian options is zero, as the actual rate depreciated below the exercise rate and the option ended up being out-of-the money.

The fifth column gives the net expected and net actual gain on Asian options, expressed in pounds. To obtain the net expected gain on Asian options, we subtract the dollar premium at the option's initiation from the dollar value of the option at expiration, and translate the difference into pounds using the upper expected exchange rate (since this profit is assumed to have arisen after the expected upper rate is assumed to have prevailed).This amount is what the firm expects to get if the pound appreciates, and is used as the denominator in the empirical hedge ratios.

The actual profit on Asian options, given also in table (6.2), is the difference between the actual value of the Asian option (after the realisation of the actual exchange rate) and the cost of the option, expressed in pounds using the average rate that prevailed in the relevant quarter.This is what the firm actually gets from taking one Asian option.The difference between the expected value of the Asian option and its actual value is due to the difference between the actual and the expected upper exchange rate.

6.6. The Statistical Approach For The Examination Of The Hedging Effectiveness Of Expected Hedge Ratios.

The hedge ratios to be taken by the UK firm are expected (anticipatory) ratios, that is ratios placed before the realisation of the actual exchange rate, actual export price and actual gain on the Asian option.The two latter parameters determine the optimal (actual) ex-post hedge ratio that completely eliminates economic exposure.However, this ratio is unknown when the hedge is placed, and we approximate it by the expected hedge ratio previously described.Since ex-post hedge ratios are expected, generally, to differ from ex-ante hedge ratios,we have to examine whether expected hedge ratios can hedge economic exposure successfully.We want, therefore, to establish a statistical criterion that will allow us to statistically examine the hypothesis that expected Asian options hedge ratios can eliminate economic exposure.

TABLE 6.2
DETERMINING THE COST OF HEDGING USING ASIAN OPTIONS

Quarter	Valuation Parameters	\$-Value Of ARO (Ordin. Call) When Hedge Placed.	\$-Actual (Expect.)Value When Hedge Removed.	£-Actual (Exp.) Profit On ARO
1985 II	T=.28,S=1.1365, c=.2135,r_d=0.09, r_f=.132,X=1.115	0.0288 (0.053)	0.143 (0.157)	0.091 (0.1)
III	T=0.302,S=1.264 c=.195,r_f=.126 r_d=0.075,X=1.258	0.021 (0.0466)	0.118 (0.1482)	0.07 (0.092)
IV	T=0.282,S=1.37, c=.21,r_f=.1156 r_d=0.081,X=1.376	0.025 (0.05)	0.06 (0.155)	0.024 (0.085)
1986 I	T=.244,S=1.439,c=.132,r_f=.118, r_d=.0797,X=1.436	0.0135 (0.031)	0.03 (0.1)	0 (0.056)
II	T=.3,S=1.4595, c=.118,r_f=.113, r_d=.073,X=1.439	0.0182 (0.037)	0.07 (.117)	0.034 (0.06)
III	T=.265,S=1.5170c=.1215,r_f=.098 r_d=.068,X=1.509	0.0165 (0.035)	0 (0.106)	0 (0.055)
IV	T=.252,S=1.447, c=.1325,r_f=.1056r_d=.06 ,X=1.4890	0.003 (.011)	0 (0.0575)	0 (0.035)
1987 I	T=.28,S=1.433 c=.107,r_f=.112, r_d=.063,X=1.430	0.008 (.024)	0.113 (0.085)	.068 (0.05)
II	T=.29,S=1.584 c=.1135,r_f=.1 r_d=.065,X=1.543	0.032	0.098 (0.14)	0.04 (0.06)
III	T=.252,S=1.6135 c=.096,r_f=.092 r_d=.07,X=1.641	0.005	0 (0.050)	0 (0.028)
IV	T=.252,S=1.6255 c=0.078,r_f=0.103	0.0121	0.136 (0.072)	0.070 (0.036)

TABLE 6.2 (Continued)

Quarters	Valuation Parameters	\$-Value Of ARO (Ordin. Call) When Hedge Placed	\$-Actual (Expec.) Value When Hedge Removed	£-Actual (Exp.) Profit On ARO
1988 I	T=.27,S=1.8295 c=.133,r_f=.095 r_d=0.083,X=1.618	0.066	0.0432 (0.206)	0 (0.068)
1988 II	T=.31,S=1.818 c=.1335,r_f=0.08 r_d=0.068,X=1.8	0.033	0.0418 (0.161)	.004 (0.064)
III	T=.252,S=1.708 c=.11,r_f=.1, r_d=.078,X=1.839	0.001	0 (0)	0 (0)
IV	T=.252,S=1.691c=0.098,r_f=.119 r_d=0.086,X=1.69	0.01	0.102 (0.106)	0.051 (0.04)

To do that, we first consider the product of the expected hedge ratio and the actual profit on Asian options.This product is the actual gain on Asian options that the UK firm will finally receive at expiration.We add this on to the actual export price from 1985/II to 1988/IV, when the export price was decreasing due to the pound appreciation.In this way, we derive what will be called here the 'hedged export price' (actual export price plus actual gain on Asian options),as opposed to the unhedged price (the price of exports itself).Using this hedged price, we can re-run the regression equation outlined in detail in chapter 3, and repeated here, for convenience:

$$(EP)'_t = b_0 + b_1 * (E.R)_t + b_2 * (E.R * D)_t + u_t \qquad (6.10)$$

where:

$(EP)'_t$:the new hedged export price (export price plus gain on option),

$(E.R)_t$:the actual average exchange rate.

In chapter 3, we used the actual (unhedged) export price in these regressions and contended that, if b_1 was statistically significant, economic exposure would be existent.Using now the hedged price series, we can statistically accept the hypothesis that Asian options have hedged economic exposure (that is, the profit on Asian options has sufficiently offset the export price cut) if b_1 turns out to be statistically insignificant.

In the section to follow, focus is placed on five of the commodities which appeared to be subject to economic exposure in chapter 3, that is: wool, petroleum, cars, office copying machines and chocolate confectionery.For each of these commodities, expected hedge ratios are calculated for the period from 1985/II to 1988/IV. After obtaining this series of data on the hedged export price, the previous statistical model is estimated. The hypothesis that Asian options hedge economic exposure is accepted, if the t-statistic of b_1 is lower than 2, at 95% confidence level.

A priori, one could argue that the closer the forecasts of export prices and gains on Asian options to actual export prices and gains on options, the closer the expected ratios to the ex-post ones, and thus, the higher the hedging effectiveness of Asian options (and the lower the t-statistic of the coefficient b_1).If the a-priori hedge ratios are different from the ex-post ratios, in statistical terms,then the hedging effectiveness is impaired, leading to either underhedging or overhedging.In fact, efficient hedging depends on two parameters:first, an 'accurate' forecast of the actual pound appreciation (which determines the actual profit on the option) and an 'accurate' forecast of the behaviour of the export price when the pound appreciates.The former parameter is, in fact, an assumption embodied in the Binomial approach to option pricing and hedge ratio determination. [See

Copeland and Weston (1988), pages 257-260].

The estimations of the model (6.4) for the five commodities mentioned, are provided in table (6.3).

6.7.Empirical Examination Of The Hedging Effectiveness Of Average Rate Options.

6.7.1. Cars.

The hedge ratios, calculated to hedge the export price reductions for cars over the period of the pound appreciation (1985/II to 1988/IV), are given in diagram (6.10).In this diagram, one can see an upward trend in the hedge ratio.This is so, since, as we get closer to the end of the period of the pound appreciation (1988/IV),the level of this appreciation is getting higher with reference to the rate at the beginning of that period.

TABLE 6.3.

REGRESSIONS TO TEST THE HEDGING EFFECTIVENESS OF AVERAGE RATE CURRENCY OPTIONS AGAINST ECONOMIC EXPOSURE.

Commodities	b_0	b_1	b_2	R^2 adj.	D.W.
Cars	7939	-1039 (-1.27)	-19 (-0.07)	.2%	2.44
Chocolate Confectionery	.745	-.147 (-1.7)	0.063 (2.13)	8.8%	2.43
Petroleum	13.9	-2.47 (-0.96)	2.45 (2.79)	15%	2.13
Wool	0.68	-.51 (-1.02)	0.035 (2.05)	6%	1.93
Copying Machines	378	-96.2* (-2.6)	27.2 (2.2)	16%	2.03

Notes: t-statistics in parentheses.
The estimated coefficients are expressed in units of currency (£).
* :Statistically significant coefficient (a=5%).

Therefore, the higher the expected pound appreciation and thus the higher the expected export price reduction, the higher the number of option contracts required to hedge the price cut, provided that the target export price is kept constant. This trend is portrayed in diagram (6.10).One can also see, in this diagram, the intertemporal variability of the hedge ratio, over the hedging period, indicating the dynamic feature of (financial) hedging readjustments to match different levels of exposure [see section (4.2.2), in chapter 4].

Using these hedge ratios and the actual profits on Asian options depicted in column 5 of Table (6.1), the series of the hedged export price was derived.This series is depicted in diagram (6.11) along with the series of the unhedged export price.The two series of prices are exactly the same for the period of the pound depreciation (from 1980/III through to 1985/I), as the Asian call was out-of-the money. After that period, one can see a downward trend for the unhedged price,indicating economic exposure.This trend has been abated by the profit on the Asian call so that the hedged price does not appear to be subject to economic exposure.The average export price, when the hedge is considered over the period of the pound appreciation, is about £6300.This is compared to a price of about £5250 when the hedge is not included, and a price of about £6200 when the pound depreciated.Thus, the variability of the average price in the two periods is lower when the hedged price is considered than when the unhedged price is considered.This reduction in the average price variability is due to the Asian option hedging.

To formally test the hypothesis that the Asian option hedge ratios, depicted in diagram (6.10), have eliminated economic exposure, we regress the hedged export price to the actual exchange rate and use a slope dummy (see chapter 3). The statistical model, estimated here, is the same as the one estimated in chapter 3, and thus, comparison can be made with regards to the hedging effectiveness of Asian option hedges.The newly estimated regression is given in table (6.3).

This estimation is expressed in units of currency to facilitate the determination of hedge ratios.

This regression should be compared with the relevant regression for cars in chapter 3 [Table (3.1)].Although a straight comparison between the estimated coefficients (b_1) can not take place (because in the latter equation all data is expressed in an index form, whereas here, the data is expressed in currency units), a comparison between the t-statistics of b_1s and the R^2's is possible.As can be seen, the t-statistic of b_1 is lower than 2 (at a 95% confidence level) and thus, we can accept the hypothesis that Asian option hedge ratios have eliminated economic exposure for the case of cars.The R^2adj. has also been significantly reduced, compared to the R^2adj. of the relevant regression of chapter 3.This result contends that the hedged export price of cars is not affected by pound appreciations.In statistical terms, the relationship between the effective (hedged) export price and the exchange rate is given by a completely horizontal line, which is compatible with the theoretically drawn horizontal line in diagram (2.7) (in chapter 2), depicting the case of no economic exposure.Thus, the Asian options have eliminated the downward trend of unhedged export prices depicted in diagram (6.11).[This empirically portrayed downward trend in the export price corresponds to the theoretically drawn one in diagram (2.6) in chapter 2].

Thus, although the negative sign of b_1 indicates that the hedged price will, in fact, decrease after actual pound appreciations,this decrease is not significant enough ,in statistical terms.For the whole period from 1980 to 1988, the regression slope appears to be the same (as the t-statistic of the slope dummy is lower than 2, as well).

The implication of this result for a UK firm which exported cars to the USA and faced economic exposure over the second half of the 1980's is that, it (the firm) could have eliminated this exposure if it had used average rate options.

Diagram (6.12) gives an indication of over-(under-)hedging by comparing the actual gain on calls and the actual export price cut, over the period of the pound appreciation.The general reasons that may have led to over-(under)hedging will be explained in a subsequent section.It appears that underhedging took place in the following quarters: 1986/I, 1986/III, 1986/IV, 1987/III and 1988/III.In all of these quarters, however, the underhedging was the result of temporary pound depreciations that rendered the Asian option worthless at expiration.Almost perfect hedging effectiveness was achieved for the following quarters: 1985/III, 1986/II,1987/I, 1987/IV and 1988/I.For the rest of the quarters, we had partial hedging coverage.

6.7.2. Chocolate Confectionery.

The hedge ratios are given in diagram (6.13).

One can distinguish an upward trend in the hedge ratios,which is due to the same reason outlined for the case of cars.

The relevant regression estimation is given in table (6.3).

Again, the t-statistic is lower than 2, implying that economic exposure has been removed.(One can accept the statistical significance of b_1 only at a 90% confidence level).As can be seen from chapter 3, the t-statistic of the estimated b_1 was about (-5), indicating the existence of very severe economic exposure.The above estimation denotes that this severe exposure has been eliminated.

Diagram (6.14) depicts the hedged vsv the unhedged export price.The average export price from 1980 to 1985/I was about £.6.The average unhedged export price from 1985/II to 1988/IV was about £.365, whereas the average hedged price over the same period was about £.514.Thus, the variability of the average prices between the two periods is reduced when the hedged export price is considered.

This result supports the argument that average rate options could have eliminated the problem of economic exposure faced by a UK firm with exports to the USA, over the second half of the 1980's.

Diagram (6.15) indicates cases of overhedging/underhedging. Underhedging was observed for the following periods: 1986/I, 1986/III, 1986/IV, 1987/III, 1988/II and 1988/III.The underhedging in 5 of those quarters was due to the temporary pound depreciations that occurred within the period of the long term pound appreciation.It was only in one quarter (1988/II) that the adverse effects of the pound appreciation on the export price failed to be captured by the Asian options.

6.7.3. Petroleum.

The hedge ratios for petroleum are given in diagram (6.16).The upward trend, observed for the hedging ratios of the previous commodities, is traced here as well.Similarly, significant intertemporal changes in the hedge ratio have occurred.

The regression equation is given in table (6.3).

Similarly to the cases already described, the b_1 coefficient is statistically insignificant, implying that Asian option hedges have successfully eliminated economic exposure.Also, reduced is the R^2.

The hedged export price is portrayed in diagram (6.17) along with the unhedged export price.The average price, over the period of the pound depreciation, was about £13.85 and dropped down to £6.2 when the pound appreciated.The hedged export price, when the pound appreciated was about £10,indicating again that the variability of the average export price between the two periods is reduced when the hedged export price is considered.

Diagram (6.18) gives a quarterly analysis of underhedging and overhedging.For petroleum, the same comments apply as for chocolate confectionery, in terms of what caused the mishedging.

6.7.4. Wool.

The hedge ratios for wool are given in diagram (6.19).The upward trend, observed in all the previous commodities, is maintained.

The regression equation is given in table (6.3)

Again, the hypothesis that Asian option hedges have eliminated economic exposure can be accepted,since the t-statistic of the b_1 coefficient is well below 2, in absolute terms.

Diagram (6.20) depicts the unhedged export price along with the hedged export price. When the pound was depreciating, the average export price was about £.652,dropping down to £.52 over the subsequent period of the pound appreciation.The hedged price is about £.595 over the latter period.

Diagram (6.21) shows the periods of underhedging and overhedging. Exactly the same comments apply here as before.

6.7.5. Office Copying Machines.

The hedge ratios are given in diagram (6.22).

The regression equation is given in table (6.3).

