Issues in stock index futures trading: evidence for the FTSE-100 and FTSE-mid 250 contacts

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ISSUES IN STOCK INDEX FUTURES TRADING: EVIDENCE FOR THE FTSE-100 AND FTSE-MID 250 CONTRACTS.

A thesis submitted for the degree of Doctor of Philosophy

by

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June 1998

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ABSTRACT

This thesis provides a detailed empirical evaluation of the role and function of the FTSE 100 and FTSE Mid 250 index futures contracts, by considering the interrelated issues of hedging effectiveness and pricing efficiency.

The aims of the thesis are outlined in chapter one, with chapter two providing a detailed review of the empirical literature relevant to this study. Chapter three investigates the hedging effectiveness of the FTSE 100 and FTSE Mid 250 index futures contracts in both an ex post and ex ante context. Despite relatively thin trading volume, the FTSE Mid 250 contract is shown to be an important hedging instrument. However, the results demonstrate the hedging effectiveness can only truly be examined by using an ex ante strategy in conjunction with spot portfolios that do not replicate market portfolios. Work into hedging effectiveness is further examined in chapter four using hedge ratios generated within the Extended Mean Gini framework. The results indicate that for both contracts the hedge ratio series are characterised by a step function which is strongly related to the hedger's degree of risk aversion.

Chapter five examines the pricing efficiency of the FTSE 100 and Mid 250 contracts. While there were many deviations from fair value, both contracts appear to be quite efficiently priced, with opportunity for index arbitrage rare. Research into the economics of arbitrage is extended in chapter six by investigating the potential for intramarket and intermarket spread trading. While the intramarket spread is found to be very efficiently priced, trading well within its no-arbitrage limits, the intermarket is much less efficiently priced frequently violating its no-arbitrage limits.

Chapter seven, provides a summary of the thesis and concluding remarks concerning the relevance of the issues investigated are drawn.

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June 1998.

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CHAPTER ONE

INTRODUCTION

1.1) OVERVIEW AND OBJECTIVES

While stock index futures contracts represent a relatively recent innovation in financial markets, they have proven extremely popular with investors, and by giving traders the ability to hedge economy wide movements in asset values have become an integral part of portfolio management. As a result index futures contracts have relevance to a much larger set of traders than traditional futures contracts relating to physical commodities. The rapid growth in trading in index futures contracts globally testifies to their phenomenal success, with the value of trading in index futures often outstripping that in the underlying spot market. Index futures are derivative contracts, in that the price of the instrument is derived from the price of an underlying basket of stocks, and given that they are not as tightly regulated as the underlying security they allow investors greater flexibility in managing market risk.

Index futures contracts are standardised agreements to buy or sell an entire stock portfolio at a future date for a price determined when the contract is written. While the buyer and seller of the contract trade through a clearing-house, both parties are compelled to fulfill certain obligations to the agreement[1]. An important reason for the success of index futures markets is that they allow investors to acquire market exposure more effectively than through spot market transactions, with minimal cash commitment owing to margin payments. Economically, these contracts provide a cost efficient means of allocating risk and promoting price discovery and thereby achieving an efficient resource allocation for the economy as a whole. Compared to trading in the spot market, index futures are endowed with specific advantages including lower transaction costs, exposure to the entire market from a single transaction, tighter dealing prices, faster execution of transactions, greater leverage, short selling and taxable exemptions. As a result of these trading advantages the futures market attracts a broad spectrum of users with different objectives who help to maintain high levels of liquidity in the market.

Although research into stock index futures trading has been an area where leading US academics have been very active[2], trading activity in UK contracts has not been researched to any where near the same extent. The main purpose of this thesis is to help to address this issue by empirically investigating the role and function of index futures contracts traded in the UK. Although work into the usefulness of the established FTSE 100 contract has been forthcoming, to date no detailed examination has been conducted for the recently introduced FTSE Mid 250 (henceforth Mid 250) contract. Academic research into the role and function of the two contracts has been motivated by the following considerations. First, index futures markets were established as a mechanism for facilitating the transfer of price risk, by extending the range of portfolio opportunities which are available to investors and portfolio managers. Thus the main justification for index futures is to allow hedging. Second, in order to perform their risk reduction role effectively index futures need to be correctly priced with respect to the underlying spot markets. Where they are found to be mispriced relative to their fair value estimates, hedging effectiveness will be impaired and arbitrage opportunities may present themselves. The pricing of index futures contracts can be tested with respect to index arbitrage, and spread trading.

Although the issues to be investigated are not exhaustive in coverage, they address what are perceived to be the most important aspects of index futures trading and the empirical findings will be of particular interest to market participants, regulators and academics in the UK. The introduction of the Mid 250 contract provides market practitioners with the opportunity to take advantage of their knowledge and their views on the prospects of the two different areas of the market. The UK index futures market also provides an example of how additional instruments can be introduced to support and supplement existing contracts.

Given the clear benefits that futures contracts afford investors it is surprising that until recently futures trading was confined to a small range of agricultural and metallic commodities. Although futures contracts have been traded on the Chicago Board of Trade since 1865, financial futures contracts were only introduced in the early 1970's, largely in response to the financial turbulence arising from the breakdown of the Bretton Woods system of fixed exchange rates. The global transition from fixed to floating exchange rates was characterised by a rapid increase in the levels of exchange rate and interest rate instability. As a consequence of this rise in market volatility investment vehicles which were capable of hedging these risks were demanded and the financial futures markets evolved. Following the decision to allow exchange rates to float foreign currency futures were successfully introduced on the International Money Market of the Chicago Mercantile Exchange in 1972, with interest rate futures being launched on the Chicago Board of Trade in 1975. However, the success and longevity of these contracts owes much to the structural changes that occurred during the 1970's and 1980's, such as the institutionalisation of the market, and the concentration of the market (Carlton (1984)).

Following the success of foreign exchange and interest rate futures, the range of financial futures contracts was expanded to stock indexes in February 1982 with the introduction of the Value Line Composite Index (VLCI) contract, which was traded on the Kansas City Board of Trade. Additional US contracts were introduced later that year, with the Standard and Poor's 500 contract traded on the Chicago Mercantile Exchange in April 1982, and the New York Composite Index futures contract traded on the New York Futures Exchange in May 1982. By 1985 six index futures contracts were actively traded on five different US futures exchanges.

The London International Financial Futures Exchange (LIFFE) began trading index futures in the UK in May 1984 with the introduction of the FTSE 100 contract. Owing to the success of this contract, and the growing importance of medium size capitalisation stocks in the UK, LIFFE subsequently launched a second contract, the FTSE Mid 250 (henceforth the Mid 250) contract in February 1992[3]. This contract was designed to support and complement the well established FTSE 100 contract by providing effective tracking on the "second tier" of UK companies.

1.2) UK INDEX FUTURES CONTRACTS

Currently, there are two index futures contracts traded in the UK, these being the FTSE 100 contract and the Mid 250 contract, and the key characteristics underpinning the trading nature and design of both the market indexes and underlying contracts are summarised in tables 1.1 and 1.2 respectively. The FTSE

100 index represents the 100 largest companies traded on the London stock market, while the Mid 250 index represents the next 250 largest companies (i.e. companies 101 to 350 by market capitalisation). Both indexes are arithmetically weighted by market capitalisation and together they provide investors with exposure to over 90% of the UK's equity market. With respect to the index futures contracts, the unit of trading is £25 and £10 respectively for the FTSE 100[4] and the Mid 250 contract. Therefore, when both indexes stand at 4000 index points, the FTSE 100 contract is valued at £100,000 and Mid 250 contract is valued at £40,000. The contracts are traded in three month cycles, with contracts expiring in March, June, September and December. At any point in time, the nearest three contracts are available for the FTSE 100 and the nearest two contracts are available for the Mid 250. The last trading day for both contracts is the final business day in the delivery month, with the settlement prices being determined by the E.D.S.P[5] at 10.30 am on the third Friday of the delivery month. Delivery is achieved through cash settlement.

This thesis is concerned with UK index futures trading from February 1994 (following the introduction of the Mid 250 contract) to December 1996. The pricing performance of both the FTSE 100 and Mid 250 contracts over this period is illustrated by the spliced series in figure 1.1. It is clearly visible from figure 1.1 that while the overall performance of both contracts are remarkably similar, with both markets declining in the early part of the period and then recovering considerably later, significant short term pricing differences exist between the two contracts. For instance, the correlation coefficient for the daily log returns of the two contracts is only 0.753. While this relatively low correlation can be partly explained by the

Table 1.1)

Key Features of FTSE 100 and FTSE Mid 250 Indexes

	FTSE 100 Index	Mid 250 Index
Number of Companies	100	250
Index Weighting	Capitalisation	Capitalisation
Market Capitalisation of Constituents	Approx. £ 30 - 1.5 billion	Approx. £ 1.5 - 0.1 billion
Total Market Capitalisation	Approx. £500 billion	Approx. £150 billion
Launched	January 1984	October 1992

Source: L.I.F.F.E. (1994)

Table 1.2)