For copying machines, one can not accept the hypothesis that Asian option hedges

DIAGRAM 6.10

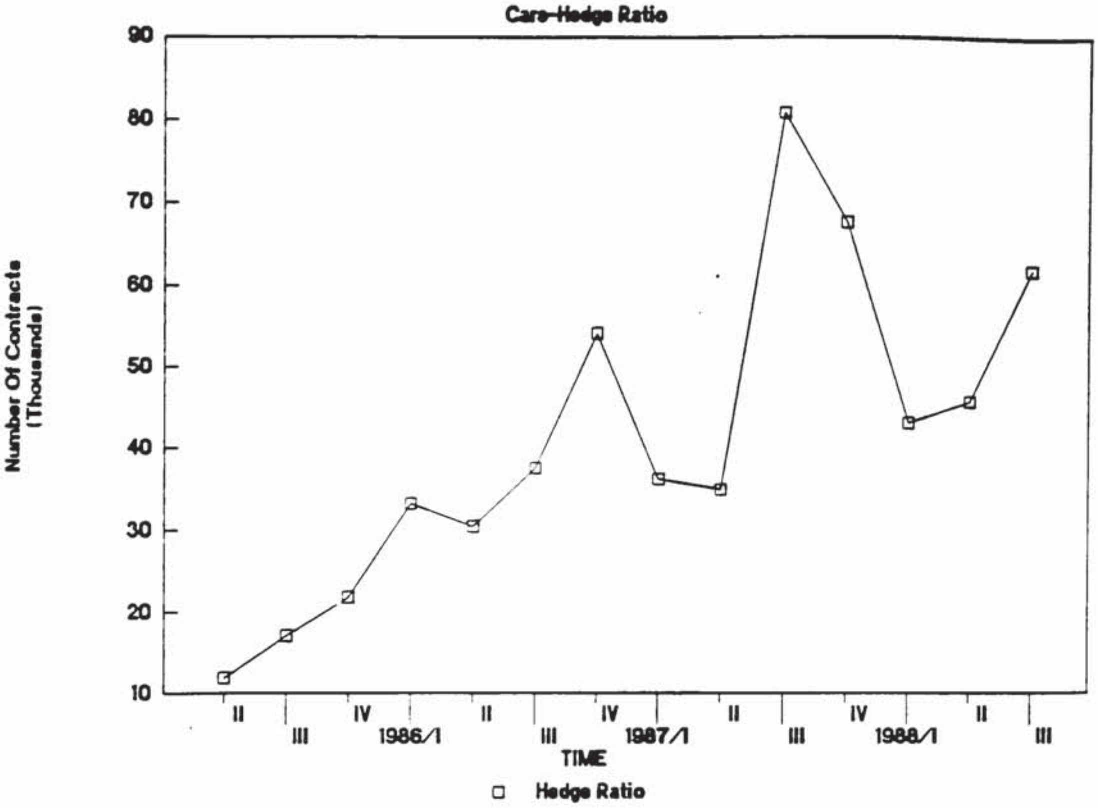


DIAGRAM 6.11

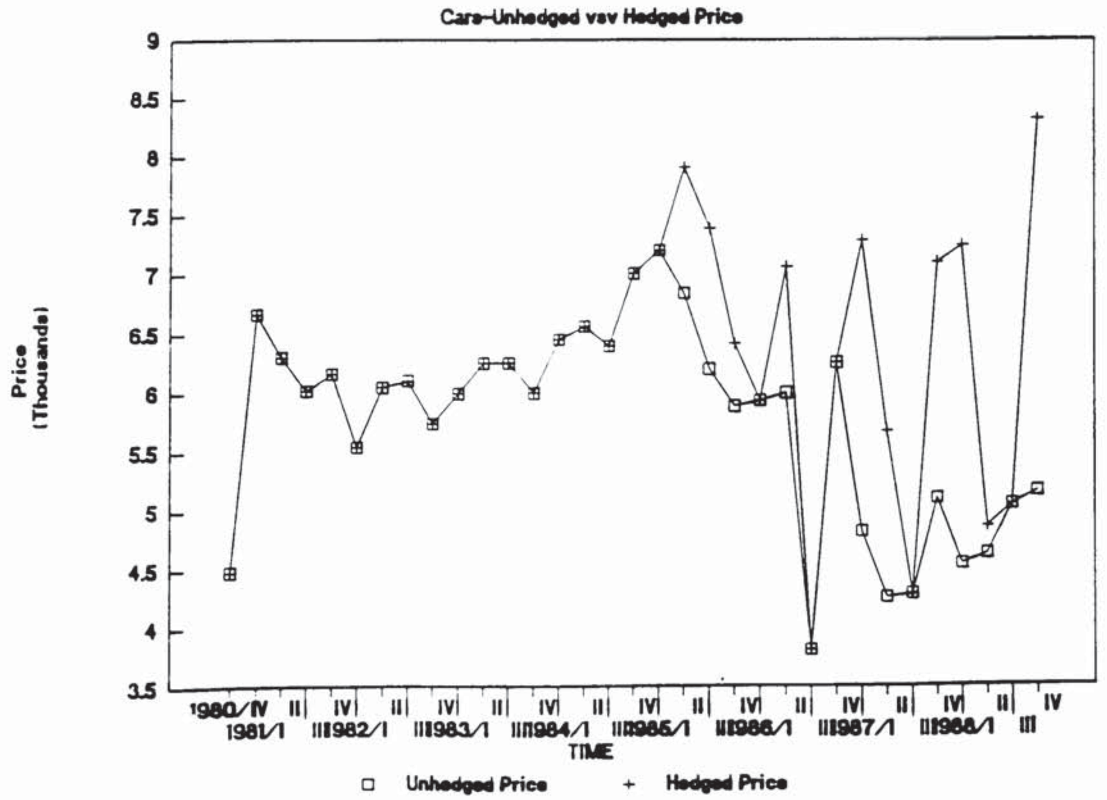


DIAGRAM 6.12

Care-Price Cuts vsv Options Gains

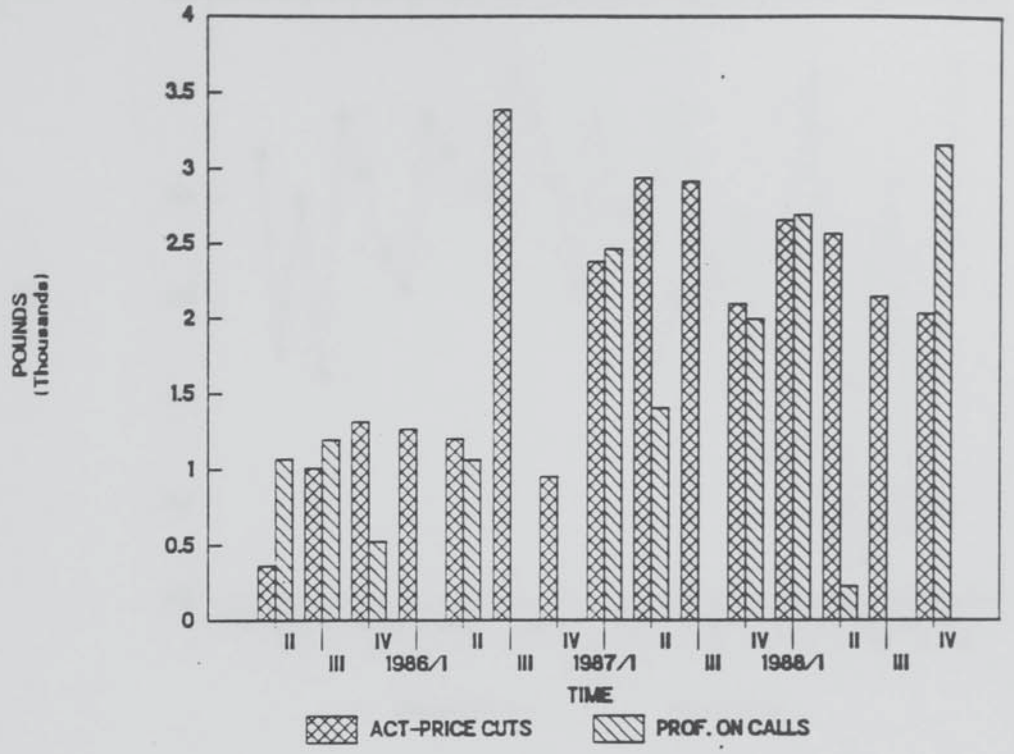


DIAGRAM 6.13

Chocolate-Hedge Ratio

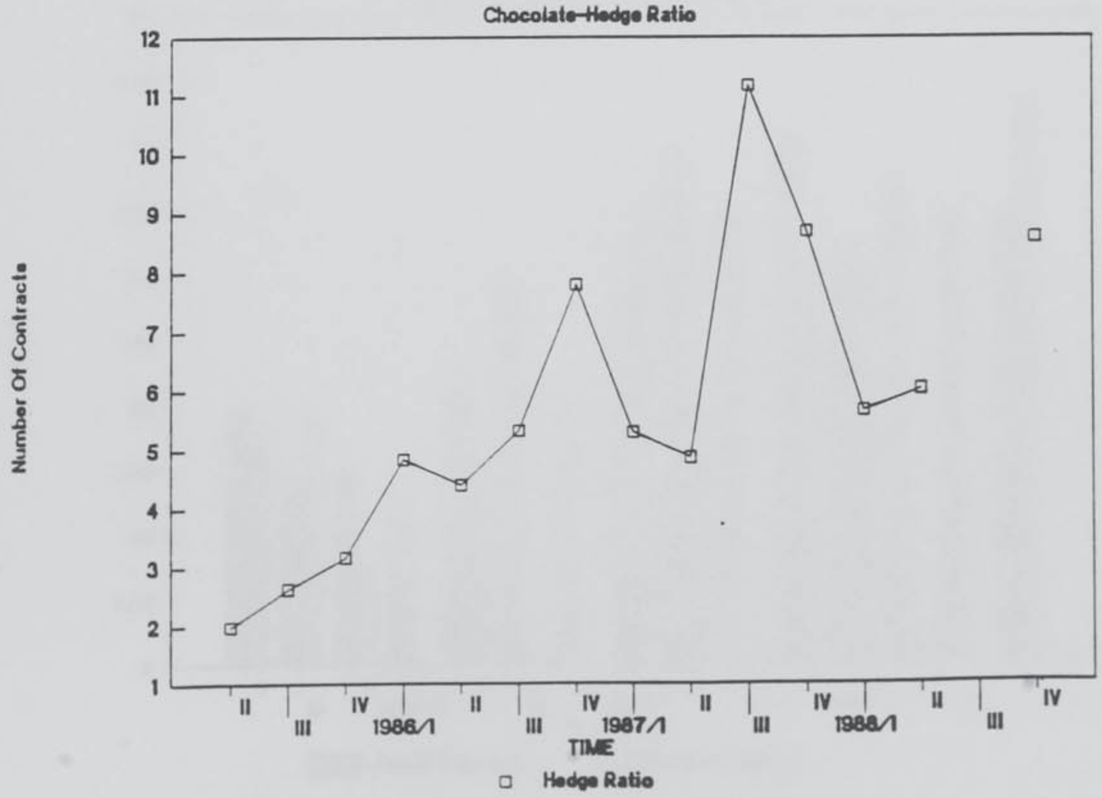


DIAGRAM 6.14

Chocolate-Unhedged vsv Hedged Price

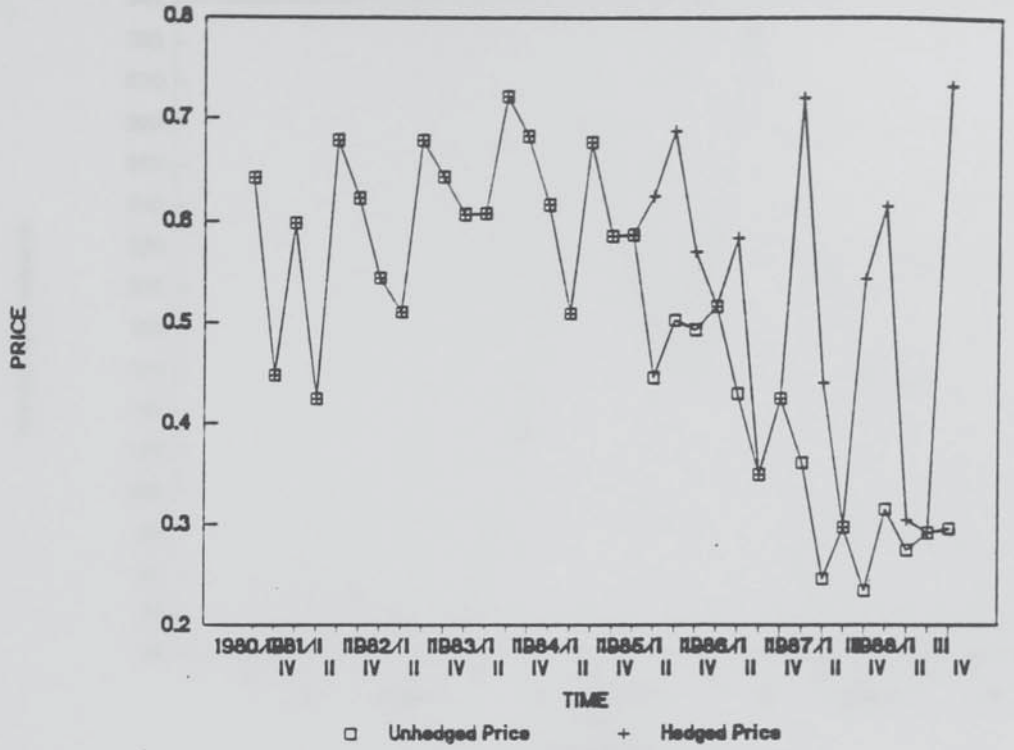


DIAGRAM 6.15

Chocolate-Price Cuts vsv Options Gains

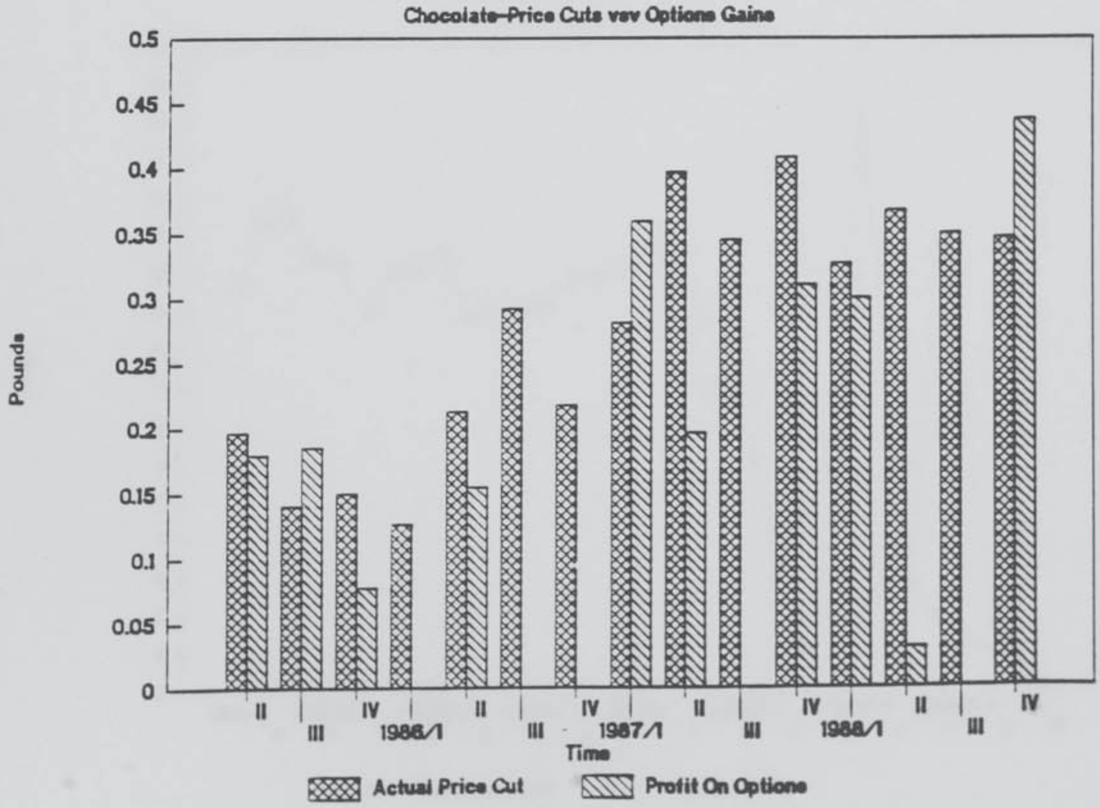


DIAGRAM 6.16

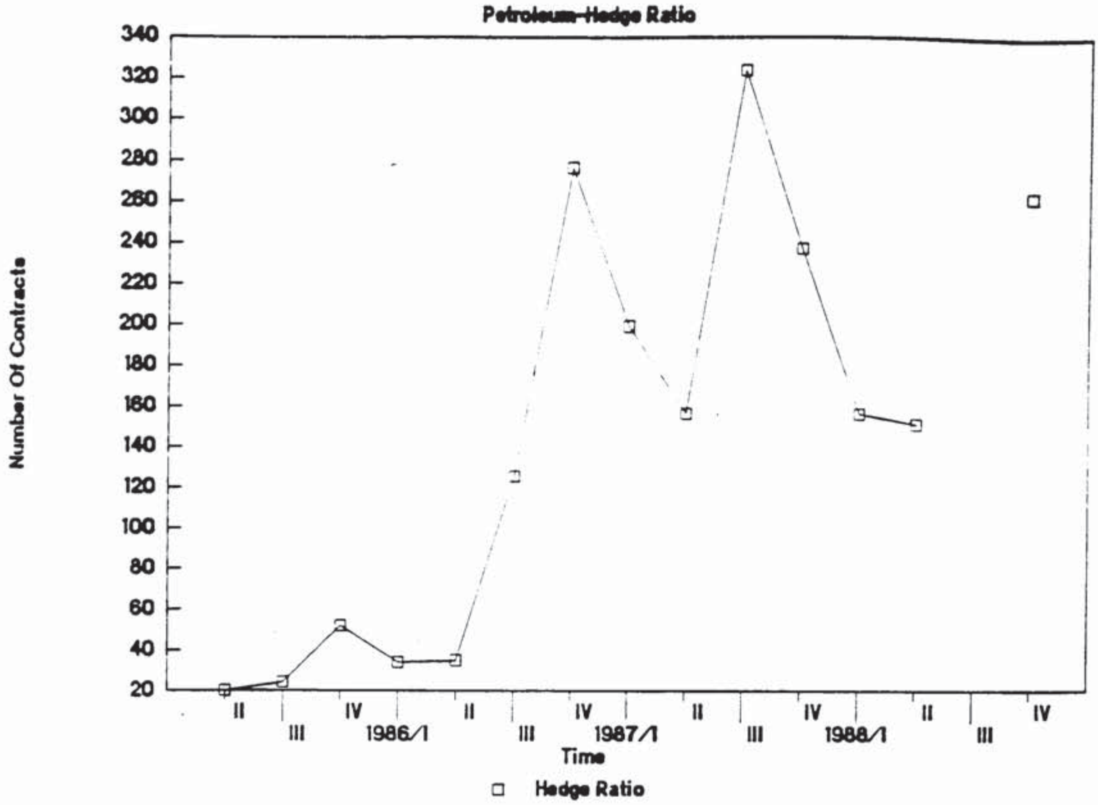


DIAGRAM 6.17

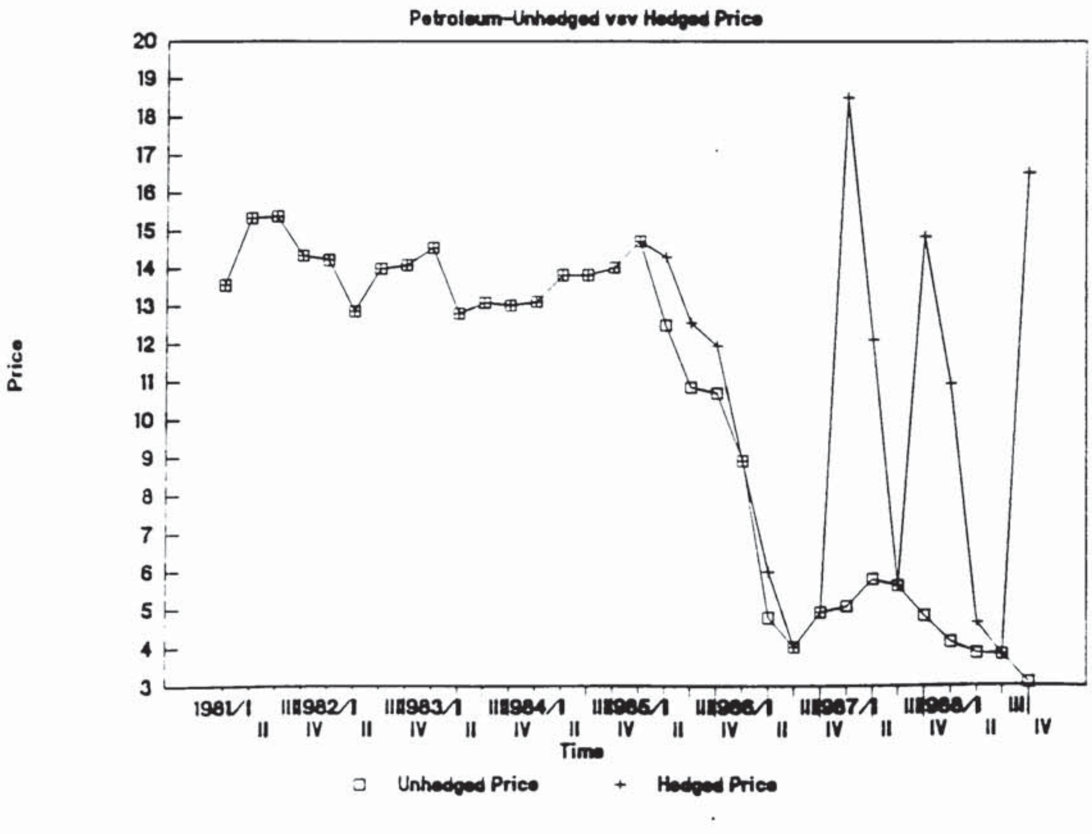


DIAGRAM 6.18

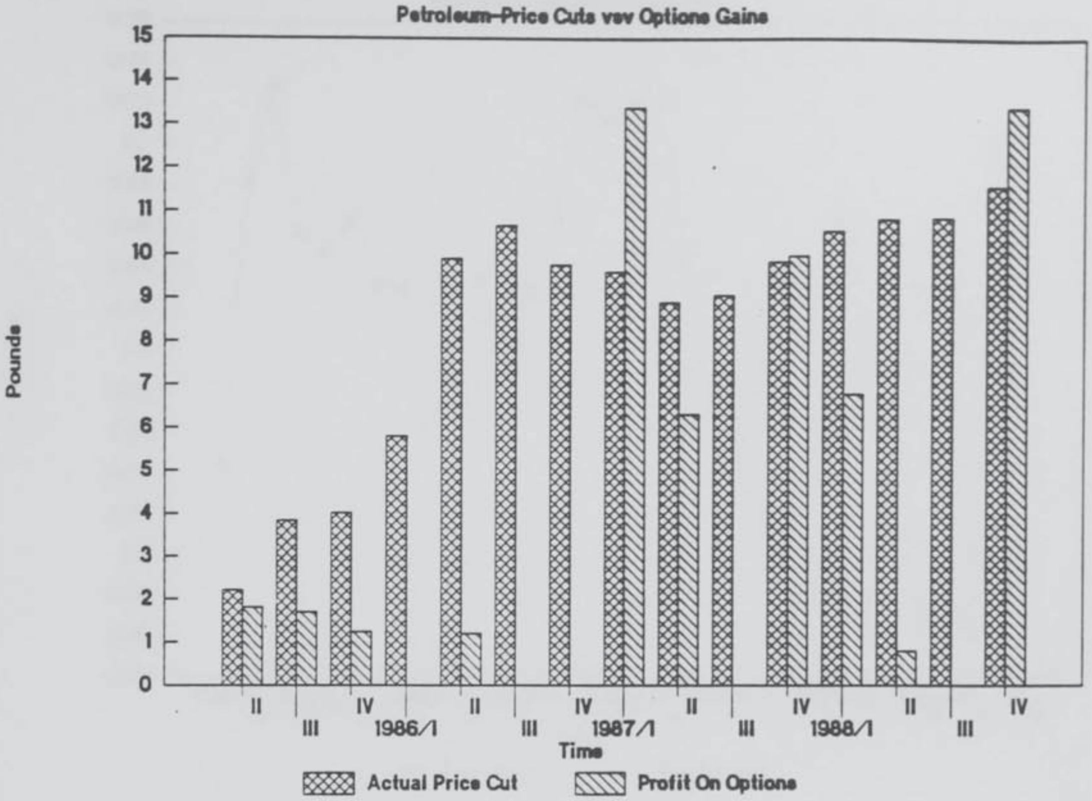


DIAGRAM 6.19

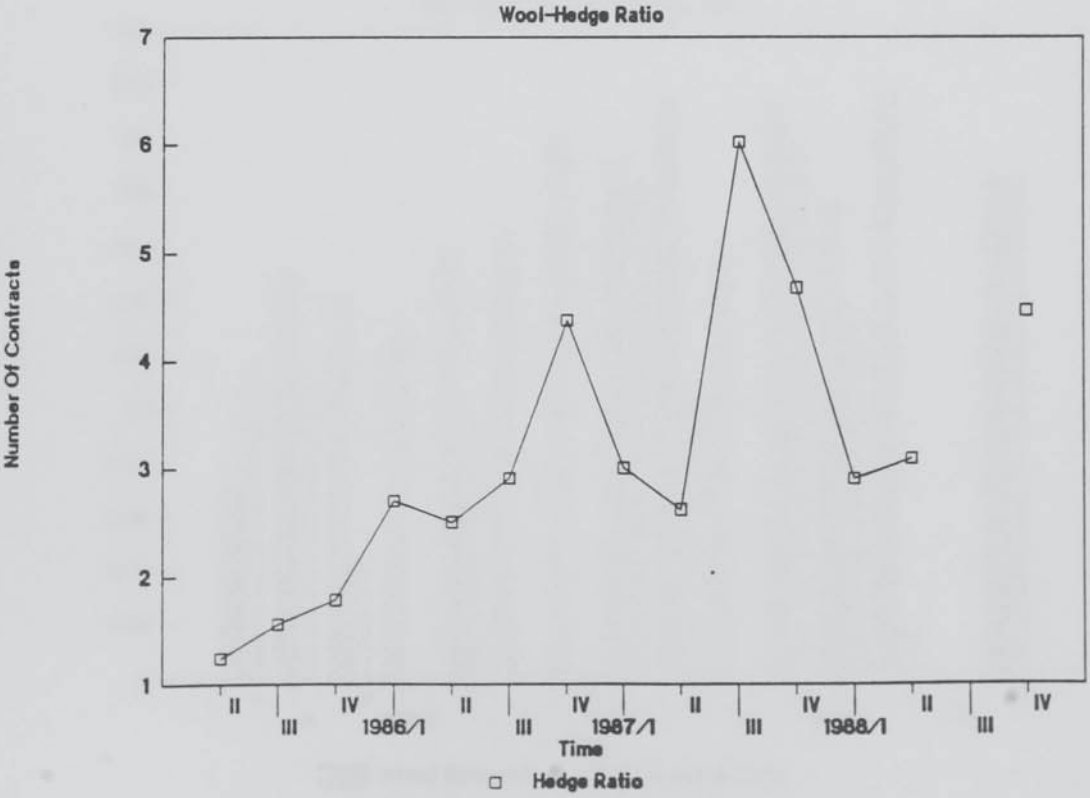


DIAGRAM 6.20

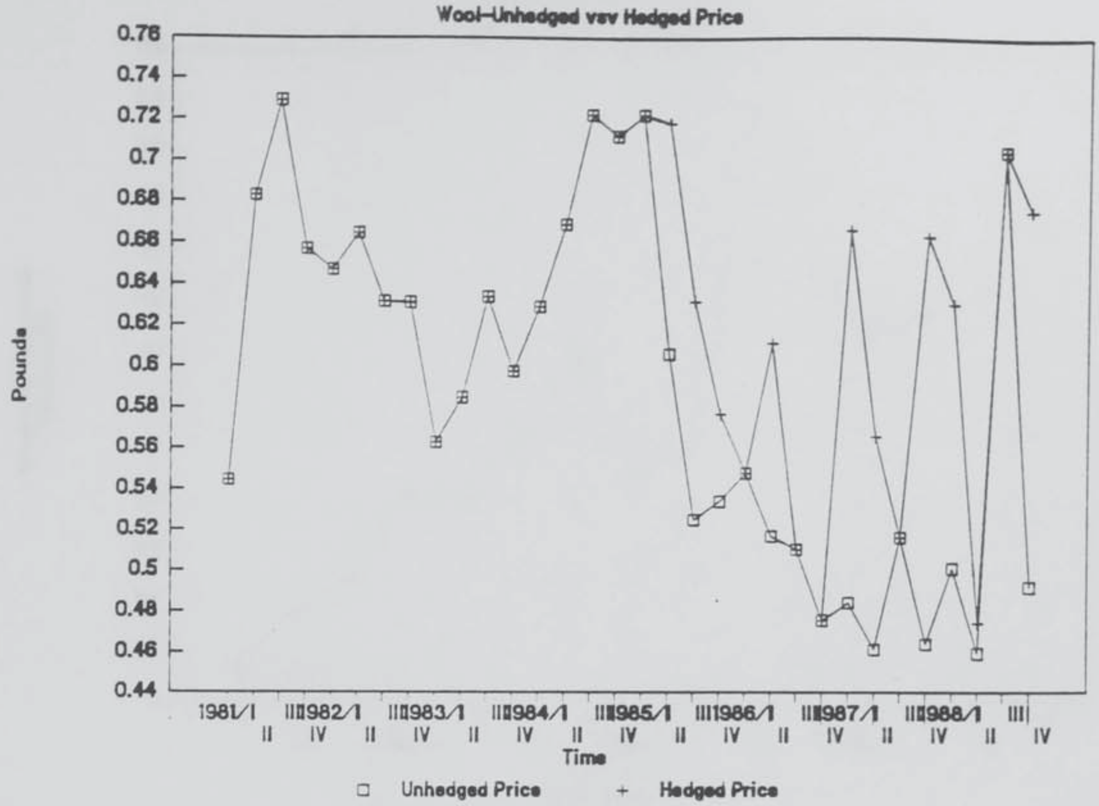


DIAGRAM 6.21

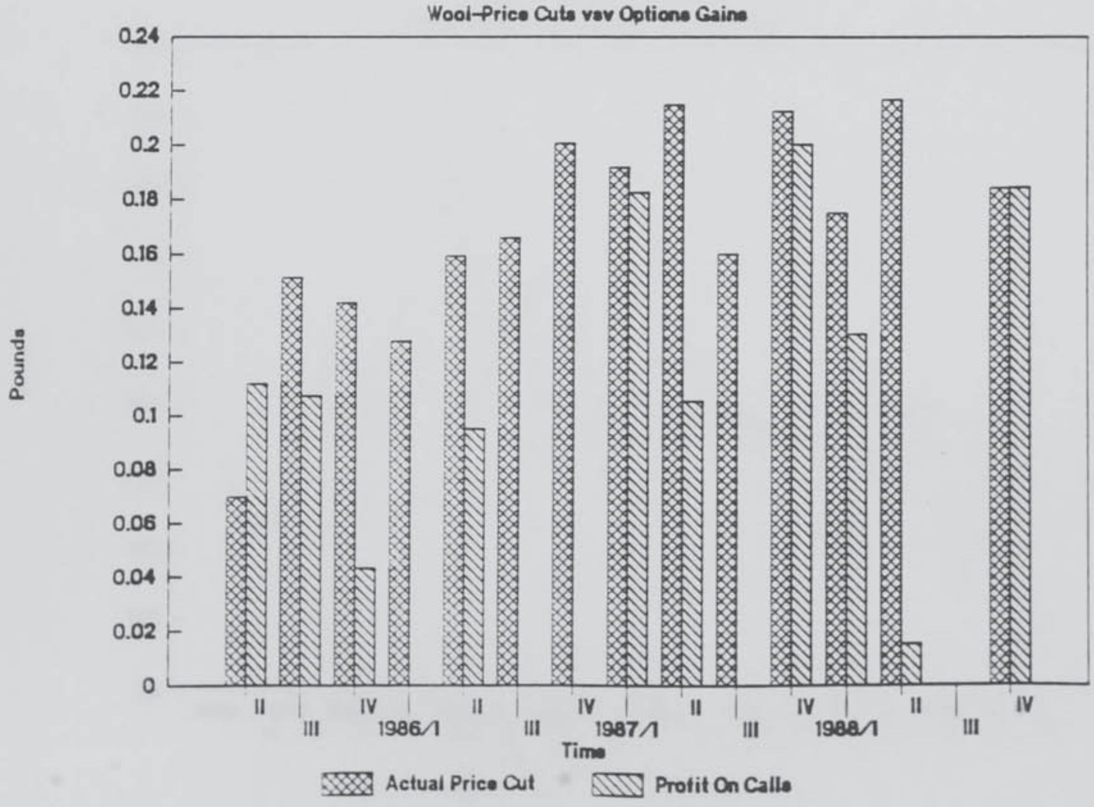


DIAGRAM 6.22

Copying Mac.-Hedge Ratio

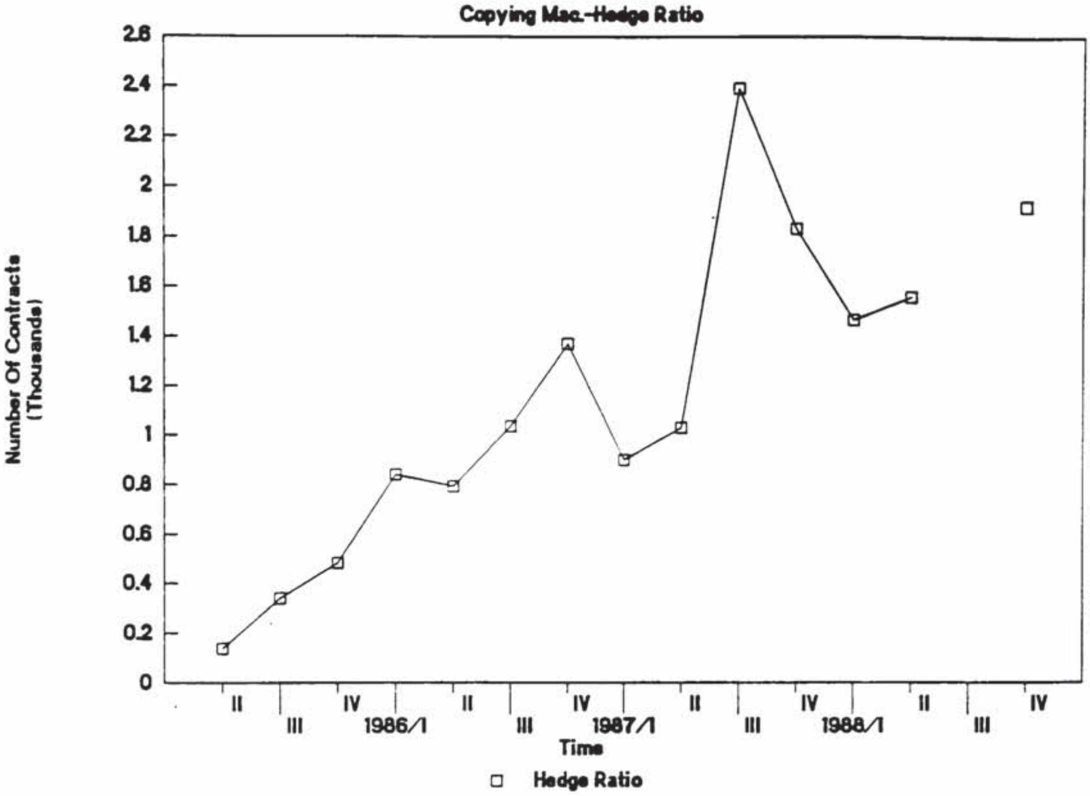
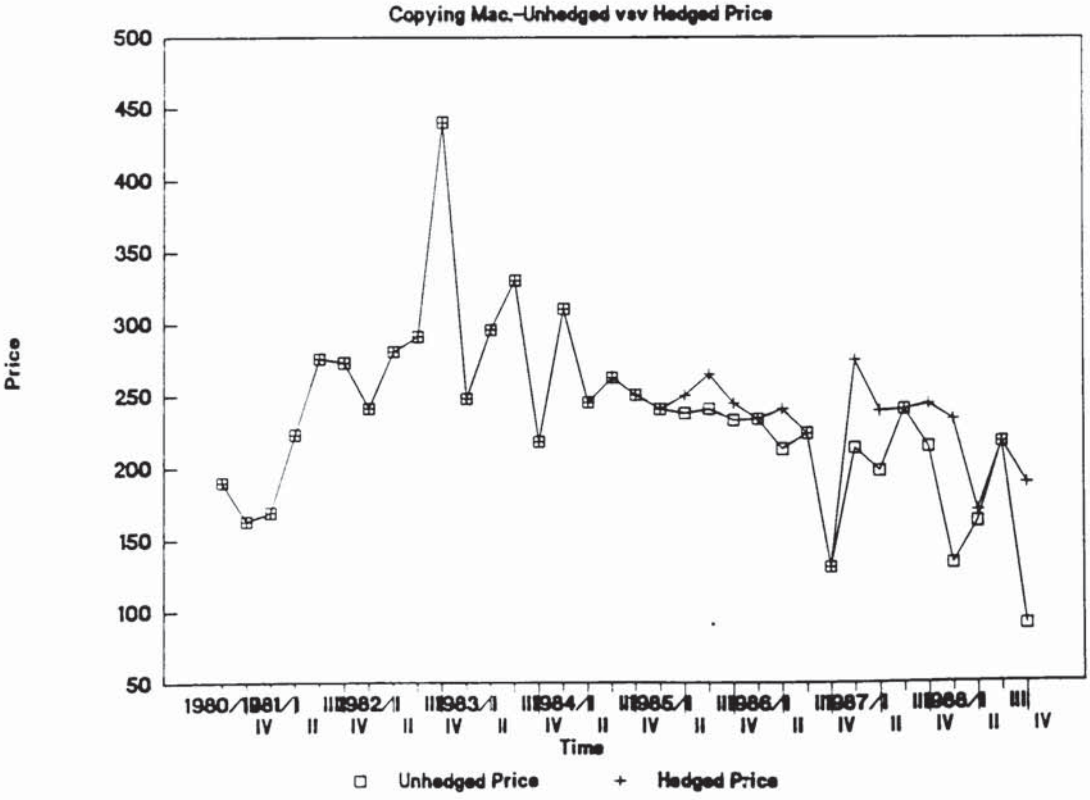


DIAGRAM 6.23

Copying Mac.-Unhedged vsv Hedged Price



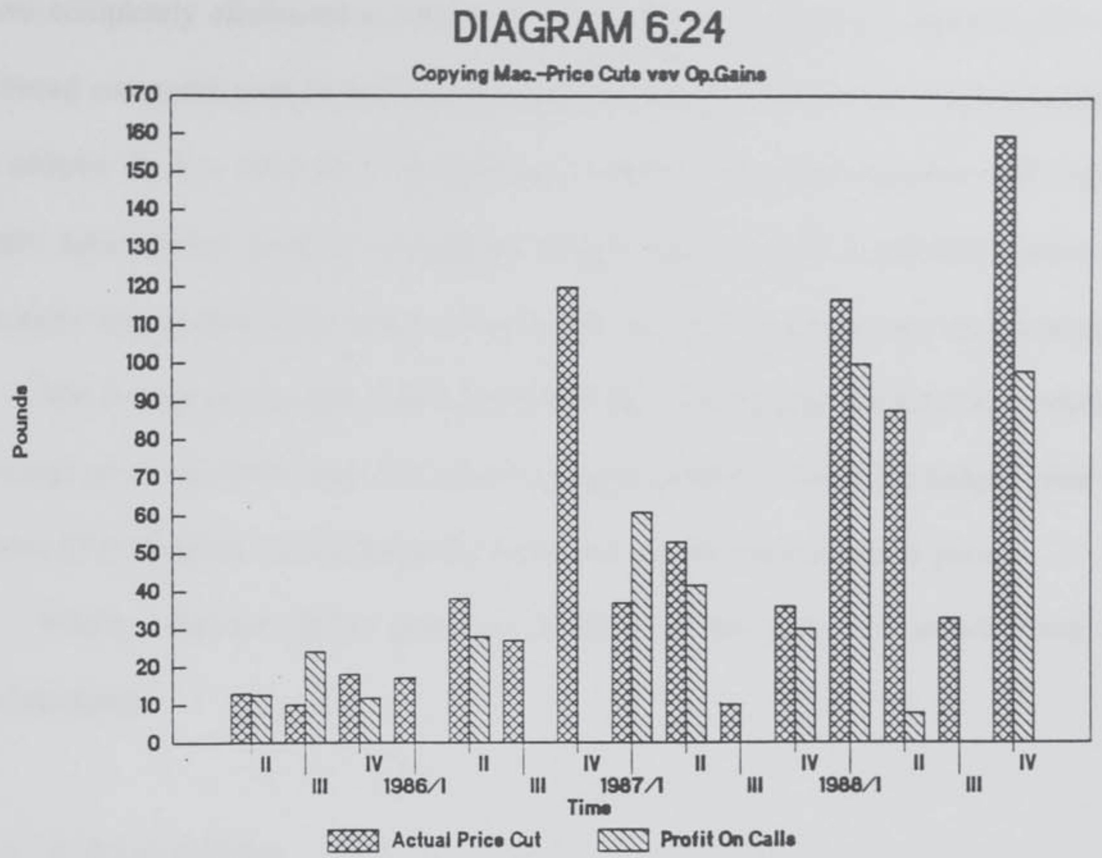


DIAGRAM 6.24
Copying Mac.-Price Cuts vsv Op.Gains
Pounds
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
II
III
IV
1986/1
II
III
IV
1987/1
II
III
IV
1988/1
II
III
IV
Time
Actual Price Cut
Profit On Calls

have completely eliminated economic exposure.Although economic exposure has been reduced compared with its initial level (see the relevant equation for copying machines in chapter 3), it is clear from the previous estimation that some exposure still remains after Asian option hedging. Significant underhedging can be a possible reason that explains why options have failed to remove all economic exposure (see next section).

The average export price when the pound was depreciating was £260.The unhedged average price was £198, when the pound was appreciating, whereas the hedged price was about £226.Diagram (6.23) gives the unhedged vsv the hedged export price.

Finally, diagram (6.24) gives an analysis of the cases of underhedging and overhedging.

6.7.6. General Points.

1.In all of the previous cases, the hedge ratio is following an upward trend due to the fact that the pound was steadily appreciating. Higher hedge ratios are required to hedge against higher pound appreciations.

2.The average hedged export price is closer to the 'target' average price than the average unhedged price is.This is due to the net profit on the options, included in the hedged price.

3.For some quarters, cases of underhedging and overhedging are observed.Several reasons can be accounted for this phenomenon. First,Asian options are only cross-hedge instruments against economic exposure, that is, their values do not depend on the variability of the export price itself, but on the variability of exchange rates which cause export price variability.The export price can be also affected by business risk (income changes, market structure changes, etc),which is not captured by the values of Asian options. As indicated in chapter 3 [section (3.3)], financial (i.e.currency options) hedging against exchange rate risk is expected to eliminate the portion of export price variability due to exchange rate changes, and not the overall price variability. It may be this remaining variability due to business risk which causes exchange rate mishedging. For example, we may have cases where the export price decreases sharply after a relatively low pound appreciation, with the 'excessive' price cut being attributable to business risks (recession in the USA market).This low appreciation will result in a relatively low profit on the Asian option which may not be sufficient to completely hedge the sharp cut in the export price.This is a case of underhedging.In the same way, sharp pound appreciations along with low export price cuts can lead to overhedging.

A second factor which can be accounted for overhedging or underhedging is the fact that hedge ratios are anticipatory, that is based on expectations about the future appreciated exchange rate, the future export price cut and the future profit on the option. Divergencies between the expected upper exchange rate and the actual upper rate (pound appreciation) may result in divergencies between anticipatory and actual hedge ratios, causing a relative reduction in hedging effectiveness.

4.A potential use of futures or forward contracts contradicts with the following two theoretical arguments:

First,futures or forward contracts would have resulted in significant hedging losses over the period of the pound depreciation. These losses can be perceived as wasting the competitive advantage that the pound depreciation was providing to UK exporters.

Second, the profit and loss profile of these instruments is a function of daily spot exchange rates.As explained above, hedging economic exposure requires instruments based on average exchange rates.[See also section (7.4). in chapter 7].

6.8. Conclusion

In this chapter, the focus was on how a currency option hedging strategy against economic exposure can be implemented in practice.An empirical hedging scenario addresses the issues of the type of currency option to be used,the determination of the exercise rate, the timing of placing and removing the hedge and the number of contracts per unit of commodity exported.

Average rate options are proposed to be adopted in the empirical hedging scenario, on the basis of the assumption that export prices are determined by period average exchange rates.

The exercise rate of these options should be based on the average exchange rate of the period prior to the time span of economic exposure, adjusted by the difference between the inflation rates of the countries concerned.

The hedge should be placed prior to or at the time of the determination of expected export prices (submission of export price lists), depending on the behaviour of daily spot rates over that period. It should expire when the actual export price is known with certainty.

The empirical determination of hedge ratios is based on forecasting future export price reductions and net profits on the options, which may arise after a possible pound appreciation.

This empirical hedging scenario was adopted to examine whether it can eliminate the economic exposure traced for five of the commodities analysed in chapter 3. Asian options were used and hedge ratios were calculated. Statistical examination of the hedging effectiveness of these hedge ratios leads to the conclusion that, although cases of mishedging exist, the overall performance of Asian options in managing economic exposure is satisfactory. The observed under(-over)hedging may be due to the fact that Asian currency options are only a cross hedge instrument against economic exposure. The overall result may appeal to firms which exported either of these commodities to the USA and faced exposure over the period from 1980 to 1988.

To obtain an improved hedging effectiveness, one should use a hedging instrument whose value is explicitly associated with both exchange rate risk and business risk. To my knowledge, such an instrument is still to be developed.

NOTES

1.There are many types of currency options, depending on the type of exchange rate on which their values are determined.See note 6, in this chapter.

2.Many firms use the average rate as an approximation for period rates.For example,the GKN's annual report for 1990 stresses the significance of average rates on the firm's business and trading results.

3.See Kanas (1989).

4.For example,the average rate for the whole of 1990 was about 15% lower than the end of period rate (1.93).Another example, is the divergence between the average rate of the second quarter of 1985 ($1.115) and the rate that prevailed at the end of this quarter(1.235).In these cases, a conventional call would be completely inefficient , although a severe pound appreciation took place.

5.Some of the banks that offer Asian options in the OTC market are:Amsterdam-Rotterdam Bank,Bankers Trust International Ltd,Barclays Bank,Continental Bank,First National Bank of Chicago and Swiss Bank.

6.Other types of options in the same category include:the 'down and out' options, the up-and-out options,the up-and-in options and generally all barrier options.For definitions on the above options, see The Mitsubishi Finance Risk Directory, 1990/91.

7.This question addresses the issue of what happens to the average option prices when the spot observations used to calculate average rates are daily, weekly, monthly, etc.It appears that the convolution method of pricing arithmetic average options,described by Clewlow and Carverhill (1990) allows for this issue.

8.See Yallop (1991).

9.This result is due to Clewlow and Carverhill (1990).

10.This is the case of Cadbury's chocolate products, according to an informal interview with the company's treasurer.

11.As the actual spot rate that enters the Asian option formula is multiplied by a correction factor (that depends on the interest rate differential) [equation (6.4.a)], it (the correction factor) decreases the effective spot rate to finally enter the formula, given that the pound rate is higher than the dollar rate.Thus, we can allow for the actual spot rates, at the time when the hedge is placed, to be a bit 'higher' than the period average rate.

It should be mentioned, however. that this hedging scenario does not offer any cover , if the exchange rate follows surprise jumps.This is the case if the rate goes up suddenly, before the hedging firm places a hedge, and stays there.In this case, the exchange rate route does not give the firm time to hedge itself against the resulting exposure.Average rate options may be inefficient in this situation.

12. In this case, the volatility to enter the valuation formula should be higher than the volatility when both periods are equal.If the averaging period is longer than the maturity period, the beneficial effects of averaging upon volatility are reduced.

13.Daily fixings give a sufficiently high number of observations for calculating average rates, neutralising the effects of different frequency fixings on option premiums.

14. This parameter,n, measures the number of binomial trials.We set it, here. equal to 1, to allow for only one major exchange rate outcome over each quarter.This is compatible with the assumption that export prices are only affected by major exchange rates and we have only one export price per quarter. For the role of 'n' in the Binomial distribution, see Copeland and Weston (1988).

15.To carry out this simulation, we wrote a computer programme, using MINITAB, that calculates premiums and deltas of Asian options.