FTSE 100 and FTSE Mid 250 Futures Contract Specifications

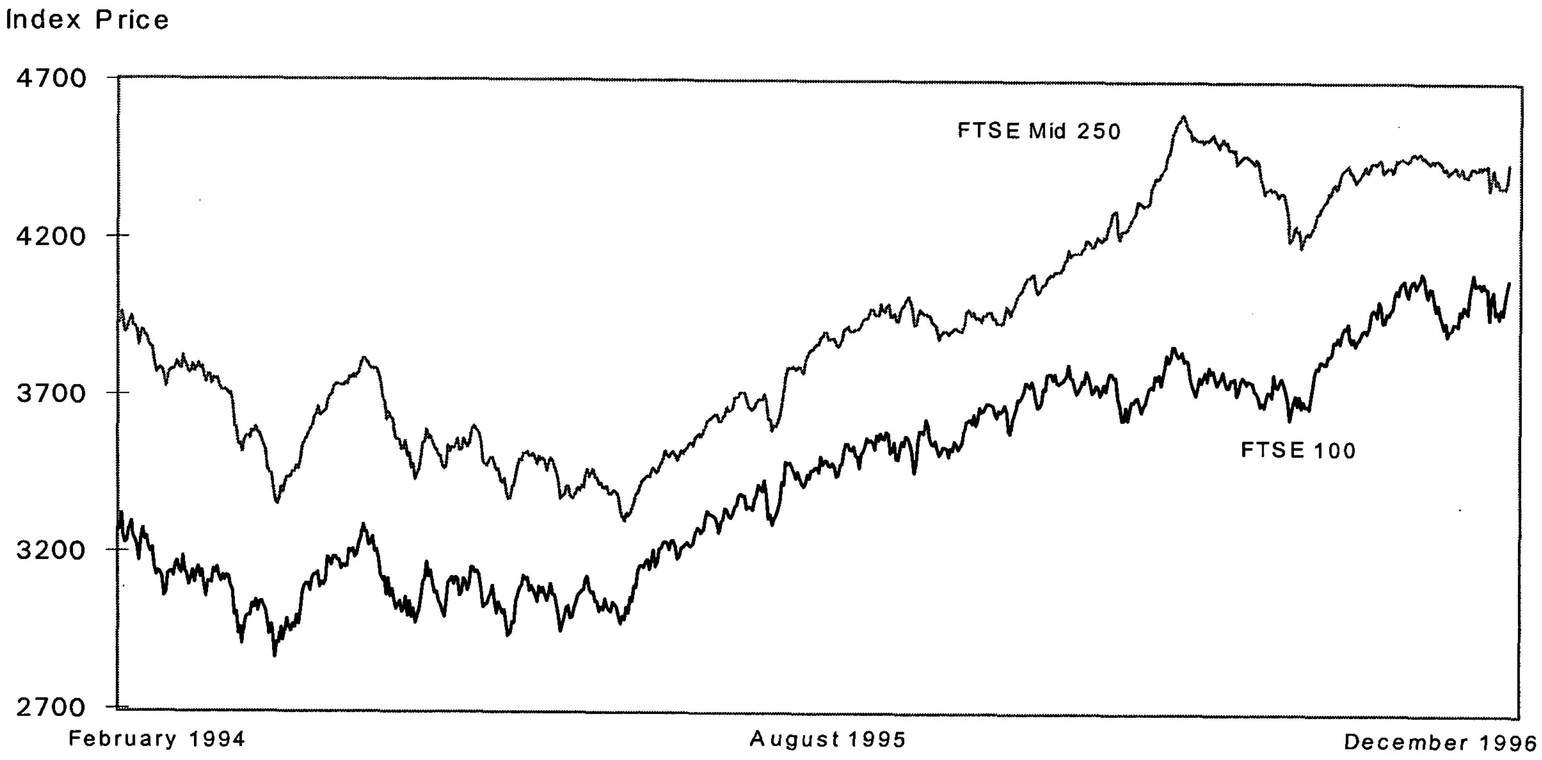
	FTSE 100 Contract	Mid 250 Contract
Unit of Trading	Valued at £25 per index point[4]	Valued at £10 per index point
Expiry Months	March, June, September and December (nearest 3 contracts are available)	March, June, September and December (nearest 2 contracts are available)
Maturity Date	Third Friday in the delivery month at 10.30am	Third Friday in the delivery month at 10.30am
Minimum Price Movement - Tick Size	0.5 index point: = £12.50	0.5 index point: = £5.00
Launched	May 1984	February 1994

Source: L.I.F.F.E. (1994)

Figure 1.1)

Plot of the FTSE 100 and FTSE Mid 250 Contracts:

(February 1994 - December 1996)



smaller capitalisation bias of the Mid 250 index, sectoral weighting differences are probably of more significance.

Figure 1.2 and 1.3 illustrate the total daily open interest for the FTSE 100 and Mid 250 contract over the research period respectively[6]. In figure 1.2 open interest for the FTSE 100 contract can be seen to have been relatively stable over this period. Although open interest reached a peak of 85,000 contracts, open interest has averaged approximately 65,000 contracts per day. By comparison, total daily open interest in the Mid 250 contract has frequently only been about 5% of this figure. Following the initial enthusiasm for the contract, open interest of almost 6,000 contracts was rapidly established. However, over the research period considered the daily open interest has averaged approximately 4,000 contracts per day. Interestingly, the daily open interest for the Mid 250 contract has been characterised by a step function, whereby any changes in the outstanding number of contracts occur at the roll-over period, with open interest remaining stable at other points. In figures 1.4 and 1.5 daily trading volume figures for the FTSE 100 and Mid 250 contracts over the research period respectively are illustrated[6]. It is clear that the FTSE 100 contract is well established with average daily trading volume of 25,000 contracts. However, the Mid 250 contract suffers from extremely thin liquidity with average trading volume of only 150 contracts per day. Furthermore, market liquidity tends to be very sporadic, and concentrated around the roll-over period when a "liquidity window" emerges and market participants move their positions forward.

Figure 1.2)
Total Daily Open Interest - FTSE 100 Contract:
February 1994 - December 1996

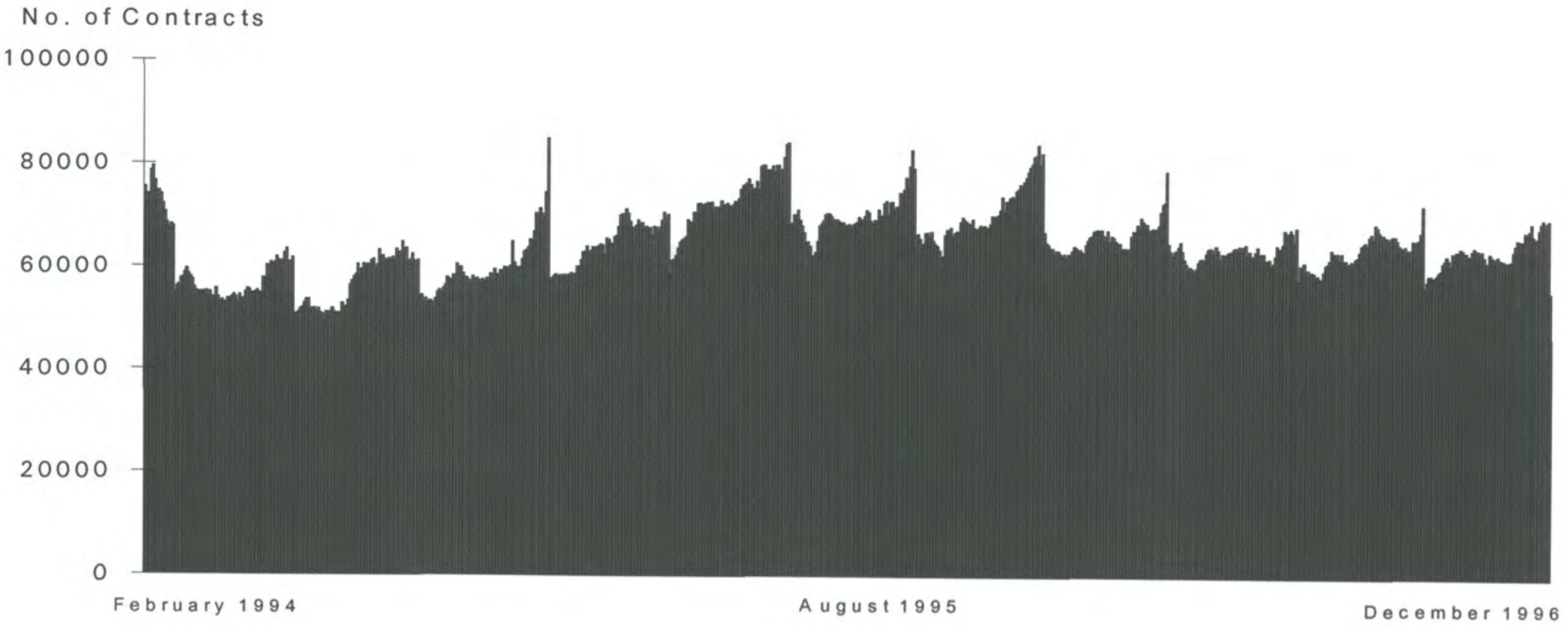


Figure 1.3)
Total Daily Open Interest - FTSE Mid 250 Contract:
February 1994 - December 1996

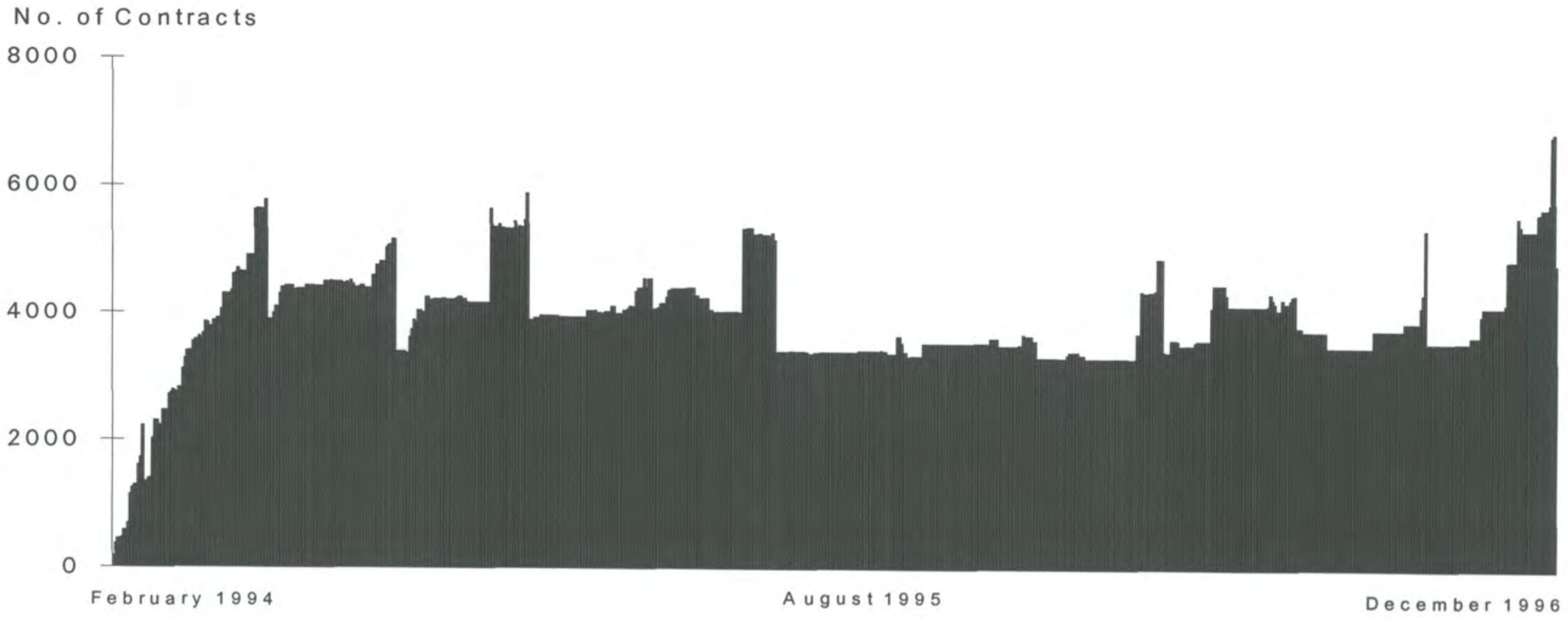


Figure 1.4)
Total Daily Trading Volume - FTSE 100 Contract:
February 1994 - December 1996