CHAPTER 7

OPERATING EXPOSURE AND CURRENCY OPTIONS:SOME EXTENSIONS.

7.1.Introduction.

The main focus of the theoretical and empirical discussion so far was on a UK firm with exports to the USA and production costs in pounds.It was assumed that its competitor had costs only in dollars and thus, economic exposure was due to changes in the \$/£ rate.Under the assumption of a market share objective, the UK firm faces asymmetric exposure, and hedging must be based on currency options.Further, as economic exposure is assumed to be determined by average exchange rates, average rate currency options should be used for hedging.

This chapter provides five theoretical extensions on these findings about exposure and hedging.These extensions are based on different assumptions about the parameters which determine exposure from those already adopted so far, and aim to provide a more general understanding of the problem and the hedging solutions against it.

The first model provides an analysis of the problem of operating exposure, under the assumption that competitors have an unhedged foreign currency payable (transaction exposure) in a common currency.It offers an extension of the discussion provided in section (2.3.4) of chapter 2, which dealt with two competitors facing transaction exposure, with the difference that hedging, using forward contracts, was undertaken.

The second model examines the problem of economic exposure of a purely domestic firm which faces import competition,and proposes hedging solutions based on options.

The third model examines under which conditions operating exposure can be symmetric, and how this exposure can be hedged.

The fourth model relaxes the assumption that the UK firm faces competition from firms with costs only in dollars. It assumes that many international competitors participate in the USA market, and therefore, a multicurrency operating exposure arises.It examines whether this type of exposure can be hedged using a multicurrency (index) average rate option.

Finally, the fifth extension examines theoretically the use of lookback currency options for hedging a single currency operating exposure.The use of this instrument is based on the assumption that export prices may not be determined by period average exchange rates but rather, by the maximum rate in a particular period.

7.2.Economic Exposure And Hedging When Competitors Have Costs In A Common (Third) Currency.

Suppose that the UK firm, analysed in chapter 2, imports an important material from Germany, and thus has a DM denominated payable (i.e transaction exposure to the DM/£ rate).We assume that its USA competitor imports the same material from Germany, and thus, has a transaction exposure to the DM/$ rate.We further assume that, the two firms do not hedge their transaction exposures.This implies that the domestic currency (£-denominated for the UK firm, and $-denominated for the USA firm) value of the proportion of costs in DMs is not known until the realisation of the actual exchange rates ($/DM,£/DM and thus, $/£). If forward contracts had been taken by both firms, then the domestic value of these costs would have been known with certainty, and the analysis would have been the same as in chapter 2 [section (2.3.4)].

This model reflects the case of UK producers of articles of tin who export to the USA.As the price of raw tin is expressed in Malaysian dollars, both UK and USA producers have costs in this currency [chapter 3,section (3.6)].

Suppose that 50% of the costs of the UK and USA firms are expressed in,say,DM. Does operating exposure arise for this portion of costs? It should not, since according to chapter 1, operating exposure arises due to different currencies in which costs are expressed.Table (7.1) provides a numerical example which illustrates the above proposition.

TABLE 7.1

THE EFFECTS OF AN UNHEDGED PAYABLE OF DM100 ON THE COSTS OF THE UK AND USA FIRMS.

Exchange Rate	Cost Of UK Firm (£)	Cost Of USA Firm ($)	Cost Of USA Firm (£)
£1=DM2 $1=DM1 £1=$2	£50	$100	£50
£1=DM2.5 $1=DM0.5 £1=$5	£40	$200	£40
£1=DM2.5 $1=DM2 £1=$1.25	£40	$50	£40

In all of the cases, the cost of the importing material incurred by the USA firm, when expressed in pounds, is the same as the cost incurred by the UK firm. Consequently, operating exposure does not arise for those costs expressed in a common currency (DM).The difference between this case and the one analysed in section (2.3.4) in chapter 2, is that in the latter, operating exposure arises for all the costs including those expressed in DMs, if these are hedged using forward contracts. Hedging a (common) foreign currency payable by both firms, using a forward contract, implies that this cost is expressed into a certain (due to forward hedging) domestic currency cost, for each firm.In this case, economic exposure arises for the whole amount of (domestic currency) costs.In the case examined here, the proportion of costs expressed in a domestic currency is smaller,and thus, exposure is reduced.Therefore, if both firms face the same transaction exposure (have the same account payable) and both hedge this exposure using forward contracts, their transaction exposure decreases but their operating exposure increases.If they do not hedge, their transaction exposure increases and their operating exposure decreases.

As a result of the above example, the lower the proportion of costs expressed in domestic currencies, the lower the competitive advantage of the USA firm in the case of a pound appreciation, and thus, the lower the downward move of its marginal cost curve [refer to diagram (2.2) in chapter 2].The latter implies that, the decrease in the export prices, when the pound appreciates, will be relatively lower, and thus,the downward line in diagram (2.6) more horizontal.In fact, we will have a 'proportional' operating exposure similar to that depicted by diagram (4.19).

The hedging implication of this model is that, we need a proportional coverage hybrid call, for this type of exposure [see diagram (4.32)], which is cheaper than the ordinary call.The fact that we hedge with a cheaper option implies lower operating exposure which is exactly due to the lower portion of costs between the two firms exposed to exchange rate changes.

7.3.Operating Exposure Of A Domestic Firm And Hedging.

In the previous chapters, the main focus was on the economic exposure of an exporting firm, facing competition from international producers in overseas markets. However, in chapter 1, it was argued that economic exposure is not due to the nationality of the markets in which the firms operate, neither is it due to the currency, in which receivables or payables are expressed.It is rather due to the different currencies in which the costs of different producers (of not necessarily, different nationalities) are denominated. This implies that one should not confine the discussion of economic exposure and hedging to exporting firms, but rather, one should consider the case of a domestic firm, which faces import competition from international firms with costs denominated in different currencies.

As an example depicting the problem of economic exposure faced by domestic firms, one could mention the footwear industry in the UK.In a Financial Times article (23 May 1988), it was mentioned that from the summer of 1987, the UK shoe manufacturers had suffered from the strengthening of the pound which, has 'fuelled a surge of imports from the Far East'.It is also reported in this article that the strength of the pound made it increasingly difficult for these firms to compete (export) in overseas markets.Further, in 1987, the shoe companies experienced a rise in imports by 15%, whilst their own output fell by 7%.This was attributed to a strong sterling.At the beginning of 1988, this trend continued, followed by a slowdown in exports by 7%. As a result,several footwear companies have been forced to close.This exchange rate driven hardship forced many companies in the industry to ask for government protection, in terms of imposing restrictions on imports.

One can analyse the problem of economic exposure faced by a purely domestic firm, using risk profiles, in similar fashion to the analysis of chapter 2.Any hedging implication should be focused on the risk profile which describes the relationship between exchange rates and the actual import price of the commodity in question.

The analysis assumes the existence of a UK firm with pound costs. This firm faces import competition from a firm with dollar denominated costs.All the assumptions, concerning market structure (oligopolistic market and pricing on the basis of the price leadership model) and equivalent levels of technological efficiency amongst producers, are carried forward here, as well.The product is, again assumed to be only marginally differentiated, and thus, the price elasticity of demand is relatively high.

Following the analysis of chapter 2, we assume that international producers fix their bid (import) prices in terms of their own currency (dollars), aiming towards a long term expansion in the UK market.

The determination of the expected price by the UK producer is given by diagram (7.1).

The future exchange rate, $E(e_1)$ is expected to depreciate.The expected domestic price,in pounds, is $E(P_1)$.The USA firm is assumed to have the same expectations about the exchange rate.It submits an import price expressed in dollars, given by (7.1).

$$\$ [£ E(P_1) * E(e_1)] \qquad (7.1)$$

The £-bid price is a function of this \$ price and the actual exchange rate.The profile of the £ price, for different exchange rates, is given in diagram (7.2).It must be noted that the slope of line AB, in this diagram, is -1.

Diagram (7.3) gives the bid price of the UK firm, fixed in pounds.

Diagram 7.1. The Determination Of The Expected Optimal Price Of The UK Domestic Producer.

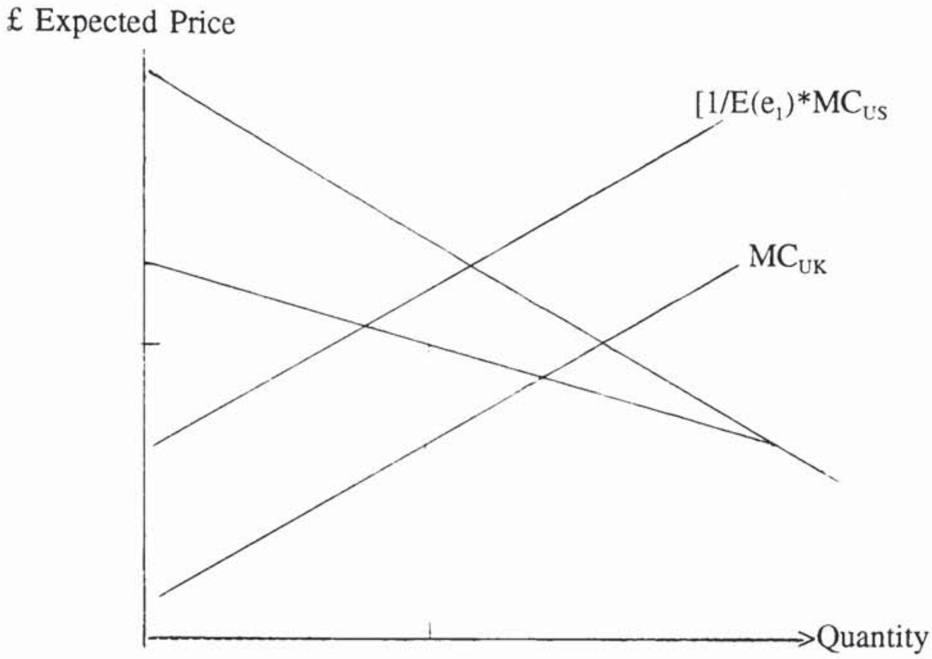


Diagram 7.2:The Pound Bid Price Of The USA Competitor.

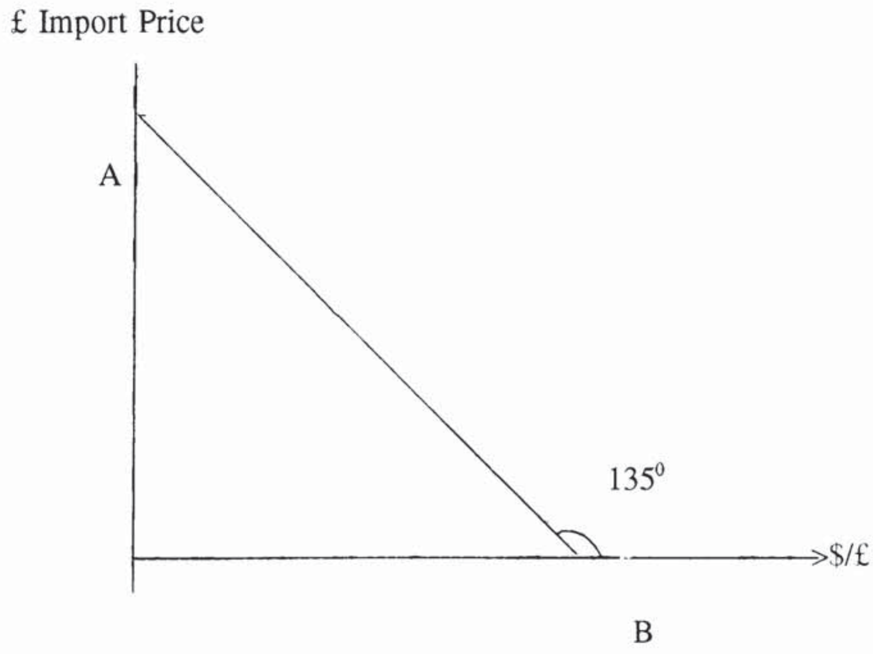


Diagram 7.3:The Pound Bid Price of the UK Firm.

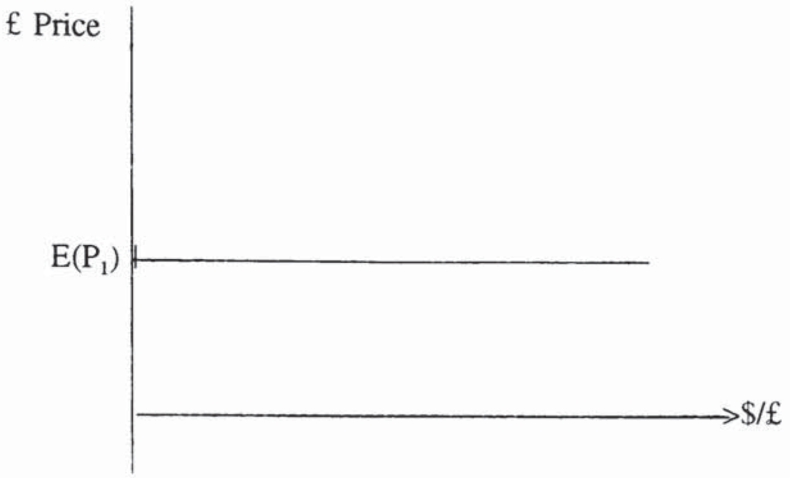


Diagram (7.4) integrates diagrams (7.2) and (7.3), to illustrate the (actual) market equilibrium domestic price (absolute minimum of different bid prices), at different levels of actual exchange rates.Diagram (7.4) gives the economic exposure risk profile for a domestic firm.

Diagram 7.4:The Risk Profile Of The Economic Exposure Faced By The UK Domestic Firm.

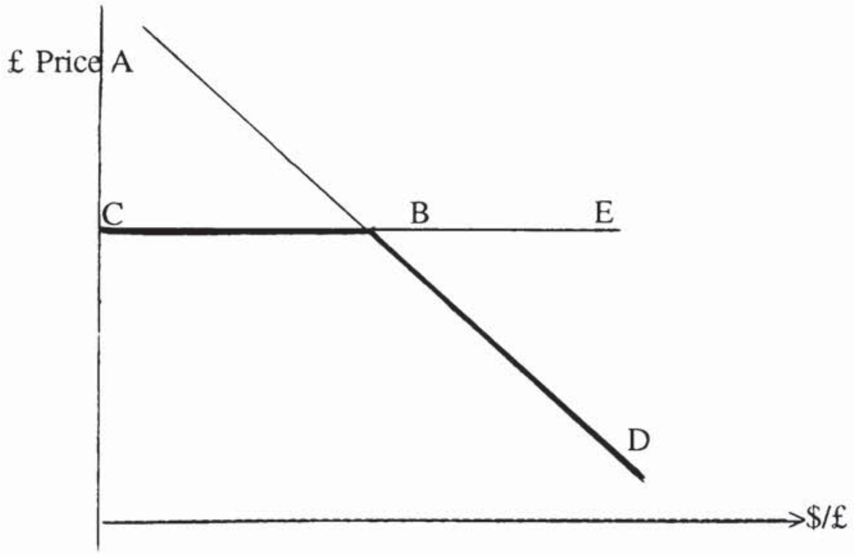


Diagram (7.4) indicates that the economic exposure faced by a UK domestic firm is exactly the same as the exposure faced by a similar firm which exports to the USA (instead of selling domestically).In fact, we kept all the assumptions in chapter 2 the same, and changed the assumption of the market where the UK firm sells its output, in order to see (through the risk profile) if the economic exposure problem is the same.The downward sloping line of the previous diagram denotes that economic exposure is relevant for a purely domestic firm, and in fact, is of exactly the same type as the exposure relevant for an exporting firm which faces exactly the same level of competition. This argument can be used against the strategic hedging proposition outlined in chapter 4 [section (4.2.2)], which favours the development of a network of different markets, in order for the firm to hedge its exposure.If the same competitors, which the UK firm faces in the USA market, expand their selling operations in the markets where the UK firm has expanded, then the economic exposure problem still exists. The intuition behind diagram (7.4) is that, if the pound depreciates, the USA imports will become relatively expensive (AB vsv CB) and the UK firm will maintain its domestic price in order to eliminate import competition.(This will probably lead the USA firm to cut its price, indicating economic exposure for it).If the pound appreciates, the USA competitor will price its product cheaper, and the UK firm will be forced to follow it (as a price taker).The difference between the actual domestic price and the expected price by the UK firm is an indication of economic exposure.

Having established that a domestic firm may face the same type of economic exposure as an exporting firm, (provided that the competition faced by both firms is exactly the same), one can proceed towards relaxing some of the assumptions regarding the relative technological efficiency amongst producers and/or the firms' objectives, in order to see how the risk profile of exposure is affected.This analysis is exactly the same as in chapter 2.

It is obvious that in economic exposure, the choice of the market (domestic or overseas), in which the firm will dispose its output, does not make any difference. provided that the same competitors exist in any market.The UK firm may expand its selling operations in, say, Greece, as a means of hedging its economic exposure.If, however, its USA competitors expand their operations in Greece as well, then economic exposure (due to the dollar/pound rate changes) will still exist.

The result of this conclusion is that the hedging policy, proposed for the exporting firm of chapter 2, should be proposed for the domestic firm analysed here.Thus, assuming that import prices are determined on the basis of average rates, the domestic firm. studied here, should buy an average rate call on the pound, to hedge its economic exposure.If, furthermore, the firm is relatively efficient,in terms of production cost, it may tend to hedge using average rate hybrid options.If, on the contrary, it is below the technological efficiency standard of the industry, it may tend to use straps or straddles.

Thus, even a purely domestic firm may face economic exposure, and thus, seek hedging coverage using currency options.The currency option based hedging policy does not depend on the market in which the firm exports (and thus, on the currency of denomination of receivables), especially when the international markets are globalised (many producers can be involved in the market). It depends on those parameters which determine economic exposure.

7.4.Hedging A Perfectly Symmetric Economic Exposure Using Average Rate Currency Options.

One of the hypotheses of this thesis is that, an exporting firm, with a market share expansion objective. faces an asymmetric economic exposure. The degree of the asymmetry depends on the firm's preference over the trade-off between market shares and profit margins.

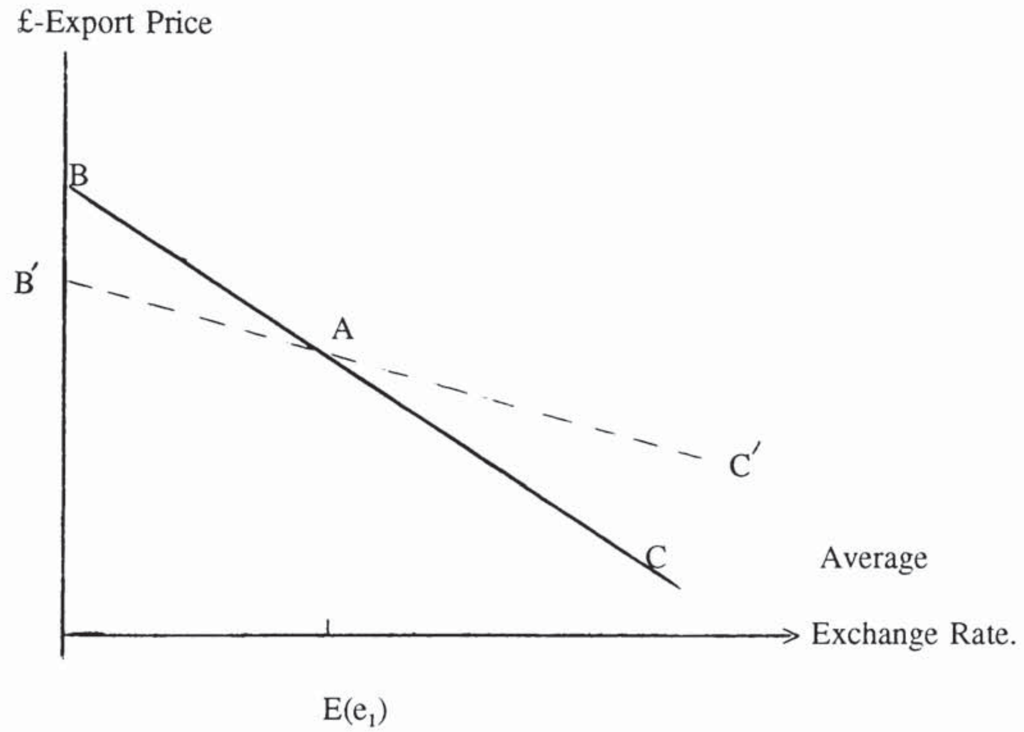
Let us assume here. that the UK firm. examined in chapter 2, has a profit margin maximisation objective, when the pound depreciates.This means that the firm prefers using a pound depreciation to increase its profit margins to passing it on to USA customers.Therefore, the firm does not want to provide any price concessions in its price list, and thus, fixes its bid price only in dollars (and not, dollars and pounds, as assumed in chapter 2, under the market expansion objective).This implies that USA customers now face two bid prices expressed in dollars. To the extent that the product is homogeneous, the two firms produce under the same levels of production cost efficiency and form the same expectations about the future exchange rate, these two bid prices will be the same.