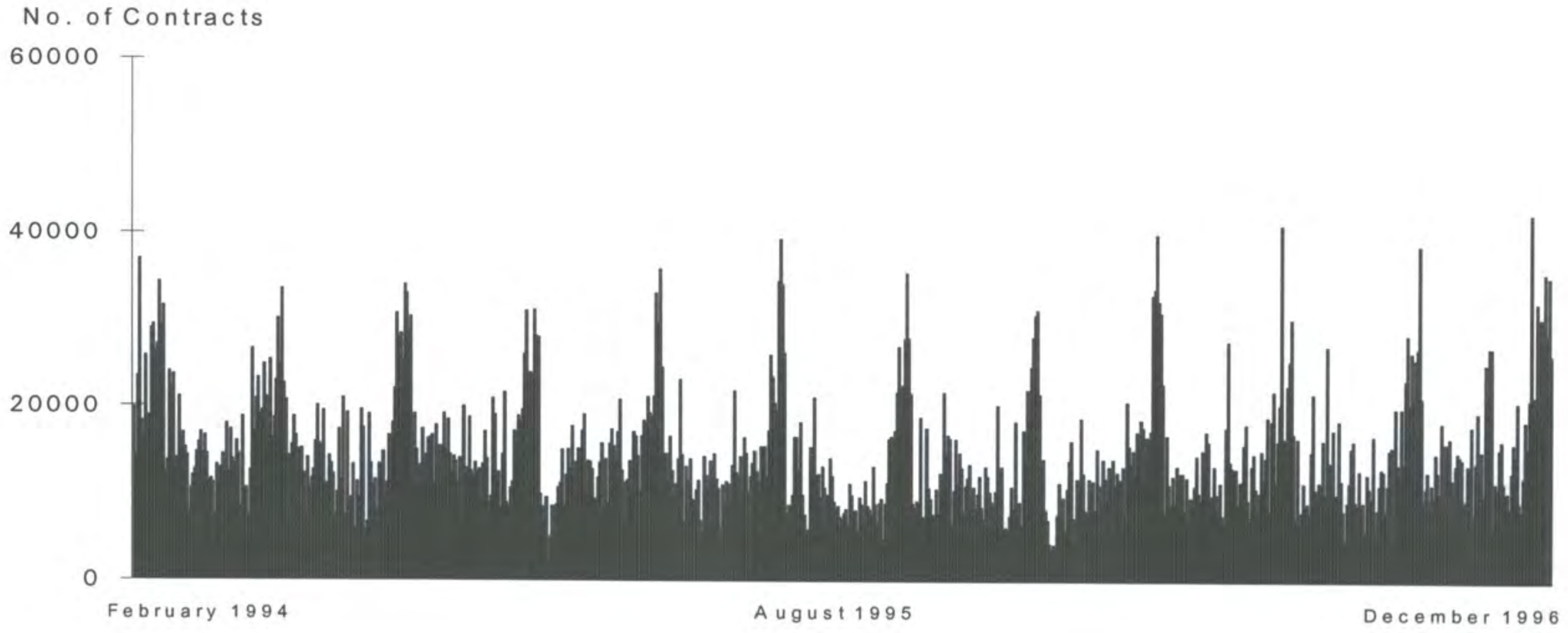
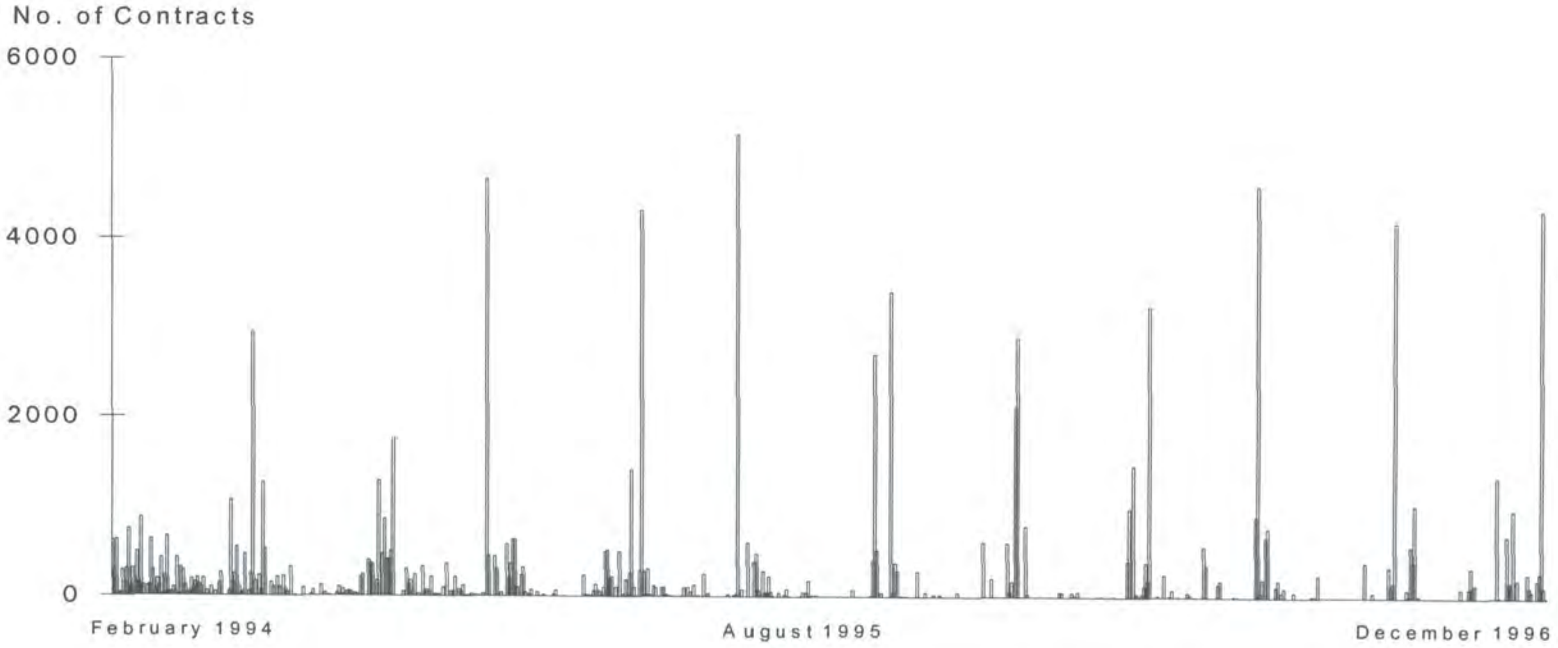


Figure 1.5)
Total Daily Trading Volume - FTSE Mid 250 Contract:
February 1994 - December 1996



While trading through the futures market is more cost effective than trading through the equity market, part of the difference in the levels of trading activity between the FTSE 100 and Mid 250 contracts can be accounted for by the actual differences in transaction costs. UK transaction costs consist of the bid offer spread in the equity and futures markets, stamp duty, equity and futures commissions and any market impact costs which reflect the size of the trade and the liquidity of the market. Table 1.3 shows the breakdown of round trip transaction costs affecting trading decision in UK equity and index futures markets.

As table 1.3 illustrates, while transaction costs in the futures markets are significantly smaller than those in the equity market, the transaction costs associated with trading the FTSE 100 contract are a considerably smaller proportion of total round trip transaction costs than those associated with trading the Mid 250 contract. Furthermore, an examination of formal transaction cost alone ignores the market impact cost of any transaction. Given that market impact costs tend to be a function of market liquidity, it is clear that owing to the lower trading volume in the Mid 250 contract the market impact costs of using this contract will be considerably greater than those associated with the FTSE 100 contract. Hence, the figures in table 1.3 understate the true transaction costs savings from using the established contract. Even so, an examination of transaction costs alone overlooks the important technical and structural differences which affect trading in UK equity and futures markets. Equity and futures markets can be distinguished by different institutional and settlement procedures. For instance, the UK stock market is a pure dealership market, where trading positions are settled on the basis of a two (or three) week account

Table 1.3)

Roundtrip Transaction Cost for UK Markets

	FTSE 100 (%)	Mid 250 (%)
Equity Index Bid - Offer Spread	0.69	1.10
Stamp Duty	0.50	0.50
Equity Market Commission	0.40	0.40
Index Future Bid - Offer Spread	0.05	0.29
Index Future Commission	0.01	0.02
Total: Institutional Investors	1.65	2.31
Total: Market Makers	0.75	1.41

Source: Bolchover and Preece (1994), p. 4

period. While trading on the LIFFE futures markets occurs through "open outcry" with trading positions being marked to market on a daily basis.

1.3) STRUCTURE OF THESIS

Owing to the short life of stock index futures trading in the UK, research into the effectiveness of these contracts has been limited in scope, and the literature remains in its infancy. The aim of this thesis is to help to bridge the gaps in the literature, by providing a detailed empirical investigation into the role and function of stock index futures contracts in the UK. While work into the usefulness of the established FTSE 100 contract has been undertaken, to date no detailed examination has been conducted for the recently introduced Mid 250 contract. Therefore, the thesis will concentrate on important aspects relating to the introduction of the Mid 250 contract and the additional benefits it has made to stock index futures trading in the UK. To allow for the diversity in the literature, the thesis will focus specifically on two related issues, which are central to evaluating the value of index futures trading in a UK context. Hence, the specific research objectives of the thesis are to investigate the hedging effectiveness of the FTSE 100 and Mid 250 contracts and the pricing efficiency of the FTSE 100 and Mid 250 contracts in both an index arbitrage and spread trading context. Furthermore, the research issues outlined will be examined using data over the period February 1994 to December 1996. However, because this data set has been built up progressively in stages, the length of the sample period employed varies for different chapters.