At this point, one may face two cases: First, the export price to finally prevail is unaffected by the actual exchange rate, and thus, is the same as the expected price set on the basis of the expected exchange rate.Second, after the actual exchange rate has been determined, the expected export price is adjusted so that the actual price reflects the actual exchange rate.

The first case can be found in industries where selling prices are known before the actual exchange rate comes up and determined by expected exchange rates. Firms do not change their pricing policy after the realisation of the exchange rate and thus, follow a 'myopic' pricing behaviour [see Giovannini (1988)]. Under this scenario, the whole case becomes an example of transaction exposure. The commonly submitted expected dollar price will be the actual price, and when translated into pounds using the actual exchange rate, the pound export price will be given by a symmetric downward sloping line.This is depicted by BAC in diagram (7.5), and its slope is -1.

If, however, selling prices are adjusted to the actual exchange rate, then the operating exposure profile is given by B'AC', in the same diagram. If the pound depreciates, the UK firm imposes its (new) optimal price, which will be lower than the expected price. If the pound appreciates (dollar depreciates), the USA price will impose its optimal price which, again, will be lower than the expected price. The resulting line B'AC' has a lower slope than line BAC.

Diagram 7.5. Symmetric Operating Exposure



The question in hand is how we can hedge against this symmetric operating exposure (which, it should be remembered, is based on average exchange rates).

Initially, we consider the case of exposure depicted by BAC, in diagram (7.5).

Does a forward contract lead to a perfectly hedged position?

One would be inclined to answer positively, since a long forward has a symmetric risk profile (see Appendix A), which matches the profile of operating exposure in diagram (7.5).A more careful analysis, however, would indicate that a forward may fail to be an efficient hedge even against symmetric economic exposure, as its value depends on end-of-period exchange rates. whereas economic exposure is due to period average rates.The problems of hedging an average-rate-driven exposure using an instrument whose value depends on end-of-period rates are discussed in section (6.2) of chapter 6.

What is needed here, is an instrument with a symmetric profile, whose value must depend on average rates. Such an instrument can be constructed by combining a long Asian call with a short Asian put, both with the same exercise rate.Such an instrument can be called an 'Asian (or average rate) forward'.Diagram (7.6) depicts the profile of this instrument.It should be noted that, as both options involved are average rate options, the value of the resulting Asian forward will be based on average rates.

The cost of an Asian forward is less than the cost of an Asian call, as the former involves the short put, the premium of which reduces the cost of hedging.An Asian forward, however, entails losses for exchange rates on the left of $E(e_1)$ (pound depreciations).These losses are expected to be offset by higher profit margins, given by line BA in diagram (7.5).

The replication of an Asian forward by a long Asian call and a short Asian put is based on the Put-Call Parity (see note 8, in chapter 5).

For sufficiently low exercise rates, the premium of the call will be the same as the premium of the put, and thus, the premium of the forward will be zero.

One can put together diagrams (7.5) and (7.6), to end up with a perfectly hedged (symmetric) economic exposure.Diagram (7.7) depicts this case.

It should be noted that,in diagram (7.7), the slopes of EF and GH are 1 and -1, respectively.

Diagram 7.6..An Average Rate Forward, Consisted Of A Long Asian Call And A Short Asian Put.

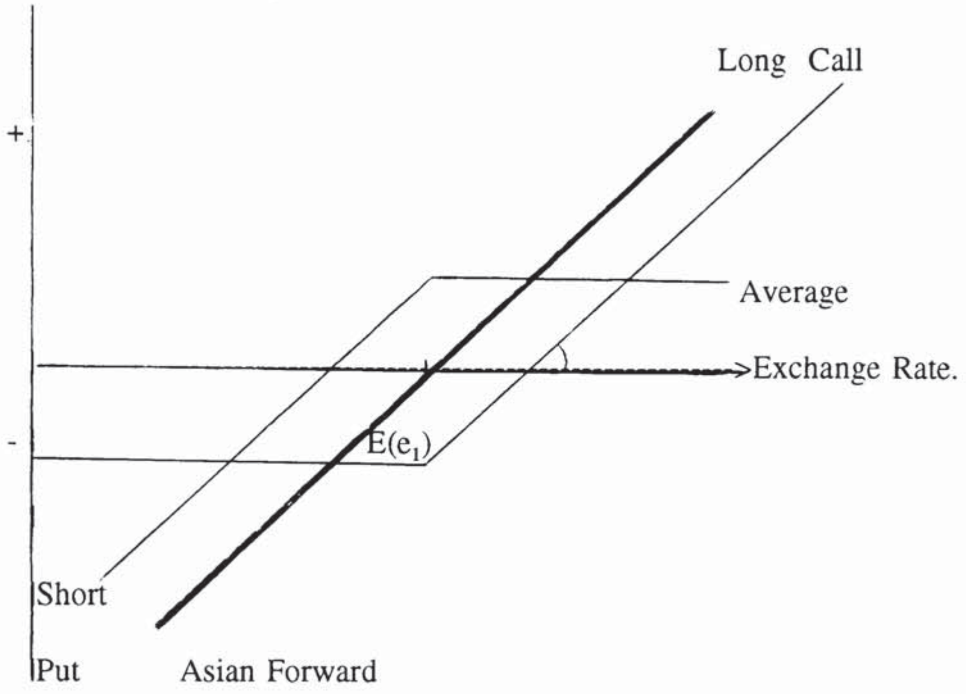
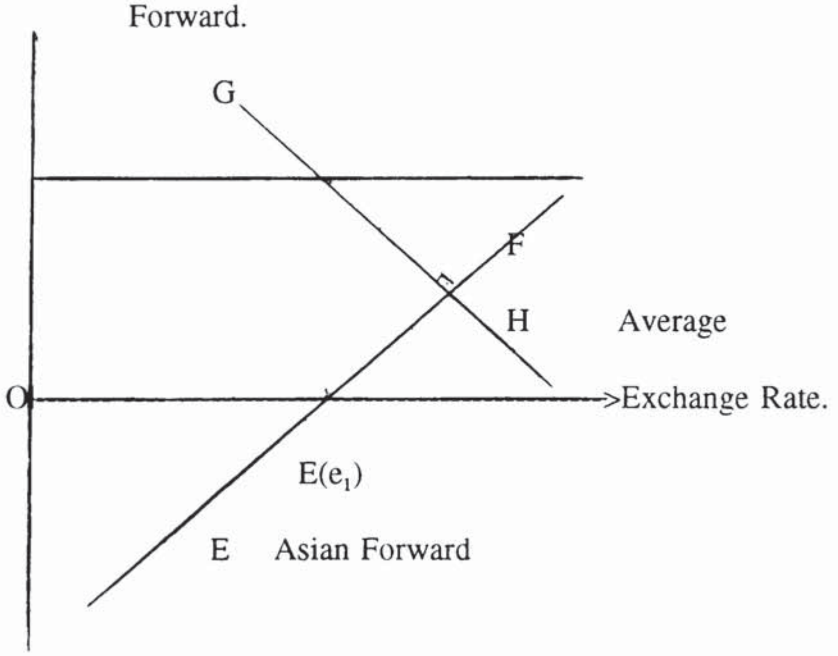


Diagram 7.7:Hedging Symmetric Economic Exposure Using An Asian Forward.



The previous diagram indicates that, even when a firm has a preference over higher profit margins, a currency option based strategy must be used in hedging against economic exposure.

Hedging operating exposure given by B'AC' in diagram (7.5) can be carried out using both a hybrid Asian call and a hybrid Asian put, with the same exercise rate, provided that we know the slope of B'AC'.The instrument which results from the combination of these two options can be called a 'hybrid Asian Forward'.

7.5.Multicurrency Economic Exposure And Hedging.

In chapters 2, 3 and 4, it was assumed that the UK firm faced exposure in only one currency (dollar).This assumption, although simplistic, was meant to enable discussion of the economic exposure problem and to develop some hedging arguments.As a result of this theoretical discussion, the empirical investigation of the risk profiles of chapter 2 involved regressions using only one exchange rate as explanatory variable.

In reality, however, a firm may have many international competitors, with costs expressed in many currencies.This can be true, especially 'nowadays', when, according to Lessard and Lightstone (1986) and George and Schroth (1991), international markets are becoming more globalised.In this case, the firm faces multi-currency economic exposure.Such an exposure may arise either when the UK firm competes with international producers with many production locations (and thus, many currencies in which costs are denominated), or when it competes with only one international producer with costs in many currencies. Multicurrency economic exposure may be relevant for such industries as cars and household appliances, where participating firms have many production locations around the world.

In such situations, the actual export price is not affected by changes of only one currency, but rather by changes of the weighted portfolio of the currencies in which competitors' costs are denominated.This portfolio can be seen as the currency of determination of export price, described in chapter 1,section (1.6.1). In this case, the significance of one currency (and thus, of one individual producer), is reduced in terms of determining market conditions and pricing, especially if one assumes that international competitors have the same level of technological advancement.

The question in hand is how a firm can hedge this multicurrency exposure.One simple way, which follows from the analysis of the previous chapters, is to buy one call option on each of the currencies to which the firm is exposed.Thus, if the firm faces economic exposure in, say, 10 currencies, it should buy 10 different currency options.This solution may involve complexities in administering the portfolio of options, and can be relatively costly. The obvious question is whether there is a unique currency option contract to hedge this multicurrency economic exposure.

Before we deal with this question, we should know the portfolio of currencies in which the firm faces economic exposure.This portfolio should be constructed using a weighting pattern that reflects the relative importance of each individual producer in affecting export prices.These weights can be estimated by running a regression equation connecting export prices and the currencies in which the producers costs are denominated. Thus, if exposure arises in,say, three exchange rates, (\$/£, DM/£, Y/£), then the relevant equation will be:

$$EP = a_0 + a_1 * (\$/£) + a_2 * (DM/£) + a_3 * (Y/£) + u \qquad (7.2)$$

where:

EP is the pound export price.

a_1, a_2 and a_3 the weights for the dollar/pound, DM/pound and Y/pound rates, respectively.

Thus, a portfolio consisting of a_1 dollars, a_2 DMs and a_3 Yen will be constructed.The value of this portfolio will be calculated at a base period T_0, as follows:

$$i_0 = a_1 * \$_0 + a_2 * DM_0 + a_3 * Y_0. \tag{7.3}$$

The value of the index, for a period-t will be given by the (7.4).

$$I_t = \frac{a_1 * \$_t + a_2 * DM_t + a_3 * Y_t}{a_1 * \$_0 + a_2 * DM_0 + a_3 * Y_0} \tag{7.4}$$

If the pound appreciates vsv the currency index, then the actual price will be lower than the export price expected by the UK firm, and the difference will reflect the existence of economic exposure.If, however, the pound depreciates, then the UK firm may use this competitive advantage to attract new customers in the exporting market.

Is there any type of currency option to hedge economic exposure due to the changes of the value of this currency index?

If export prices are determined on the basis of average exchange rates, this multicurrency economic exposure can be hedged using an average rate currency index option, the value of which explicitly depends on the value of the index which determines export prices. Provided that the hedging firm knows the currencies in which it is exposed as well as their weights (that is, it knows the currency index) , it can buy a call on this specific index.

The value of an average rate currency index call, at expiration, is:

$$\text{Max } [\ I_t - K \ , 0\ ]. \tag{7.5}$$

where:

I_t :the value of the index at period t, calculated on the basis of average rates

K :the exercise price of the currency index option.

Thus, if the index has depreciated vsv the pound and the export price is negatively affected, the call on the currency index will pay the firm the difference I_t - K, which will (partially or totally, depending on the hedge ratio) offset the decrease in the export price.This amount,I_t - K, will be received by the firm in cash, as the currency index option is cash settled.

However, in order for a firm to design and execute any hedging scenario involving options, it should know how much the option costs.This implies that the buying firm (as well as the selling bank) should possess an appropriate valuation formula and observations on the data entered in this formula.A valuation formula for an average currency index option can be derived using the insights of the valuation of two different types of currency options:the (geometric) average rate options and the currency index options.

The valuation of a European call based on the geometric average was analysed in the chapter 6 [equation (6.4)].

The formula to value a currency index option is the same as the formula to value an index on a continuous leakage stock [Tucker, (1991)].Focusing on a European call, the relevant formula is:

$$C_i=S_t*\exp(-r_f*T)*N(d_1)-X*\exp(-r_d*T)*N(d_2) \qquad (7.6)$$

$$d_1=\frac{\ln(S_t/X)+[(r_d-r_f)+(c^2/2)*T]}{c*(T)^{1/2}}$$

$$d_2=d_1-c*(T)^{1/2}$$

where:

C_i :the value of a currency index call

S_t :the value of the currency index at t

r_f :the index's yield

r_d :the interest rate on the pound

X :the exercise price of the index

c :the future index volatility

This formula is, in essence, the same as the formula for pricing a conventional call option, except that the parameters, used here,refer to an index of currencies rather than to a single currency.

Combining the above formula with the formula of pricing a geometric average option (under the assumption that the average rate is calculated using the geometric formula), we end up with the following formula for pricing a European call on an average rate index:

$$C^{AVER}_{IND}=S_{AV}*\exp(-r_f*T)*N(d_1)-X*\exp(-r_d*T)*N(d_2) \qquad (7.7)$$

$$d_1=\frac{\ln(S_{AV}/X)+[(r_d-r_f)+(c^2/2)*T]}{c_{AV}*(T)^{1/2}}, \quad d_2=d_1-c_{AV}*(T)^{1/2}$$

$$c_{AV}^2=(c^2)/3, \quad S_{AV}=S_t*\exp\{[-T*(r_d-r_f)/2]+(T*c^2_{AV})/2\}$$

where

C^{AVER}_{IND} :the value of an average rate currency index call

and all the other parameters are the same as in (7.6).

In this formula, there are two parameters, the yield and the volatility of the currency index, which are non-observable, and should be estimated.The yield of the portfolio of currencies can be calculated as the weighted average of the yields of the individual currencies involved in the index.Similarly, the volatility of the currency index can be estimated as the volatility of the portfolio of currencies, taking into account weights and diversification effects.In both cases, the weights are the same as those used in the construction of the index.

Taking a currency index to hedge a multi-asset exposure may be cheaper than taking individual options on each of the currencies involved, since the overall variance of the currency index is expected to be lower than the sum of variances of individual currencies (due to the diversification effect).

The hedging firm can take an option on a currency index, which can include as many or as few currencies as the firm wants. It can also include currencies, on which there are no traded options in the OTC market.Thus, the solution of a currency index option, as a means of hedging multi-currency exposure, may give the firm considerable flexibility and reduce hedging costs.

7.6.LookBack Options To Hedge Economic Exposure.

In chapters 2, 3 and 6, it was argued that export pricing is based on the average exchange rate, assumed to reflect the 'significant' exchange rate over a specific period.The result of this assumption was that, average rate currency options should be used in hedging economic exposure.

If, however, export pricing is not determined by average rates but rather by another type of exchange rate (e.x the period maximum rate), then the effectiveness of average rate options in hedging decreases in export prices is questioned. Hedging effectiveness is, a priori, secured, if the value of the currency option, used to hedge against economic exposure, depends on the type of exchange rate (e.g. arithmetic average, geometric average or maximum rate over a period) which determines export pricing.

Another candidate of 'significant' exchange rates, which can be assumed to determine export pricing, is the maximum rate over a specific period.In this case,hedging cuts in export prices,due to pound appreciations, requires a currency option which allows the holder to consider the historical course of the exchange rate, at the option's expiration date.This feature is provided by the type of option known as 'lookback option'. traded in the OTC currency options market.A specific type of lookback option is the option on the maximum of the exchange rate that prevailed over a predetermined period.This type of option can be used to hedge adverse export prices, due to maximum (instead of average) exchange rates over specific periods.

A call on the maximum has the same risk profile as the ordinary call, except that. at expiration, the spot exchange rate is replaced by the maximum rate that prevailed over the option's life.Therefore, for an option on the maximum,the effect of the spot exchange rate at expiration (which is irrelevant in terms of export pricing) on the value of the option is zero.

Conze and Viswanathan (1991) derive a valuation formula on the European call on maximum, given by (7.8).

$$C_t = S_t * N(d) - \exp(-r*T) * X * N[d - c*(T)^{1/2}] + \exp(-r*T) * [(c^2)/(2r)] * S_t *$$

$$\{-(S_t/X)^{(-2r)/c*c} * N[d-(2*r)*(T)^{1/2}/c] + \exp(r*T) * N(d)\} \qquad (7.8)$$

if $X >/ M$

where:

C_t :the value of a call on the maximum, at t,

$r = r_d - r_f$

M: the maximum exchange rate over the life of the option.

The other symbols are the same as in formula (5.4), in chapter 5.

This type of currency option is expected to be much more expensive than the ordinary option [see, Conze and Viswanathan (1991)], and thus, even more expensive than the average rate option. However, its use is strongly advised when export pricing is based on period maximum exchange rates (which increases the uncertainty of the exporting firm compared to if export prices were to be determined by average rates).

Similarly to average rate option hedging, if the exchange rate reaches a relatively high maximum, causing the export price to decrease, this maximum rate will be used as the spot rate at expiration, to determine the value of the call.The higher the period maximum rate (and probably the deeper the export price cut), the more probable that the call will end up in the money (i.e. will have some intrinsic value).This intrinsic value of the option can be used to offset the export price cut.

7.7.A Final Word On Extensions

These extensions aim to provide a theoretical background,when dealing with a case study of hedging economic exposure. In case studies, one may face different situations with regards to the following parameters:

-the type of exchange rate (i.e. average exchange rate or maximum rate) which determines export prices.

-the frequency of export price fixing (probably dependent on the volatility of exchange rates),

-the number of currencies in which exposure arises,

-firms' objectives, cost structures,market structure and technological efficiency outlined in chapter 2.

Any theory, dealing with the hedging of economic exposure, should provide considerable flexibility in handling different scenarios about the above factors, which may be encountered in case studies.Applying the arguments outlined here to case studies could well be a direction of future empirical work on the issue of hedging economic exposure.

7.8.Conclusion

In this chapter, five extensions of the previous discussion on economic exposure and hedging were discussed. These were the exposure problem when firms have unhedged transaction exposures,the use of options in hedging symmetric exposure, the use of lookback currency options,instead of average rate options,in hedging exposure, the domestic firm's exposure and hedging and the multicurrency exposure hedging.

The main points of this chapter may be useful in empirical investigations of the problem of economic exposure and hedging, in case studies.

CHAPTER 8

CONCLUSIONS AND PROPOSITIONS FOR FUTURE RESEARCH

8.1.Introduction

This work is in the area of financial engineering and consists of two different parts: the examination of the problem of exchange rate economic (operating) exposure within the context of the theory of the firm and the hedging of this exposure.

The first part aims to analyse the problem of operating exposure under two specific assumptions:the existence of international competition and the target of market share expansion by exporting firms.There has been an effort to justify that these assumptions are realistic, focusing on empirical evidence from previous work.Within this framework, the problem of operating exposure takes a specific theoretical content, which appears for the first time in the relevant literature.It is proved that operating exposure can be depicted by an asymmetric profile, connecting export profit margins and exchange rates.In fact, this behaviour of operating exposure leads us to argue that, export business can be seen as a real option awarded by exporting firms to overseas customers.This asymmetry hypothesis is the first hypothesis of this work, stated in chapter 2 and empirically examined in chapter 3.

Based on this conclusion, it was argued that a hedging policy should be engineered to eliminate this specific type of exposure.This engineering should involve currently available hedging instruments. Further, it should ensure flexibility in terms of adapting the hedging solution under new conditions, and thus, a financial engineering solution is assumed to be preferred to a strategic solution (chapter 4).Consequently, we reach the theoretical conclusion that a currency call option can optimally hedge an (asymmetric) exposure, the profile of which is given by the profile of a written call option.This is the second major hypothesis of this thesis stated in chapter 4 and empirically examined in chapter 6.

Below, there is a general discussion of the theoretical and empirical findings of this work.The usefulness of these results is examined along with some comments on recommendations for future research.

8.2.The Main Arguments Of The Thesis

8.2.1.Theory.

Measuring operating exposure by the variability of export profit margins due to real exchange rate changes, it was established that operating exposure is asymmetric.This conclusion depends on two assumptions:first, international export markets are competitive and there is a strategic dependence amongst international producers, and second, as a result of such conditions in international markets, some exporters set strategic pricing towards outpricing their competitors and expanding their presence in the market.In fact, these conditions force some firms to offer concessions to overseas customers.One price concession would be to pass the benefits of a currency depreciation on to them.This is achieved if the exporting firm publishes a dual currency price list, expressed both in their currency and the currency of their customers. If it is the customers' currency which depreciates, customers will choose to pay the price in their own currency.If it is the exporting firms' currency which depreciates, customers will prefer the price expressed in the other currency.In any case, they will buy the product at a depreciated currency, which will result in a lower price for them. Further, customers are in a position to require the publishing of a dual currency price lists, due to the existence of other (local) producers.

The implications of this scenario for the profitability of an exporting firm, is that its selling price decreases when its currency appreciates, and does not increase when its currency depreciates.In the latter case, the benefits of the depreciation are passed to foreign customers as a means of investing in a future market expansion.

If we now view this asymmetry through the financial options' terminology (see Appendix A),then one could state the asymmetry hypothesis using the financial options' jargon.In fact, we could state that operating exposure is given by the profile of a written call option, which in fact is a business option to buy the commodity at the depreciating currency, given by exporting firms to foreign customers.In practical terms, this option can be seen as flexibility given by these firms to customers, and operating exposure results from the lack of such flexibility by firms.

From this point on, we can consider the use of currency options to hedge this type of exposure.After ruling out the use of real (strategic) options due to inflexibility in manipulation (chapter 4), currency calls are considered.Further, it is proposed that many currency strategies can be engineered towards meeting different versions of exposure,which may result for different assumptions about the specific market structure and firms' objectives.

Although this theoretical discussion focused on an exporting firm which faces single currency exposure, the discussion was extended to examine the exposure problem of a purely domestic import competing firm, and concluded that the hedging scenario (currency call option), proposed for an exporting firm, must be taken by a purely domestic firm, provided that both firms face the same competitors in the two markets.This implies that the hedging scenario is independent of the nationality of markets in which firms sell their output.It does not make any difference in terms of hedging if the firm exports its output or if it sells it in the domestic market, provided that the same competitors exist in both markets.

The final model examines operating exposure in more than one currency (multicurrency exposure).The hedging proposition is that an index currency call option can hedge this exposure.

Another part of the analysis focused on the hedging scenario to be applied, in terms of providing details regarding the type of currency option, the timing of placing and removing it, and finally, the determination of the expected hedge ratios.These parameters may be different amongst different cases, but the general methodology is expected to be the same, and is outlined in chapter 6.

The type of currency option to be utilised (i.e.average rate currency option,lookback option or ordinary option) depends on the type of exchange rates (average rates, historical rates or end of period rates, respectively), which are assumed to determine export prices.The timing of placing the hedge is important, as it may affect the cost of hedging, and therefore, its hedging effectiveness.If average rate options are used, then the hedging firm should carefully monitor the course of these rates, as the time of publishing price lists comes closer.Optimally, this should be the time of initiating the contract.However, this rule can not be generalised, because there may be cases when the daily rate, as we approach the time of publishing price lists, may be temporarily overshooting its average value over the period in question.In this case, placing an average currency option hedge, at the time of publishing price lists, may be relatively costly, reducing its hedging effectiveness. Therefore, the hedging scenario,described here, leaves an open point with regards to the timing of placing the hedge.

Finally, the determination of hedge ratios is undertaken at the time of taking the contract, and thus, is based on expectations about a possible decrease in future profit margins and possible gains on options, if the currency of the firm appreciates.Hedging effectiveness depends on forecasting successfully possible currency appreciations (since it is only an appreciation which may cause exposure and create the need of hedge taking), and export price cuts due to these appreciations. Here, we take the view that such expectations can be obtained from a methodology based on volatilities implied in prices of currency options, traded in organised markets assumed to be efficient.The closer the expected currency appreciation to the actual one (if one comes up), the more accurate the forecasts of the actual export profit margin cut and the actual gain on the call option.These two types of forecasts determine the actual (optimal) hedge ratio which completely eliminates exposure.This ratio, as implied from above, is unknown when the hedge is initiated, and is estimated by the expected hedge ratio.

8.2.2. Empirical Evidence.

The empirical work focuses on the empirical validity of the two major hypotheses: the asymmetry hypothesis of operating exposure and the hypothesis of hedging using currency options.

With regards to the first hypothesis, export price data was collected, representing unit values for several commodities exported from the UK to the USA, for the period from 1980/III through to 1988/IV.The sample of commodities consists of relatively more homogeneous (cocoa, wool, petroleum, tin articles, copper articles, leather, leather shoes and nickel) and relatively less homogeneous (cars and office machines) goods. Although one would expect to find that the operating exposure and the asymmetry hypotheses may hold better for the first category of products (for which competition is expected to be 'higher'), it turns out that, these hypotheses hold equally well for the second category as well. The hypothesis of operating exposure seems to hold for nine out of the ten goods examined, with the only exception being the case of articles of copper.The asymmetry hypothesis holds for six out of these nine goods (wool, petroleum, chocolate confectionery, articles of tin, leather shoes and office machines), and the strong form of this hypothesis holds for three (petroleum, wool and articles of tin).

One problem with the methodology of collecting published data, is the accuracy of unit values as proxies for export prices and the general (and thus, in-sufficient) cost index used to derive profit margins.Clearly, using non accurate data may result in a wrong estimation of the exchange rate effects on export prices, and thus, on hedging ratios.It is assumed that when this methodology is applied in specific case studies by firms, accurate data on selling prices and costs may be available.

The second part of the empirical work examines whether the previously briefed hedging scenario, based on Asian options, can eliminate economic exposure, if the latter is estimated using the previous methodology.Focusing on five of the commodities which appeared to be subject to operating exposure (cars, wool, petroleum, chocolate confectionery and office copying machines), it was found that for four out of five cases (with the only exception being the case of duplicating machines), average rate options did hedge exposure, in statistical terms.For the case of duplicating machines, some exposure remained after hedging, although it was significantly reduced compared to that before hedging.

The use and empirical effectiveness of forward (futures) contracts was ruled out, since there are not forward contracts based on average rates.

A general point, regarding the empirical evidence here, is that it is based on simulations regarding the exchange rate effects on export prices of individual goods, as well as pricing currency options in the OTC market.An attempt was made to simulate the timing of placing and removing a currency option hedge,its effectiveness and its weak points.This piece of evidence does not claim to have empirically proven that currency options hedge economic exposure faced by firms which trade the above commodities, as the (commodity-based) data available does not allow for drawing such conclusions. It could be inferred, however, that if a firm has, for example, only one operation for producing and exporting,say, cars to the USA, then according to this evidence, it must have faced operating exposure during the 1980's, which could have been hedged using currency options.

8.3.Limitations Of This Work And Areas For Future Research.

8.3.1.Theory.

One critical point of the analysis in this work is that it considered only a type of competition reflected on the price of the products. This was a result of the assumption that actual exchange rates do affect export prices.Some authors [for example,Giovannini (1988)], however, adopt the assumption that export prices are predetermined and unaffected by actual exchange rates (and actual production costs). In these cases, the price leadership model (used here) is irrelevant in analysing operating exposure. The latter now portrays the effects of a currency appreciation on the market shares, and not on profit margins. Thus, one could analyse this exposure on the basis of a type of competition which focuses on quantities sold by each competitor. One way of doing that is to adopt the Cournot model which assumes that the strategic variable on which firms decide is the quantities sold. Therefore, an interesting extension of modelling operating exposure would be to examine the effects of a pound appreciation on the market shares and thus on the profitability of a UK exporting firm, adopting the Cournot model.

A second critical point of this work is that it did not consider the effects of the relative significance of the UK producers in the USA market on the effects on export prices, and thus, on operating exposure.It was assumed that export prices are determined on the basis of the conditions which prevail in the USA market, abstracting from the influence of international markets of the former.In other words, it assumed the large/small country effect on operating exposure was non existent .Such an assumption can be realistic, if one is prepared to accept the empirical violation of the Law Of One Price.If this is true, then different prices can exist in different markets, and therefore, these markets are rather segregated in terms of how prices are determined.As reported in chapter 1 [section (1.6.3)], there is some strong evidence which supports the empirical collapse of the Law of One Price.

If, however, one believes that this law plays an important role in the determination of the international prices, then an open area for research is to model operating exposure assuming that export prices are affected by domestic (UK) prices.Again, a risk profile must be drawn on which hedging implications could be based.

A third strand of criticism is the fact that, we could not obtain a rule with regard to the timing of placing an average rate currency option. This problem stems from the (already known) formula of pricing (geometric) average rate options, which is a function of the spot rate of the date when the option is taken.If this rate is far beyond the period average (which is equal to the exercise rate), then the hedging effectiveness of the hedge is reduced, as its cost increases.

A fourth and rather general limitation of this work is that, it examined the effects of only exchange rate changes on the competitiveness of firms. As Mann (1986) argues, foreign demand and/or domestic cost shocks may well affect competitiveness, and thus overall (and not only exchange rate) economic exposure.In this work, the previous parameters were kept constant.It would be interesting for one to examine operating exposure through an integrated approach, modelling exchange rates, income and cost shocks at the same time.This requires the specification of a general model, which will allow for the effects of both business and exchange rate risks on the risk profile of overall exposure.

In the model described in chapter 2, it was assumed that the exchange rate changes were a non-problem.One, however, would expect that the future exchange rate may move according to the prospects of the economy in question (according to the asset approach of exchange rate determination,see note 2 in chapter 1). For the case of the UK firm which exports in the USA, one could attribute a possible dollar depreciation to a weakening USA economy.The latter may cause a two-fold problem for the UK firm.Firstly, the weakening USA economy will demand less imports (exports for the UK firm).This is a business exposure. Secondly, the accompanying dollar depreciation will give a competitive advantage to USA producers over the UK exporters. The task is to construct a unique model to allow for changes in both national income and exchange rate changes, and to study a risk profile which will give a picture of the firm's overall (business and exchange rate) exposure.

Further, one should consider the question of hedging such an exposure, that is, if there is any hedging instrument in the OTC market, the value of which depends on both the course of economic activity (recession or boost) and exchange rates.

It is reported in Keller (1989) that, a new innovation in the OTC market is constructing financial hedges against economic recession. An initial attempt towards this end is to take an option on the domestic stock index, which is expected to go up when prosperous economic conditions are forecast and vice-versa. For the case of the UK firm, it could obtain an index option on the Dow-Jones index, to hedge against its business exposure in the USA market. [It is reported in Hudson (1991), that stock index options are also available on S&P500, DAX, CAC-40, Nikkei and FTSE100)]. A put option on the Dow-Jones may help the UK firm to at least partially recover some lost profitability, due to possible recessionary conditions in the USA.

To account for the part of the exposure due to exchange rates this option could be struck in pounds. The value of the Dow-Jones index, when expressed in pound, falls as the £ appreciates vsv the dollar. Consequently the value of a stock index option, expressed in a foreign currency, is affected by both economic recession and exchange rate changes, and can be seen as a first approach towards hedging an overall exposure of firms' profitability. Such options are known as foreign currency stock index options and are available in the OTC market. [Hudson,(1991)]. Consequently, a put foreign currency Dow-Jones options may be a possible hedging solution for a UK firm with exports in the USA.

An interesting area of research is,therefore, is to examine whether a foreign currency stock index option is an efficient way of hedging against overall exposure. Such a hedging exercise may involve looking at the pricing of such options, the determination of hedge ratios and the empirical evaluation of their hedging effectiveness.

8.3.2.Empirical Work.

One weak point in the empirical analysis is probably the lack of firm based data on export prices and costs. The published data used may be subject to measurement errors and/or in-efficiencies in capturing real costs and thus, the real exchange rate effect on profit margins is distorted. Developing more detailed data on export prices by commodity and destination, as well as cost indexes for different general categories of products, may be helpful in terms of measuring properly the exchange rate effects on profit margins. It is assumed that firms may be able to reach relatively sufficient estimates of these effects, on the assumption that they possess accurate information on individual costs and selling prices.

A second piece of further empirical work, which can be seen as an extension of this thesis, is the empirical evaluation of average currency options in hedging the exposure of a domestic firm facing import competition. This work dealt only theoretically with the issue. Empirical analysis would involve the examination of how domestic selling prices and profit margins change after exchange rate changes, and whether these changes can be wiped out by average options. The general methodology, which can be applied, is in line with that adopted in chapter 6.

Finally, a last piece of empirical extension is to examine empirically the usefulness of multi-currency index options in hedging multi-currency exposure. Again, this issue was analysed here on a theoretical basis. Similarly to the comments above, the methodological steps in this piece of empirical work are expected to resemble with those taken here in chapter 6.

As a result, this work is hoped to have indicated some areas of future research on the issues of modelling and hedging exchange rate economic exposure.

8.4.To Whom This Work May Be Of Interest.

The arguments of this work may be of interest for two different categories of people:

option traders in the OTC market, and treasurers and marketing managers of firms with international concerns.

Currency options traders in the OTC market want to expand their business of selling derivatives to corporations along with some advice about their uses. Their job becomes easier, if they possess marketing skills, which partly depend on how well they understand what each product can do, and what the corporate problems are. The theory produced here may enable traders to launch a new use of (average) currency options to meet a specific type of exposure. It can be seen as an innovative move in the OTC market, in terms of providing a new "product" or a new service. Further,improved theoretical understanding of how option strategies (spreads, straps, hybrids, etc) can be used to match different combinations of firms' objectives and levels of competition, attracts the interest of managers, who are the second category of people which may be interested in using currency options for hedging.

Marketing managers and treasurers of firms with international concerns establish the pricing policy of the firm on the basis of such factors as exchange rates, firms' objectives and levels of competition. They want to submit always competitive bids to match the level of competition and firms' objectives, and yet have them hedged, if adverse exchange rates arise.This thesis attempts to illustrate that currency options give managers considerable flexibility to construct competitive bids and, at the same time, take option hedges which match these bids. On the basis of this proposition, this thesis may appeal to such categories of people.

8.5.Examples Of Firms Which Have Used Options To Hedge Operating Exposure.

It is relatively difficult to find examples of firms which have used a specific hedging policy, due to confidentiality problems.Below, there are two examples of firms, which are reported to have used options to hedge against adverse selling price effects of exchange rates.