The structure of thesis is as follows. In chapter two, the established literature which is relevant to the *economics of stock index futures trading* in the aforementioned areas will be thoroughly reviewed. The purpose of this literature survey is to highlight the specific research issues investigated, the methodological techniques employed, together with a critical discussion of the empirical findings. Furthermore, by identifying the limitations in the existing literature, it is possible to provide a rationale for the research being undertaken.

While the Mid 250 contract was introduced to enable investors to acquire market wide exposure to medium size capitalisation stocks, it is possible that the hedging effectiveness of this new contract may be seriously impaired by the low levels of trading volume and high transaction costs which discourage trading. To investigate this issue chapter three compares the hedging effectiveness of both the Mid 250 and FTSE 100 contract, to determine whether the Mid 250 contract provides any additional benefits. Hedging effectiveness is examined in both an ex post and ex ante context for a diverse range of spot portfolios. It is shown that in terms of risk reduction, the FTSE 100 contract provides a more effective hedge for spot portfolios dominated by large capitalisation stocks, while the Mid 250 contract provides a more effective hedge for portfolios dominated by lower capitalisation stocks. In particular, when consideration is given to professionally managed portfolios, hedging effectiveness is greater for the new contract in all cases. Furthermore, the problem of inter-temporal hedge ratio instability is considered. Using historical data, hedge ratios are estimated on the basis of a dynamic moving window procedure. It is shown that as the window size increases ex ante hedge ratios stabilise, coverging towards the ex post benchmark, and maximising risk reduction.

Chapter four extends the work conducted in chapter three by examining the hedging effectiveness of both the FTSE 100 and Mid 250 contracts using hedge ratios generated within an extended mean Gini (EMG) framework. The EMG approach provides a more robust alternative to the mean variance approach by distinguishing between different classes of risk averse hedgers, and producing hedge ratios that are consistent with the rules of stochastic dominance. The results illustrate that the EMG hedge ratio series is characterised by a step function which is strongly related to the hedger's degree of risk aversion. The implication of this result is that each spot - futures relationship is associated with several optimal hedge ratios.

Given that index futures are frequently used to initiate short term hedging strategies, the effectiveness of these strategies in allocating risk depends crucially on whether the contracts are efficiently priced relative to their underlying fair value. Where they are found to be mispriced relative to their fair value estimates, hedging effectiveness will be impaired and arbitrage opportunities may present themselves. In chapter five the pricing efficiency of the FTSE 100 and Mid 250 index futures contracts is examined. This is an important issue not only because of issues of efficiency but also because while index arbitrage strategies have been discouraged in the US, they have been actively encouraged in the UK. The results from this chapter indicate that while there are many deviations from fair value, both contracts appear to be efficiently priced, with mispricing being generally constrained within transaction cost limits.

An alternative approach used for testing for futures market efficiency is spread trading, and because spread transactions are associated with very low transaction costs, deviations from fair value which are often too small to be exploited by index arbitrage can be exploited by spread trading. An examination of spread mispricing is important in that it enhances the discussion on the economics of arbitrage, with spread mispricing having important implications for the effectiveness of spread trading in the same way that index futures mispricing has important implications for hedging effectiveness. In chapter six, the fair value model used in chapter five is adapted to test the ex post profitability of intramarket and intermarket spread trading strategies based on the FTSE 100 and Mid 250 contracts.

Finally, in chapter seven the main results in the thesis are summarised and concluding remarks are drawn.

Endnotes

[1] The main regulations which govern the operation of futures markets are common to most exchanges and include characteristics such as standardisation of contracts, delivery, clearing requirements, margin requirements (initial, maintenance and variation) and trading limits. These requirements serve to reduce default risk and increase market liquidity. For a discussion of these characteristics see Daigler (1993), Sutcliffe (1993) and Tucker (1991).

Cox, Ingersoll and Ross (1981) demonstrate that futures contract are distinguishable from forward contract, in that they are designed to be traded, and hence are standardised contracts on well organised exchanges. Futures contracts are standardised in terms of quantity, quality, delivery date, location and counter party risk.

[2] The economic and social importance of the derivatives literature was recently acknowledged with the awarding of the 1997 Nobel Prize for Economics to Robert Merton and Myron Scholes for their work in derivatives.

[3] LIFFE introduced futures trading on the FTSE Eurotrack index - a European benchmark index which encapsulated the largest companies in Europe, excluding the UK - in June 1991. However, trading in this contract was later suspended owing to insufficient trading volume.

[4] The contract multiplier associated with the FTSE 100 contract was reduced on 17 December 1997 from £25 to £10 for the June 1998 delivery month onwards in response to market demand.

[5] The Expected Delivery Settlement Price (EDSP) is based on the average level of the underlying index between 10.10am and 10.30am on the last trading day.

[6] Owing to the large differences in the vertical scale of figures 1.2 and 1.3, and figures 1.4 and 1.5, these plots are not directly comparable.

CHAPTER TWO

THE ECONOMICS OF STOCK INDEX FUTURES TRADING

2.1) INTRODUCTION

The justification for this thesis has been presented in chapter one, where it was argued that to date no detailed examination has been conducted into the contribution made by the introduction of the Mid 250 index futures contract. The purpose of this investigation is to concentrate on the important aspects relating to the introduction of the Mid 250 contract and evaluate what, if any, are the additional benefits provided by the new contract with respect to the *economics of stock index futures trading* in the UK. Although index futures contracts have the potential to increase investor utility by extending the possible range of investment opportunities, by providing a low cost means of acquiring market exposure, in evaluating the contribution made by the Mid 250 contract it is necessary to take account of the specific costs and benefits of trading the new contract, together with the degree to which it supports the established FTSE 100 contract. To assess the success of the Mid 250 contract in this respect, the trading performance of the new contract will be examined in two specific areas; hedging effectiveness and pricing efficiency. First, since hedging provides the principal justification for the existence of futures markets, hedging performance will be considered in terms of the contract's ability to reduce the market risk faced by investors. Second, pricing efficiency in relation to index arbitrage and spread trading is investigated by measuring the degree to which futures prices stray from their fair value estimate.

An investigation of these areas in relation to the FTSE 100 and Mid 250 contracts will comprise the main body of the thesis, constituting the work undertaken in chapters three to six. However, in order to place this work in its correct context it is important to consider previous research which has addressed these issues. The remainder of this chapter consists of a literature review of the research in relation to the issues identified above. This review will serve to highlight both the strengths and weaknesses of the established literature, and provide the rationale for the work being undertaken.

2.2) HEDGING WITH STOCK INDEX FUTURES CONTRACTS

While the development of stock index futures contracts has been a relatively recent development, research into the hedging effectiveness of these contracts has been widespread. Although the majority of these studies relate to stock index futures contracts traded in the US, more recently studies for other national index futures contracts have been published, reflecting the growth in popularity and importance of these contracts. Academic research examining the hedging effectiveness of these contracts has employed both the mean variance approach, which considers ex post and ex ante performance, together with the extended mean Gini (EMG) approach which takes account of different levels of investor risk aversion. This review of the hedging literature will be based around this trichotomy.

2.21) EX POST APPROACH TO HEDGING

Figlewski (1984a) provided the first comprehensive investigation into the hedging effectiveness of stock index futures contracts. Figlewski examined how effectively the Standard and Poors 500 index futures contract was in hedging the risk associated with five major US stock portfolios. All five stock indexes were diversified portfolios but characterised by a different market composition, and thereby possessed different levels of non-market risk. Two indexes were composed of only the largest capitalisation stocks, two included smaller capitalisation stocks and the fifth index contained only thirty stocks. The sample period extended from 1 June 1982 to 30 September 1983. Hedges of daily, weekly and monthly duration were employed.

Figlewski's weekly futures return series consisted of the S&P 500 series nearest to maturity. The nearest to maturity contract was chosen because it was associated with the greatest liquidity and therefore could be expected to be the most efficiently priced. Furthermore, the returns on the five index portfolios were inclusive of dividends. However, given that Figlewski found dividends to be of little explanatory significance, it has not been the practice to include dividends in subsequent studies. Both the minimum variance hedge ratio (henceforth MVHR) and the beta hedge ratios were generated for each of the five stock portfolios.

On the basis of a risk reduction and return retention criterion, the MVHR was found to be superior to the beta hedge ratio for all of the index portfolios. For the larger capitalisation indexes risk reduction measured in terms of the lowering of the standard deviation of returns for hedges of one week duration was found to be in the region of 65% to 75%. While for the smaller capitalisation indexes risk reduction was found to be in the range of 35% to 40%. However, when evaluating hedging effectiveness on the basis of return retention, Figlewski found that the superiority of the MVHR over the beta hedge ratio became even more evident. The MVHR retained between 25% and 30% of the unhedged return for the larger capitalisation indexes and between 40% and 53% of the unhedged return for the smaller capitalisation indexes. This compared with the beta hedge ratio, which retained between 12% and 16% of the unhedged return from the larger capitalisation indexes and between 29% and 44% for the smaller capitalisation indexes. Consequently, Figlewski concludes that owing to basis risk:

> "the minimum variance hedge ratio was less than the portfolio's beta in every case, with the adverse effects of over hedging being more serious for the returns than the risk levels" (1984a, p.663).

Figlewski also examined the contribution made by the various determinants of basis risk to hedging effectiveness. Specifically, consideration was given to the exclusion of dividends on hedging performance, and whether the size of the hedging period and the time to maturity of the futures contract have any bearing on hedging effectiveness. Figlewski found that dividend risk was insignificant. Furthermore, a duration effect was evident with a weekly hedge being more effective in terms of risk reduction than an over night hedge. However, a four week hedge was not found to be any better than a one week hedge, a result which was suggested to have arisen from sampling error. Finally, an expiration effect was not evident between zero to one month, nor one to two months from expirations, but hedging performance was found to deteriorate once hedges were lifted between two to three months from expiration.

Nordhauser (1984) using the traditional hedging approach, examined whether a hypothetically constructed Value Line Composite Index (VLCI) futures contract was capable of hedging two US mutual funds. Over the period 1962 to 1981, Nordhauser found that by using the VLCI as a proxy for the futures contract, the resulting hedged portfolio could "substantially reduce the variability of the returns with only a minor reduction in the rate of return" (p. 61). However, Nordhauser did not provide any explicit evaluation of hedging effectiveness.

Figlewski (1985) investigated the effectiveness of hedging five US stock portfolios (the spot portfolios were the same as in Figlweski (1984a)) using index futures contracts traded on the VLC Index, the S&P 500 Index and the NYSE Composite Index. The sample period employed covered the last seven months of 1982, with both beta and MVHR's being computed, with the duration of the hedges ranging from one day to three weeks.

Figlweski found that the use of a beta hedge ratio was very ineffective for hedging over short durations. For instance, hedging the NYSE Composite Index overnight with its underlying futures contract eliminated only 15% of the risk associated with the unhedged portfolio. However, risk reduction improved as the length of the hedging period was extended to several weeks. The beta hedge ratios for the indexes composed of small capitalisation stocks were found to be even less effective, and over the shorter durations the hedged portfolio was found to be riskier than the unhedged spot portfolios. While risk reduction improved for hedges over a longer duration it amounted to a maximum of approximately 70% for the high capitalisation indexes and 30% for the low capitalisation indexes.

The MVHR was found to dominate the beta hedge ratios in the vast majority of cases, being both smaller in size and superior in terms of risk reduction. Once again, daily hedges were found not to be effective, with risk reduction increasing along with the absolute size of the hedge ratios for longer duration hedges. Figlewski suggested that the ineffectiveness of short duration hedges may have been a consequence of the use of non-synchronous prices for computing the value of the indexes. Furthermore, Figlewski rather surprisingly found that there was no obvious benefit from hedging a stock portfolio with its associated futures contract. In fact, when measured in terms of risk reduction, cross hedges were often found to be more effective instruments than the underlying direct hedge.

Junkus and Lee (1985) investigated the suitability of the S&P 500, NYSE Composite and VLCI index futures contracts as hedging vehicles for their underlying stock indexes. Junkus and Lee examined the appropriateness of four different hedging strategies, each of which were concerned with a different aspect of hedging motivation. The different hedging strategies included the traditional 'one to one' hedging strategy, the Working (1953) strategy, the Johnson (1960) minimum variance strategy and the Rutledge (1972) utility maximising strategy. Daily hedge ratios were computed using data over the period 31 May 1982 to 1 March 1983 for the closest to maturity, farthest from maturity and an intermediate maturity contract.

Junkus and Lee found considerable variation in the effectiveness of the various strategies. For instance, the traditional strategy was often characterised by 'overhedging' with the hedged portfolio on NYSE Composite and VLCI being associated with greater risk than the unhedged stock index. On the basis of risk reduction the Johnson strategy was found to be the most effective, reducing the greatest proportion of the variance on the long stock index. Finally, Junkus and Lee did not find a consistent relationship between contract maturity and hedging effectiveness.

Peters (1986) examined the components of basis risk which arise when using index futures contracts to hedge equity portfolios. Extending the work of Figlewski (1984a), Peters used the S&P 500 index futures contract to investigate the effectiveness of both the MVHR and beta hedge ratios as strategies for hedging the S&P 500, NYSE Composite and Dow Jones stock portfolios. For the period 15 March 1984 to 31 March 1985 Peters decomposed the return on the index futures contract in terms of the return due to changes in the index, the return due to changes in the cost of carry and the return due to mispricing. Peters found that the MVHR dominates the beta hedge ratio in terms of risk reduction. It was found that changes in the index accounted for only 80% of the variance of the futures return, and therefore the hedger who adopted the beta hedge ratio ignored an additional 20% of futures variance which arises from sources other than the underlying index. Consequently, the hedger would be over-hedging.

Peters used daily returns rather than weekly returns to reflect the interest in daily hedging performance. Consistent with Figlewski (1984a), Peters found that the MVHR dominated the beta hedge ratio in terms of lower risk and higher return for all stock portfolios. Peters' results suggested that for market practitioners who wished to hedge equity portfolios, the beta hedge ratio which is concerned with minimising only market risk rather than overall risk, was not the optimal hedge ratio.

Grieves (1986) investigated how effectively corporate bonds could be hedged using a composite hedge consisting of S&P 500 futures contracts and Treasury bond futures contract. Using monthly data over the period July 1982 to January 1985, and utilising a minimum variance hedging strategy, Grieves found that for industrial bonds, a composite hedge was more effective than a hedge consisting of Treasury bond contracts alone. Furthermore, as bond quality decreases hedging effectiveness improves, and the proportion of stock index futures in the hedged portfolio increases. However, this is to be expected since lower grade bonds tend to be more stock-like than their higher grade counterparts.

Junkus (1987) considered the issue of hedge ratio instability by examining whether hedge ratios are characterised by any systematic changes during rising and falling equity markets. Using weekly returns over the period June 1982 to June 1985, Junkus tested the stability of both the MVHR and beta hedge ratios for three index futures contracts (S&P 500, NYSE Composite and VLCI) against a range of widely differing portfolios. However, when Junkus augmented the market model with a dummy variable which measured the differential effect of bull market conditions there was no consistent pattern which applied to all index futures contracts. Therefore, given that the optimal hedge ratio was not associated with any significant variation during periods of major market movements, Junkus argued that portfolio managers were justified in using previously estimated hedge ratios when making market timing decisions.

Graham and Jennings (1987) considered the hedging performance of the S&P 500 index futures contracts with respect to ninety randomly selected equity portfolios, which were partitioned into nine different categories on the basis of systematic risk and dividend yield levels. Systematic risk and dividend yield levels were chosen because they are determinants of stock selection. For each systematic risk - dividend yield category ten equally weighted portfolios consisting of ten shares each were constructed. Using weekly returns Graham and Jennings compared the effectiveness of the traditional, beta and minimum variance hedging strategies, over one, two, three and four week durations in terms of the degree of return retention and degree of risk reduction. On the basis of return retention the MVHR was found to dominate the alternative strategies, preserving more of the unhedged return, over all three hedging periods for each portfolio category. Furthermore, a duration effect was also evident with four week hedges preserving more return than either the one or two week hedges.

Evaluated on a risk reduction criterion, the minimum variance strategy did not dominate the other strategies to the same extent as was the case for return retention. While the MVHR was the most effective in terms of risk reduction for one week hedges, its superiority was found to diminish as hedge duration increased. Compared to Figlewski (1984a), stock index futures were found to be less than half as effective at eliminating risk, when the spot instruments were undiversified non-index portfolios, with risk reduction having been found to be within the 25% to 30% range.

Lee, Bubnys and Lin (1987) investigated issues relating to the functional form and stability of the MVHR for the S&P 500, NYSE Composite and Value Line index futures contracts using daily data for the period April 1982 to August 1983. Lee et al compared the effectiveness of hedge ratios generated using price levels, price differences and logarithmic differences. They found that for all three contracts the regression residuals based on raw price levels exhibited significant autocorrelation, and thus tended to produce inefficient hedge ratios which overstated the degree of hedging effectiveness. However, hedge ratios generated on the basis of price and logarithmic differences were found to be quite similar and capable of reducing between 60% and 85% of the unhedged portfolio risk. Furthermore, estimated hedge ratios were found to be unstable, and tended to rise as the time to contract expiration declined. Volume effects were suggested as an explanation for this phenomenon.

Morris (1989) examined the hedging effectiveness of the S&P 500 index futures contract in reducing the risk associated with a fully diversified portfolio of stocks composed of the largest companies on the NYSE. The portfolio of stocks constituted 10% of the NYSE capitalisation. Using monthly data over the period 1982 to 1987, Morris found that use of the MVHR reduced the risk associated with the unhedged spot portfolio by 91%.

Malliaris and Urrutia (1991) questioned the assumption made by previous studies that hedge ratios and measures of hedging effectiveness are stable over the entire sample period. Changes in the amounts of information being impounded into prices may change over time, and this will influence hedging decisions and the stability of the optimal hedge ratio. Malliaris and Urrutia investigated the issue of stability for both the S&P 500 and NYSE index futures contracts, together with four foreign currency futures contracts. To test the stability of the estimated hedge ratios and measures of hedging effectiveness, the random walk hypothesis was employed. Using fortnightly hedges over the period January 1984 to December 1988, moving window regressions were estimated for a one year period, rolled forwards by three months. Having generated hedge ratio and hedging effectiveness estimates for each quarter, the hypothesis that they both followed a random walk was tested using a Dickey-Fuller unit root test and the variance ratio approach of Lo and Mackinlay.

Malliaris and Urrutia found evidence consistent with the hypothesis that both hedge ratios and measures of hedging effectiveness for stock index futures contracts follow a random walk. The hypothesis was confirmed by both tests, indicating that both the estimated hedge ratios and measures of hedging effectiveness were random variables which have a tendency to change as the sample period changes. The main implication of the result is that hedgers cannot place perfect hedges, and a dynamic approach to hedging needs to be adopted, whereby hedgers continuously readjust their positions. However, Malliaris and Urrutia suggested that an adverse consequence of dynamic hedging was that of additional transaction costs which accrue from repeatedly modifying the size of the futures position. Thus, in view of the cumulative cost of dynamic hedging, it may be more profitable over the life of the hedge to adopt an imperfect static hedge. However, where the adjusted hedge ratios associated with the dynamic approach are smaller in absolute size than those generated by the traditional approach, these additional transactions costs would be offset by reduced margin requirements.

Lindahl (1992) also explored the issue of hedge ratio stability. Using weekly data over the period 1985 to 1989 for the MMI, and from 1982 to 1989 for the S&P 500 index futures contracts, she investigated the issue of hedge ratio stability with respect to changes in hedge durations and the time to contract maturity. Hedge durations of one, two and four weeks were considered, with hedges being lifted at weekly intervals between zero and twelve weeks before the contract expiration date.

For both index futures contracts, Lindahl found evidence of a duration effect, with a rise in both the size of the MVHR and the respective measure of hedging effectiveness as hedge duration increases. The MVHR's were all less than unity, but were found to converge towards the beta hedge ratios as hedge duration increased. The duration effect was influenced by the fact that longer duration hedges were lifted closer to the expiration date, and the MVHR's were found to increase for hedges lifted closer to maturity. However, the coefficient of determination showed no tendency to increase as the expiration date approaches. A restricted least squares regression was found to corroborate the pattern evident from the sample of bivariate regressions, with the size of the MVHR's converging towards one as maturity approaches. Lindahl concluded that:

> "the minimum variance strategy, is a dynamic process that should be monitored as hedge duration increases and as expiration is approached. To remain fully hedged additional contracts need to be added to the original position" (1992, p. 43).