Monsanto is a St Louis chemical and pharmaceutical maker, which has used options to hedge its economic exposure.It's agricultural subsidiary has used an option contract to hedge against an expected price reduction in the British market, due to an expected appreciation of the dollar vsv the pound for 1989.The price reduction was announced in 1988 to become effective from 1989.The manager of international administration of Monsanto Agri., took the view that 'although the pound was fairly strong at the time...there were some fundamentals in the UK economy which did not look good to us'.On the basis of the asset approach to exchange rate determination, this view indicated an expected pound depreciation vsv the dollar.

This depreciation could not be passed on to the market and the decision was to cut prices to protect sales volumes.To protect its income in dollars, the firm bought an option for the selling period of the product, paying a premium of $700.000.Had the firm taken a forward instead, it would have saved this premium.The benefits of having hedged using an option contract, however, are significant, and highlighted by Dave Guthie, Monsanto's manager of worldwide foreign exchange rate risk:

1.'Our hedging costs are known up-front.Regardless of what happens down the road, you are not going to see your costs going higher than that'.This implies that if the dollar appreciates, there will be no more costs than the option premium.If forward contracts had been used, an opportunity loss would have resulted depending on the level of the dollar depreciation.

2.'Not being 100% sure of the currency direction, we did not want to be left out if the dollar takes a bounce'.This implies that the firm is risk averse and prefers hedging to no hedging.

This example illustrates the importance of currency options when the local currency is assumed to appreciate, and only briefly states their benefits if the currency depreciates instead.The work here takes the latter benefits far beyond this argument and associates them with corporate objectives.

Finally, another firm which has used currency options is Eastman Kodak, which has an economic exposure in Yen [see section (1.8) in chapter 1].When the Yen depreciated vsv the dollar, Kodak's competitor Fuji was able to sell cheaper, forcing market prices down.Kodak bought a series of put options of Yen to offset these cheaper prices when the Yen depreciated.

Neither the first nor the second example clearly state that the use of options was meant to hedge an option-like economic exposure.However, one should not expect to find many details on the (strategic) reasons which may have led these firms to consider options hedging against operating exposure.

8.6.A Final Word

In the context of economics (or social sciences in general), it is always difficult to say that one has proved that a new (theoretical) idea is expected to work properly in real world situations.We take the view that this applies for the results of this thesis. In fact, the applicability of the results of any theoretical work depends on both their soundness, and how open to new ideas managers are.

It is hoped that this thesis has aroused some academic and business interest in the analysis of economic exposure and the possible use of options in hedging against it. and has indicated some considerable steps for future research.

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APPENDIX A

FORWARD AND CURRENCY OPTIONS CONTRACTS :AN INTRODUCTION.

A.1.Introduction

The purpose of this Appendix is to provide a quick review of the main technical points which underline forward and currency options contracts.It is not meant to provide an exhaustive exposition of these instruments but rather to offer an introduction to their main features, which are used in the analysis of chapters 2, 4,5 and 6.Complete coverage of these issues can be found in Shapiro (1989), Tucker (1991), Giddy (1983), Fitzgerald (1987),Cox and Rubinstein (1985) and Copeland and Weston (1988).

A.2. Forward Contracts.

A forward contract is an agreement to buy (long position) or sell (short position) a specific currency at a specific time in the future, at a fixed exchange rate.The currency is exchanged against dollar payment.Active forward contracts are offered by banks for almost all major currencies, such as the pound, the DM, the FF, the Swiss Franc, the Yen etc.

A forward contract's value, at maturity,depends on the relationship between the spot exchange rate at maturity and the agreed upon forward rate.For a long forward in pounds, assuming a forward rate of £1=\$2 and a spot rate of £1=\$2.2, at maturity, a profit of \$.2 per pound is returned.In this case, the holder of the long forward buys the pound at the 'cheap' rate of \$2, avoiding the spot expensive rate.If, however, the spot rate was \$1.8, the holder has lost \$.2, as he is obliged to enter into the forward transaction.The risk profile of a long forward contract is given in diagram (A.2.1).

Diagram (A.2.1)

A Long Forward Contract.

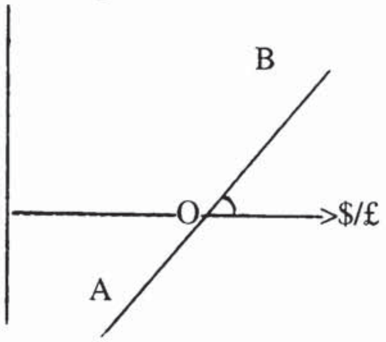
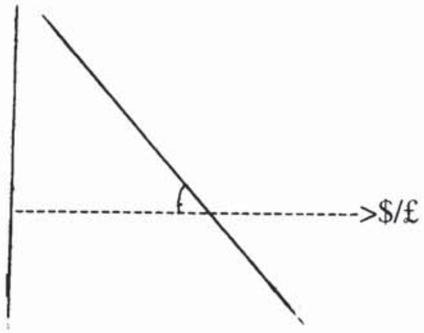


Diagram (A.2.2)

A Short Forward Contract.



The line AOB forms a 45' angle with the horizontal axis, as the gain/loss on the forward contract moves one-to-one with the spot rate.Similarly, a short forward's value depends on the spot rate at expiration.If the spot rate is £1=$1.8 (and the forward rate is £1=$2), the holder of the short position incurs a profit of $.2.If the rate is £1=$2.2, he incurs a loss of $.2. The risk profile of a short forward is given by diagram (A.2.2).

It should be pointed that a forward contract entails obligation for the holder, and thus, should not be perceived as insurance.

The forward rate, when the contract is undertaken, differs from the spot rate at that date, to the extent that the interest rates of the currencies concerned for a period covered by the contract, differ.For a three month forward in pounds, if the three month interest rate on the pound is higher than the three month rate on the dollar, the forward rate will be lower than the spot rate.In this case, the forward rate is said to be at a forward discount.If the interest rate of the pound was lower, the forward rate would be higher than the spot rate.In this case, it is said that the forward rate is at a forward premium.

Forward contracts are tailor made deals (in terms of sizes, maturities and currencies involved) between hedging firms or individuals and banks.They are extensively used to hedge against symmetric exposures (such as transaction exposures).

A futures contract is almost the same as a forward contract, in terms of risk profiles and pricing at maturity and at the time of initiation.In fact, futures contracts are standardised (forward) contracts, which are traded in organised markets. Contract sizes, currencies and maturities are fixed, in order to facilitate trade.Futures contracts, though, carry lower default risk, as in organised markets a clearing house guarantees both sides of the contract.This does not apply for forward contracts.This difference in the default risk may cause the futures rate to divert, marginally though, from the forward rate.

A.3.Currency Options

A.3.1.Concept.

A currency option gives the holder the right to buy (call) or sell (put) a foreign currency, at a predetermined exchange rate, at a given expiration time.The holder of the option has no obligation in terms of exercising his option.Such obligation is borne by the option seller (writer), who has to fulfil the holder's exercise claims, if the latter so desires.To acquire the option, the holder pays the writer a premium (in dollars) when the contract is initiated.

There are two types of options: the European option, which gives the holder the right to exercise it at the expiration date, and the American option, which gives the holder the right to exercise it at any time prior to or at the exercise date.

A call option is the right to buy foreign currency (say pounds) against the dollar at a specified price (exercise price). The call is said to be in the money, if, at maturity, the spot rate is higher than the exercise rate.The profit on the call is given by the difference between the spot rate and the exercise rate.If the spot rate is below the exercise rate, the call is said to be out of money. In this case, the holder does not exercise the option which has no value.His maximum loss potential is the premium of the call.Diagram (A.3.1) gives the profile of a long call at maturity.In this diagram, the line AOB gives the payoff of the call, after the initial premium paid has been deducted.As shown by this line. the loss potential is limited to the option's premium, but its gains are unlimited.

Diagram A.3.1

A Long Call.

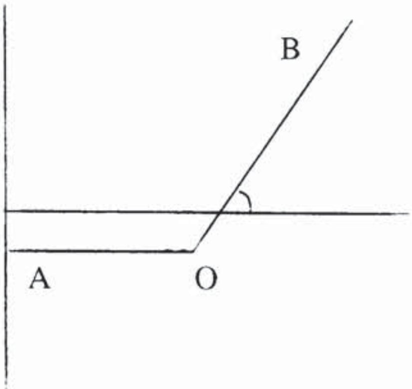
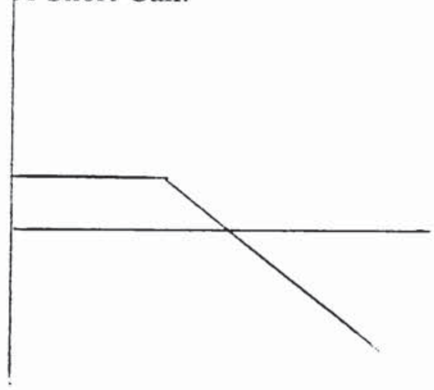


Diagram A.3.2

A Short Call.



If the spot rate is c1, c2, etc above the exercise rate, the gain is c1, c2, etc.This implies that the line OB forms a 45' angle with the horizontal axis.

A short call entails the obligation to the writer to meet the holder's request, if the option is exercised.If the option is in the money, the holder will exercise it and the seller will lose the difference.If the option is not exercised the writer (seller) stays with the option premium in the pocket which reflects its maximum gain.Diagram (A.3.2) gives the profile of a short call.Its losses can be unlimited, whereas its gains are limited.

A.3.2.Hedging Properties.

The hedging properties of a currency option refer to the option's delta, gamma, theta and vega (kappa), and are derived from the pricing formula given by (5.4) in chapter 5.

The delta of an option is its hedge ratio.It is the expected change in the option's value, for a one-unit change in the exchange rate.Mathematically, it is given by the first partial derivative of equation (5.4), with respect to the exchange rate.

The gamma factor is a measure of the expected change in the delta of the option, for a small change in the exchange rate. Mathematically, it is the second partial derivative of equation (5.4) with respect to the exchange rate.

The theta measures the expected change in the option premium, as the time to expiration decreases.Mathematically, it is the partial derivative of (5.4) with respect to the time.

The vega (or eta) measures the option premium changes for a small change in the volatility.It is the partial derivative of (5.4) with respect to the volatility.

For the mathematical expressions of these derivatives, see Garman and Kohlhagen (1983).

A.3.3.The Over-The-Counter (OTC) Currency Options Market.

In the previous chapters, it was argued that firms should use the Over-The-Counter (OTC) currency options market to hedge their exposure, without outlining the features of this market or describing how it works.

The OTC currency options market consists of commercial and investment banks and investment houses, which are willing to buy or/and sell currency options to either corporate clients or to other banks.There is not a specific marketplace and the transactions are made over the telephone.The main feature of the OTC currency options market is that, it provides tailor made currency options, according to customers' requirements. Corporations would be reluctant in buying options in organised currency options markets (Philadelphia Stock Exchange), due to the size, type of contract, expiration time and exercise price standardisation of the currency options in these markets. In the OTC market, the firm can determine these parameters according to its needs, and let the selling bank determine the option premium (which is, of-course, a function of these parameters).Further, in organised markets there are transaction costs (see chapter 5) which are not applicable in the OTC market, implying that hedging costs in the OTC market are relatively low.

A strong OTC currency options market now exists in the major financial centres, especially London and New York, with the Tokyo market growing fast.In London. the first developments of the market took place in the 1970's, and since then, it has expanded significantly, with many domestic and foreign banks now offering currency options.Many banks provide complex options contracts, and as there is significant competition in the market, these options are offered at competitive prices.Furthermore, the existence of many trading banks in the market ensures liquidity and secondary market operations.

The activity of the OTC market is divided into two broad categories:First, there is the 'retail' market, where banks sell options to corporations wishing to hedge their exchange rate exposures. The significance of options to banks is that they not only sell a new (financial) product, but also offer advice on issues related to exchange rate risks.

These retail market operations, involving writing options, result in open (unhedged) positions that many banks wish to close out.They can do that in the 'wholesale' operations, which reflect the second category of the OTC market.Mainly, however,banks in the OTC market close out their open positions utilising the organised currency options market, in which they try to match their short positions with long positions [see Fitzgerald, (1987)].

Some comments should be made about the usefulness of having a liquid and competitive OTC currency options market for the macro-economy as a whole, since economic exposure is both a microeconomic and macroeconomic concept.This is so since, if many firms of one country face economic exposure, the Trade Balance Of Payments of this country will be, probably, in deficit, implying competitiveness problems at an aggregate level.If there is a highly liquid and competitive OTC currency options market, and many firms use it to hedge against economic exposure, then the hedging benefits enjoyed by individual firms will be reflected in the Balance of Payments, indicating a strengthening of competitiveness at both a firm based and macroeconomic level.

Furthermore, hedging economic exposure using currency options (and not by moving production operations overseas) may help firms maintain production and make investments for expansion in the home country.This may offer some relief in unemployment and domestic economic development problems.

Finally, one could argue that an efficient OTC currency options market can be seen as an alternative to having an efficient production technology to support competitiveness changes, due to exchange rate movements.

A.3.4.Accounting Considerations Of Currency Options.

So far, we have discussed the features, hedging characteristics and pricing of different types of currency options. We have not commented, however, on the accounting and taxation considerations of currency options.This extension is important since firms, before considering any hedging transaction, will examine its accounting and taxation implications.

As stated in Fitzgerald (1987), any deal involving options has accounting implications, that is issues to be resolved before the preparation of accounts.Accounting (as well as taxation) treatment of options is not internationally uniform.In the UK. there is no authorative guidance on accounting for options, and any problems in this area are handled on the basis of the accounting principles, set out in International Accounting

Standards -1 (IAS-1).

These principles are:

-The going concern concept, according to which the firm will continue its operations in the future,

-the accruals concept, under which, revenue and costs are accrued and dealt with in the accounting period to which they relate,

-the consistency concept, which reinforces the consistent treatment of accounts from period to period and the treatment of items within the same account,

-the concept of prudence, which states that revenues and costs are recognised only when realised and provision is made for all known liabilities.

The most important concept for accounting on options is the accruals concept, which captures the real results of any transaction to be reflected in the accounting policy adopted.

The two important problems in options accounting are the valuation of open positions and the determination of the accounting period in which profits/losses should be recognised.

With regards to the first issue, the most acceptable practice to value open positions is the 'mark-to-market' principle, according to which, open positions should be valued at the market value of the option, at its expiration.Thus, the value of an open position will be given by the difference between the market value of the position at the valuation day and the contracted price of the position.

However, the application of this principle may entail the recognition of non-realised profits/losses.Nevertheless, the adoption of the 'mark-to-market' principle is supported by the following arguments:

1.A well functioning market ensures that profit/losses are instantly realisable.

2.The mark-to-market principle prevents the possibility of manipulating accounting reports, where the management has the flexibility to choose which accounts to close or not.

3.Whenever the market moves, the value of the option effectively changes.The mark-to-market policy grasps the effective, although unrealised, profits/losses.

The mark to market valuation of open positions in the OTC currency options market is relatively difficult, since there is no 'official' market value of the option in this market.A good approximation of the market value of the option can be obtained by using the appropriate option pricing formula along with data on the parameters involved in this formula.

The second issue, pertinent to options accounting, refers to the determination of the accounting period in which profits/losses already known should be recognised.To illustrate the problem, suppose that a firm buys an option at 31/10/X1, with expiration at 31/3/X2.The firm's accounting period ends at 31/12/X1.The option yields a profit of A-pounds, determined on a mark-to-market basis.The question is whether this profit should be recognised at the accounting period which terminated at 31/12/X1 or whether it should be carried forward to the next accounting period.

The answer to this problem depends on whether the option transaction is a trading or a hedging one. If the transaction is a trading one, then the profit should be included in the accounts of the period which ends at 31/12/X1. If the transaction was aiming towards hedging potentially adverse price changes to be realised later, the accounting treatment of options should reflect this purpose, and thus, the profit should be carried forward on to the next period, in order to be matched with the price changes.

A.3.5.Taxation Of Options

As new financial products and markets are developing, changes in the tax system occur to match the conditions of the new markets.In the UK, there have been significant changes in the tax system as a result of activities of the various currency options markets.Generally, there are two methods of taxation of options transactions:

1.Treatment under Schedule D case I, which recognises the options transaction as a trading transaction.

2.Treatment under the Capital Gains Rule.

These methods can apply to a wide range of tax payers, including:banks and financial institutions, investment trusts, insurance companies, individuals and non-financial companies.

When applied to the latter, and the option transaction is considered as being used to protect a company from exposure in the course of its normal business activities, the results of these options should be taxed in the same way as ordinary income or expenditure arising from trade.In this case, options are considered part of the trading activity, and thus, are taxed similarly.

The second method of options taxation treats gains/losses from options as capital gains, in which case the capital gains tax rate is applied.If the latter is lower than the taxation rate of ordinary income, then firms will try to pass their options transactions as capital gain transactions.To achieve this aim, the firm should convince the Inland Revenue on that effect, producing documentary evidence to prove the capital motive of the option transaction.

The tax effects of applying the capital gains tax rate on options transactions are complicated, and in fact, depend on the type of the transaction (e.x. exercising a call, buying and selling a put or a call, buying and exercising a put, etc).