Ghosh (1993) argued that the traditional approach to estimating hedge ratios was theoretically misspecified, because by failing to take account of the influence of lagged values the model excluded the influence of short run dynamics, with the consequence that any resulting hedge ratios would be sub-optimal. Using daily logarithms of the prices over the sample period January 1990 to December 1991, Ghosh estimated hedge ratios for the S&P 500 index, NYSE Composite index and

DJIA with respect to the S&P 500 index futures contract using an error correction mechanism which takes account of the long run equilibrium relationship between the spot and futures series. Ghosh found that the coefficients relating to the error correction mechanism (ECM) were significant for all three spot indexes, indicating that the equilibrium error in the last period had a significant influence on the subsequent change in the spot price. Furthermore, the log likelihood ratio statistics for all three indexes are highly significant indicating that the hedge ratios estimated using ECM's were preferable to hedge ratios estimated by traditional method. Ghosh found that both the optimal hedge ratio and the coefficient of determination for the error correction mechanism are higher than those estimated by the traditional approach, indicating greater hedging effectiveness.

While all of the previous studies which have been reviewed relate to index futures contracts traded in the US, the first investigation into the hedging effectiveness of the FTSE 100 contract traded on LIFFE, was conducted by Holmes (1996). Using weekly data over the period July 1984 to June 1992, Holmes considered which was the appropriate econometric technique for generating the optimal hedge ratio, whether there were duration or expiration effects and whether hedge ratios were characterised by stability.

When comparing the MVHR's estimated by the standard OLS approach, error correction mechanism and generalised autoregressive conditional heteroscedsatic (GARCH) process, Holmes found that while all three approaches were very effective, removing between 78% and 90% of the risk associated with the underlying FTSE 100 spot portfolio, the traditional OLS approach was the most effective. Furthermore, on the basis of risk reduction and return retention, the MVHR was also found to dominate the beta hedge ratio, a finding which is consistent with Lindahl (1992).

Holmes investigated the possibility of a duration effect using hedges of one, two and four week duration. The MVHR's, together with the measures of hedging effectiveness were found to increase for longer duration hedges, indicating that hedging effectiveness increased with hedge duration. Expiration effects were tested for by using multiple regression models for hedges of different duration. While no consistent relationship was evident, hedge ratios tended towards unity as expiration approached. Finally, regarding the issue of the stability of the MVHR, while they were found to vary over time, unit root tests indicated that all hedge ratios were stationary.

In a paper that examined the impact of portfolio composition on both systematic risk and hedging effectiveness, Holmes and Amey (1995) constructed portfolios of UK stocks and gave consideration to the FTSE 100 contract. They showed that as the number of stocks in the portfolio increased from 1, through 5, 10, 15, 20 and 25 the hedging effectiveness of the FTSE 100 contract increased markedly. However, they found that while previous studies had suggested that the FTSE 100 contract was capable of removing approximately 80% of the risk of the spot portfolio when that portfolio was the underlying index, risk reduction was only about 60% when the portfolio comprised of 25 stocks. Holmes and Amey concluded that previous studies had overstated the actual hedging effectiveness of this contract.

2.22) EX ANTE APPROACH TO HEDGING

Little attention has been given to the issue of ex ante hedging effectiveness and the associated problem of inter-temporal hedge ratio instability. This section provides a brief review of the research papers which have investigated the issue of ex ante hedging performance for a range of financial futures contracts.

Marmer (1986) considered the hedging effectiveness of Canadian dollar futures in an ex ante framework using hedges of one, two, three and four week duration, and the near, middle and far contract over the period July 1981 to September 1984. The effectiveness of the MVHR was examined in an ex ante context by estimating the optimal hedge ratio for one period and then applying it to a subsequent period. These results were then compared against those achieved using the traditional approach. Marmer found that the usefulness of the MVHR on an ex ante basis was rather limited, since although ex ante hedge ratios were found to be more effective than the traditional approach, the difference was not statistically significant.

Lasser (1987) analysed the risk reduction potential of the minimum variance hedge ratio applied on an ex ante basis with regard to treasury bill and treasury bond futures contracts. Using data over the period January 1978 to December 1982, hedges of two, four, six and eight weeks duration were employed. Lasser found that ex ante hedges generated on the basis of a longer estimation period proved to be more effective hedges. However, the ex ante hedges were not found to be significantly better than the traditional hedge.

Benet (1990) investigated the ex ante risk reduction potential of a large number of foreign exchange futures contracts, comparing the difference in performance between minor and major currency futures. Monthly data over the period August 1973 to December 1985 was used. Benet found a discrepancy between hedge ratios calculated on an ex post and ex ante basis. This problem was especially acute for the minor currencies, and a number of adjustment techniques were employed to alleviate this problem. Benet suggested that these results represented a more indicative measure of the effectiveness of these markets to currency traders.

Holmes (1995) investigated the ex ante hedging effectiveness of UK index futures contracts. Using data over the period 1984 to 1992, hedging effectiveness was examined for hedge ratios of one and two week duration with respect to the FTSE 100 contract. Two types of ex ante hedge ratios were evaluated. Firstly, annual ex post hedge ratios generated in one period and then subsequently employed in a later period, and secondly, ex ante hedge ratios estimated using a rolling regression procedure. Holmes found that while the performance of ex ante hedge ratios was not as good as the ex post hedges, they were still very effective, eliminating up to 80% of the risk of the underlying index. Furthermore, the ex ante hedge ratios were found to dominate both the traditional and beta hedge ratio strategies.

2.23) EXTENDED MEAN GINI APPROACH TO HEDGING

Cheung, Kwan and Yip (henceforth CKY (1990)) proposed the use of the mean Gini as an alternative measure of risk in the context of hedging with derivative instruments. CKY investigated the hedging effectiveness of futures and option contracts in both a mean variance and mean Gini framework on a daily basis over the period September 1983 to December 1984 for five currency contracts - Sterling, the

Canadian dollar, the German mark, the Japanese yen and the Swiss franc. CKY argued that because the mean Gini coefficient does not require the same restrictive distributional assumptions as the mean variance approach it is better suited to measuring price variability in a futures context[1]. CKY found that using the mean variance framework results in the selection of hedge portfolios that are sometimes dominated stochastically by another alternative. By contrast the mean Gini approach is specifically designed to exclude the adoption of a dominated position.

Comparing the risk reduction potential of both futures and option contracts CKY found that futures were more effective than options as a hedging vehicle in both the mean Gini and mean variance frameworks. In both frameworks the futures contracts reduced spot market risk by more than 55%, while options contracts reduced the spot market risk by about 45%.

Hodgson and Okunev (1992) extended the analysis of CKY (1990) by employing the extended mean Gini coefficients. The extended mean Gini approach can be used to determine hedge ratios for different classes of risk averse investors. Hodgson and Okunev pointed out that this approach would be of particular value to professionally managed funds who have different classes of clientele who match the different risk averse categories. Using a basket of shares in the Australian All Ordinaries Index and All Ordinaries futures contract over the period July 1985 to September 1986 they compared the hedging effectiveness of the mean variance approach with the extended mean Gini approach for differing levels of risk aversion. For low levels of risk aversion hedge ratios generated by the EMG approach are similar in absolute size to the MVHR, but at higher levels of risk aversion investors adopted hedge ratios that were significantly different from the mean variance approach. This finding arose because while the mean variance approach weights all return realisations equally, the EMG approach increasingly focuses on the worst return realisations, and attributes a greater weight to this subset of observations as risk aversion increases.

Hodgson and Okunev also investigated the issue of dynamic hedging where the investor is assumed to continuously readjust their futures position over the life of the contract. While the hedge ratios estimated on the basis of mean variance analysis were found to be generally stable over time, extended mean Gini hedge ratios estimated for moderately to strongly risk averse investors were rather unstable. This finding suggested that a strongly risk averse investor who adopted a simple buy and hold strategy could be seriously mishedged. Therefore, Hodgson and Okunev argued that the extended mean Gini approach offers more flexibility in determining hedge ratios than the minimum variance approach, which is seriously flawed because "it assumes the variance is observable and that there is only one class of risk averse investors" (1992, p. 211).

Kolb and Okunev (1992) compared the MVHR with the EMG hedge ratios computed for a wide range of the risk aversion parameter. Using daily data for a variety of futures contracts that included the S&P 500 index futures contact over the period January to December 1989 the empirical properties of the EMG hedge ratio were examined. Generally these results are consistent with the findings of Hodgson and Okunev (1992). For instance, the EMG hedge ratios for low levels of risk aversion are quite similar to the MVHR's, but at higher levels of risk aversion there are substantial differences. Kolb and Okunev also investigated the stability of the hedge ratios over time using a moving window procedure. While the minimum variance hedge ratio was fairly stable, the EMG hedge ratio (for high levels of risk aversion) was not, indicating that the hedger would be required to continuously adjust their futures position.

Kolb and Okunev (1993) compared the hedging performance of the risk minimising and utility maximising hedge ratio in an EMG framework. Kolb and Okunev argued that because their are different classes of risk averse investors, the hedge ratio that minimises risk in EMG space would not necessarily maximise utility. Using monthly Cocoa spot and futures prices for Ghana, Nigeria, the Ivory Coast and Brazil over the period 1952 to 1976, Kolb and Okunev generated risk minimising and utility maximising hedge ratios for different levels of risk aversion. They found that at very low levels of risk aversion, the risk minimising and utility maximising hedge ratios differed significantly, with the utility maximising hedge ratio characterised by reverse hedging (or speculative) behaviour. However, at high levels of risk aversion the risk minimising and utility maximising hedge ratios converged towards one another.

Lien and Luo (1993) used a non parametric estimation procedure to estimate EMG hedge ratios. Using weekly S&P 500 spot and futures data over the period January 1984 to December 1988 they investigated the relationship between the optimal hedge ratio and changes in the risk aversion parameter. Lien and Luo found that the optimal hedge ratio decreases with increasing risk aversion. Lien and Luo also investigated the effect of moving window sizes on the stability of EMG hedge ratios. They found that while at low levels of risk aversion hedge ratios were stable, at higher levels of risk aversion hedge ratios were characterised by a "widely swung step function" of the data windows.

2.24) SUMMARY AND IMPLICATIONS

The literature review relating to the hedging effectiveness of index futures contracts highlights a number of important points. First, of the various techniques which have been used to estimate the optimal hedge ratio, the MVHR provides superior hedging performance. Measured in terms of risk reduction the MVHR is found to be more effective than the hedge ratios estimated using either an ECM or GARCH model, and will be employed in the empirical investigations in chapters three and four. Second, a duration effect is evident, with longer hedges being more effective. In contrast, there is no strong evidence of expiration effects. Third, the nature of the portfolio hedged is an important determinant of hedging performance. For example, Figlewski (1984a) found hedging effectiveness was less for portfolios comprising small stocks, Graham and Jennings (1987) found the hedging of portfolios comprising only ten stocks was much less effective than for portfolios matching an index and Holmes and Amey (1995) found similar results for the UK. While the composition of the spot portfolio is clearly important, previous studies have failed to address true hedging effectiveness by examining hedging performance for actual stock portfolios. Portfolios used for examining hedging effectiveness have been either market indexes or constructed by the researcher.

From the brief review it is clear that ex ante hedging effectiveness has been largely confined to currency and interest rate futures, and where the ex ante effectiveness of index futures has been examined, research once again focused on the use of spot portfolios which mirror the underlying futures contract. To date, no examination has been undertaken of ex ante hedging effectiveness with stock index futures where cross hedges are involved. In other words, no studies have investigated the effectiveness of stock index futures for hedging actual portfolios.

Previous studies which have applied the mean variance approach to hedging have implicitly assumed that there is only one optimal hedge ratio (the risk minimising hedge ratio) which is appropriate for all categories of risk averse investors. However, considering that there are numerous categories of risk averse investors who engage in futures trading for a variety of reasons, the assumption of one optimal hedge ratio is clearly flawed. The extended mean Gini approach addresses this problem by allowing for a range of optimal hedge ratios which accommodate the observed diversity in hedging behaviour. While this new approach has only very recently been applied to the stock index futures literature on hedging it is already clear that the robustness of the EMG framework in distinguishing between different categories of investors offers great promise in examining hedging behaviour.

While research into the hedging effectiveness of UK index futures has been undertaken, to date there has been no work conducted on the effectiveness of UK stock index futures using hedges of short duration or in relation to spot portfolios comprising of small capitalisation stocks. Furthermore, no attention has been given to the hedging effectiveness of the Mid 250 contract and to whether this new contract provides market participants with another important means by which to hedge stock portfolio risk. In chapter three hedging effectiveness will be investigated within a mean variance framework. This chapter addresses shortcomings of previous work in a number of important ways. Firstly, the first assessment of the hedging effectiveness of the Mid 250 contract is presented. In addition, comparisons are made between the performance of this contract and that of the FTSE 100 contract for a number of different portfolios. Given that one aim of the introduction of the new contract is to enable more effective hedging of small capitalisation stocks, this is clearly important. Secondly, together with assessing hedging performance for spot portfolios mirroring broad market indexes, cross hedging performance is analysed by examining the hedging of actual spot portfolios held by professional managers in the form of investment trust companies (ITC's). Since returns on ITCs represent the returns on professionally managed, well diversified portfolios, evaluation of hedging effectiveness in relation to these portfolios provides new insights into the capabilities for hedging actual portfolios. Thirdly, consideration is given to the hedging effectiveness of a 'synthetic' FTSE 350 contract, which comprises of various weighted combinations of the FTSE 100 and Mid 250 contracts.

The analysis undertaken in an ex post context is extended further by examining the hedging effectiveness of the Johnson MVHR approach within an ex ante context for the same broad range of spot portfolios. As such, the chapter makes a number of important contributions to the literature. Firstly, the analysis presents the first test of the ex ante hedging performance of the Mid 250 contract. Secondly, ex ante hedging effectiveness is compared with the ex post benchmark. This is an important issue because a high degree of ex post hedging effectiveness is meaningless if the hedger cannot attain similar levels on an ex ante basis. Finally, the inter-temporal stability of ex ante hedge ratios will be investigated, together with the extent to which stability is a function of window size.

The hedging effectiveness of the FTSE 100 and Mid 250 contracts will be further examined using hedge ratios generated within an EMG framework. In chapter four EMG hedge ratios will be evaluated with respect to spot portfolios comprising of different market indexes. To date this approach has not been employed in relation to either UK futures contracts or cross hedges. Given the relevance of this approach to different categories of investors these results are important in casting light on the strength of the relationship between risk aversion and hedge ratio selection.

2.3) PRICING OF STOCK INDEX FUTURES CONTRACTS

The work on hedging effectiveness in chapters three and four are both related to the pricing efficiency of the FTSE 100 and Mid 250 index futures contracts. For instance, the imposition of no-arbitrage limits improves the correlation between spot and futures prices, which increases hedging effectiveness. Therefore, an analysis of the pricing efficiency of index futures contracts is an important issue for research when investigating the economics of stock index futures trading.

Since the introduction of index futures contracts in 1982 both researchers and practitioners alike have been interested in the extent to which actual index futures prices deviate from the theoretical values predicted by the no-arbitrage condition. A vast literature has evolved examining the related issues of pricing efficiency and index arbitrage in stock index futures markets. The overall findings indicate that mispricing is common, and that substantial and sustained deviations exist of actual futures prices from their theoretical values. While the majority of the earlier studies focused on the issue of mispricing in US markets, more recently greater consideration has been given to the issue of pricing efficiency in non-US index futures markets.

The theory of arbitrage pricing suggests that in an efficient market where the actual futures price trades at the theoretical value predicted by the cost of carry model the no-arbitrage condition applies. Only when the actual futures price deviates from its theoretical value by more than the existing transaction costs will profitable arbitrage be possible. Where the no-arbitrage condition ceases to exist, an index arbitrage transaction should be promptly triggered resulting in the rapid elimination of any mispricing. If the futures contract is found to be underpriced the arbitrageur initiates a long futures arbitrage position, which involves buying the futures contract and simultaneously short selling the equivalent stock portfolio. Alternatively, if the futures contract is found to be overpriced the arbitrageur initiates a short futures arbitrage position which involves selling short the futures contract and simultaneously buying the equivalent stock portfolio. The traditional arbitrage strategy assumes that the positions are held until maturity but given the assumption often made that arbitrage capital is limited, researchers have examined the profitability of the early and delayed unwinding options.

Specifically, with respect to stock index futures pricing the empirical literature has focused on two related issues. Firstly, researchers have employed various forms of the cost of carry model to determine the theoretical fair futures price to use as a benchmark for evaluating any mispricing. Secondly, a contract's history of profitable arbitrage deviations has been examined to determine whether it contains any information which can be used to predict any subsequent price movements in the underlying market. While this literature review is not exhaustive, its intention is to highlight the main findings together with a discussion of the strengths and weaknesses of the principal empirical investigations in this area. The remainder of the section is structured as follows. The review will initially concentrate on the pricing of stock index futures contracts traded in the US, and then subsequently on the pricing of non-US stock index futures contracts.

2.31) PRICING OF INDEX FUTURES IN US MARKETS

Cornell and French (1983a) compared the actual and predicted prices for the S&P 500 and NYSE Composite index futures contracts for selected days over the period June to September 1982. Cornell and French found that the no-arbitrage model generally over predicted the actual futures price, leading to the futures price trading at a discount to its theoretical value. Cornell and French suggested that this discrepancy could possibly be attributed to a "tax timing" option which arises from differential tax treatment in both stock and futures markets. As a consequence the equilibrium price of the index futures contract may be below the predicted fair value by an amount equal to the value of the tax timing option.

Modest and Sundaresan (1983) investigated the potential for stock index arbitrage for S&P 500 stock index futures contracts using daily data over the period April to December 1982. Modest and Sundaresan found that the futures price violated the limits of the arbitrage window by trading at a discount to the theoretical futures price. Modest and Sundaresan accounted for this discount by arguing that arbitrageurs selling short seldom obtain full use of the proceeds of their short sales. The short seller must pay dividends on the shares borrowed and if the proceeds are not available for investment in the money market, then a long futures arbitrage position is only profitable where the futures price trades at a discount which is in excess of the dividend yield on the underlying index portfolio.

Figlewski (1984a) investigated deviations from the no-arbitrage condition for the S&P index futures contract, using daily data for the period encompassing June 1982 to September 1983. Figlewski found that in the period immediately following the onset of trading in this contract the index futures contract was significantly underpriced. However, in later periods deviations from the theoretical value were greatly reduced, implying that as the market developed it simultaneously became more efficient. Figleski argued that "noise" was the primary cause of any mispricing, and as the market matured approximately 70% of any arbitrage opportunity was eliminated within a day

Figlewski (1984b) used daily data for the period 1 June 1982 to 30 December 1982 and found that both the NYSE composite and S&P 500 index futures contracts were significantly underpriced. Discounts on the NYSE composite index futures were larger than those on the S&P 500 index futures, and the deferred contracts were more underpriced than the nearby contracts. Figlewski rejected both the short selling and tax timing option arguments as explanations for the observed discounts because even when considered together they appeared insufficient to account for the magnitude of the observed mispricing. Rather Figlewski attributed the existence of early index futures discounts to a temporary disequilibrium caused by a lack of knowledge and experience amongst investors regarding the workings of these markets, which resulted in a reluctance to trade. Figlewski suggested that as investors acquired greater familiarity with the way index futures markets operate:

> "Futures discounts should diminish and, finally, all but disappear as large investors begin to integrate stock index futures into their overall equity investment programs" (1984b, p. 47).

Mackinlay and Ramaswamy (1988) employed transactions data on the S&P 500 index futures contract at quarter hour intervals, together with stock index quotes, over the period April 1982 to June 1987 in order to investigate the pricing behaviour of index futures prices, together with the extent to which they deviate from their fair values. Specifically, Mackinlay and Ramaswamy were concerned with whether mispricing increased on average with maturity, and whether mispricing was path dependent. Mackinlay and Ramaswamy reported the following findings. Firstly, when investigating the extent to which non-synchronous (or stale) prices were a problem in index quotes Mackinlay and Ramaswamy found that this problem can be alleviated by using differencing intervals of a longer duration. Even so, whenever the autocorrelation in the index series was high, the futures series also appeared to be characterised by high autocorrelation, which led Mackinlay and Ramaswamy to conclude that issues other than just stale prices accounted for the autocorrelation. Secondly, the variability of futures price changes exceeded the price changes in the underlying index, even after controlling for non-synchronous prices in index quotes. Mackinlay and Ramaswamy suggested that this indicated that information was incorporated into the futures market more rapidly than the spot market. Thirdly, using a linear theoretical framework Mackinlay and Ramaswamy found that the magnitude of the average absolute mispricing fell as maturity approached. This finding was consistent with the view that as maturity approached arbitrage risk arising from dividend and interest rate uncertainty fell. Furthermore, pricing errors were found to have declined over time, indicating that the market had become more efficient as it had matured. Finally, the issue of path dependence in the mispricing series was investigated. Path dependence in the mispricing series was found to have arisen because once the no-arbitrage window had been violated in one direction, the arbitrageurs' option to unwind early ought to preclude significant mispricing in the opposite direction. Mackinlay and Ramaswamy found that each individual contract was generally dominated by either upper or lower bound deviations. Thus:

> "The evidence is consistent with the notion that the arbitrageurs' option to unwind prematurely introduces path dependence into the mispricing series" (1988, p. 156).

Saunders and Mahajan (1988) proposed an arbitrage model of index futures pricing based on the familiar CAPM framework which related to the returns on an index portfolio. The CAPM based model was used to test for any mispricing by regressing the futures adjusted returns against the spot index returns, where the alpha and beta parameters test for both significant unsystematic and systematic inefficiencies respectively. Saunders and Mahajan investigated the pricing efficiency of both the NYSE index futures contract and the S&P 500 index futures contract using daily data over the period October 1 1982 to September 1984. The sample period was split into 8 quarterly sub-periods with 4 different contract maturities being considered at the beginning of each sub-period - 3 months, 6 months, 9 months and one year respectively.

Saunders and Mahajan found that for the NYSE index futures contract the hypothesis that the beta coefficient equals unity was rejected only for the first two sub-periods and accepted for the subsequent six sub-periods. The results for the S&P 500 index futures contract were very similar. Over the sample period betas for both contracts declined and were insignificantly different from one from June 1983 onwards. Saunders and Mahajan's evidence supported the efficiency of futures markets finding that as the market matures price discrepancies have shrunk. Furthermore, no systematic relationship was observed to exist between the parameter estimates and the length of time to maturity of the different contracts, suggesting that efficient arbitrage pricing was common to all contracts of different maturity.

Swinnerton, Curcio and Bennett (1988) empirically examined whether deviations from the no-arbitrage condition which trigger index arbitrage contained any information which could be used to predict subsequent intraday price movements in the underlying market index. Using minute by minute data for the Major Market Index (MMI) futures contract over the period March to December 1986, Swinnerton et al found that futures price deviations were only modest indicators of subsequent intraday movements in the underlying index. They found that positive deviations provide stronger indicators of subsequent price changes than negative deviations, arguing that this reflected the Uptick rule which restricted short sales and impeded the operation of the undervaluation strategy. Swinnerton et al found that while deviations with a lead time of five minutes provided the best prediction of future cash index movements, futures mispricing retained some predictive ability for up to a thirty minute lead time.

Merrick (1989) explored the profitability of the early unwinding option associated with arbitrage positions, by employing daily data on the first sixteen S&P 500 index futures contracts, over the period 17 May 1982 to 21 March 1986. Merrick found that mispricing reversals occurred frequently within the data and this suggested that arbitrage strategies that included an option to unwind early should prove profitable.

Merrick assumed that an arbitrage position would be undertaken as soon as the transaction cost limits of the no-arbitrage window were violated, and that the arbitrageur would subsequently unwind that position on the first profitable occasion. On the basis of this trading rule Merrick found that the early unwinding option was exercised on 99.5% of occasions, with the duration over which the arbitrage position was held ranging from 4.6 days to 25.2 days. The profits accruing from the early unwinding option were found to constitute 34% of total profits. However, the major flaw with unwinding a position as soon as it became profitable to do so was that the arbitrageur would lose the opportunity to exploit an even more profitable mispricing reversal at some point in the future. Consequently, Merrick amended his trading rule to unwind a position only if the resulting profit was at least one index point. Following this revised trading rule Merrick found that the early unwinding option was exercised on only 36% of occasions, and that in the case of nine of the sixteen contracts all of the trades were held to maturity. Given the more restrictive trading rule, the average duration over which the arbitrage position was held increased, ranging from 14 to 57.3 days and the profits arising from the early unwinding option rose to 44% of total profits. The profits associated with the early unwinding option had risen by 51% following the introduction of the second trading rule, even though the number of potential unwinding opportunities had fallen by 63%. Furthermore, the early unwinding option led to transaction costs discounts on the arbitrage transaction of 27%.

Merrick also considered the contribution that the options to unwind may have on any subsequent expiration day price movements. Merrick argued that it may be possible to predict expiration day price movements by examining the history of arbitrage opportunities prior to the contract maturity date. The contract's mispricing history should serve as a useful indicator of the net accumulated cash position of arbitrageurs. For instance, where the contract had been characterised by net overpricing, arbitrageurs would be associated with an accumulated net long cash position, which would suggest a fall in the cash price at maturity. Alternatively, where the contract had been characterised by net underpricing, arbitrageurs would be associated with accumulated net short cash positions which would suggest a rise in the stock price at maturity. However, this rule correctly predicted only 38% of the expiration date price movements over the sample period.

Brennan and Schwartz (1990) utilised the mispricing series calculated by Mackinlay and Ramaswammy (1988) for the S&P 500 index, to determine the optimal arbitrage strategy for a trader who was subject to both transaction costs and position limits. They demonstrated that the imposition of position limits increased the value of the arbitrageurs option to unwind early. Brennan and Schwartz (1990) examined the profitability of the early unwinding arbitrage strategy and found that where unprofitable arbitrage positions were initiated on the expectation of a subsequent profitable mispricing reversal, this produced an average profit of one index point per contract.

Bhatt and Cakici (1990) working with daily data on the S&P 500 investigated potential arbitrage opportunities over the period April 21 1982 through to June 19 1987. Closing prices on the nearest to maturity contract and next nearest to maturity contract were examined. Specifically, Bhatt and Cakici considered whether the mispricing series was significantly different from zero. It was found over the sample period that the near contract was characterised by a premium of 0.2% and the next nearest to maturity contract by a premium of 0.42%. These finding are in contrast to earlier studies which found that the S&P 500 index futures contract had been trading at a discount. It was suggested that this may have reflected a risk adjusted return to the arbitrageur. The incidence and size of any mispricing was found to be greatest for the contract furthest from maturity. Even so, mispricing generally fell for both maturity contracts over the sample period, supporting the argument that as a market matures traders become more informed leading to more efficient pricing. Finally, Bhatt and Cakici found that the mispricing series for both maturity contracts were systematically related to the accumulated dividend payment and the length of time to maturity rather than being stochastic over time as had been suggested by Brennan and Schwartz (1990).

Habeeb, Hill and Rzad (1991) investigated the potential for maximising index arbitrage profitability through the adoption of optimal entry and exit rules. Habeeb et al explored the potential returns available to arbitrageurs who adopted a path dependent trading strategy after taking account of entry and exit costs. Habeeb et al employed data on the S&P 500 index futures contract at five minute intervals over the period December 21 1987 to June 15 1990. Arbitrage was initially triggered when any mispricing exceeded the entry rule for two consecutive observations and the resulting arbitrage position was unwound early when the subsequent mispricing reversal satisfied some predetermined exit rule. Clearly any arbitrageur who was prepared to exploit both limits of the arbitrage window improved their arbitrage profitability. A variety of entry and exit rules were examined and arbitrage was found to be most profitable when the arbitrageur required an entry inducement of 0.9 to 0.8 index points and exit inducement of 0.2 to 0.4 index points. Habeeb et al concluded that:

> "Much of the art of stock index arbitrage involves the skill with which different traders or portfolio managers can assess different market environments and adjust the entry and exit levels accordingly" (1991, pp. 184 - 5).

Chung (1991) examined the pricing efficiency of the Major Market Index futures contract and the profitability of index arbitrage. Chung used transactions data over the period June 24 1984 to August 31 1986 and calculated mispricing on a second by second basis. The fair pricing formula was adapted to accommodate transactions costs for different classes of traders, various execution lags and the Uptick rule. The evidence suggested that the frequency of any mispricing had declined dramatically as the market had matured. For instance, in 1986 arbitrage was triggered in only 1% of cases for the most unfavourably placed trader and in only 9% of cases for the most favourably placed trader. It was suggested that previous studies had overstated the frequency of arbitrage violations by using the reported index rather than transactions data.

Chung argued that the profitability of index arbitrage had been exaggerated because other studies have focused on ex post rather than ex ante tests, neglecting the issue of execution risk. Chung suggested that:

> "What appears ex post as a riskless profit opportunity is not necessarily a real ex ante exploitable profit opportunity because there is no guarantee that the prices at the next available transaction will still be favourable for the arbitrageur" (1991, p. 1792).

Allowance was made for the presence of execution risk by assuming alternative execution lags of twenty seconds, two minutes and five minutes. Chung's findings demonstrated that ex ante profits are not riskless and that as the length of the execution lag increased so did the probability of the arbitrageur incurring a realised loss. Thus Chung concluded that the size of the ex post mispricing often represented a poor indicator of the ex ante profitability of index arbitrage.

Klemkosky and Lee (1991) employed a fair value pricing formula modified to account for the effects of differential transactions costs, marking to market and taxation. Using transactions data at ten minute intervals they evaluated the profitability of index arbitrage for the near S&P 500 contract for a variety of arbitrageurs over the period March 18 1983 to December 17 1987. Klemkosky and Lee produced a no-arbitrage condition which was a function of the market position and tax status of the relevant arbitrageur. It was found that the no-arbitrage condition was violated on 42% of occasions for the most favoured arbitrageurs, and on 5% of occasions for the least favoured arbitrageurs. The frequency and extent of overpricing was found to be much greater than that for underpricing. However, the inclusion of taxation into the fair value assessment was found to reduce mispricing considerably - by 43% for member firms and 61% for institutional investors.

Klemkosky and Lee found that mispricing was a positive function of the length of time to maturity, with the frequency and size of mispricing being significantly less on expiration days than on non-expiration days. Consistent with the evidence provided by Chung (1991), Klemkosky and Lee found that an execution lag reduced the profitability of index arbitrage considerably. Even so, arbitrage remained profitable for all arbitrage classes for a period of ten minutes after the initial arbitrage trigger.

Sofianos (1993) examined the profitability, timing and riskiness of index arbitrage for the S&P 500 index futures contract, using a unique data set based on Daily Programme Trading (DPT) reports provided by the NYSE member firms. Sofianos considered 2,659 S&P 500 index arbitrage trades over the period January 15 1990 to July 13 1990. The mispricing series was calculated from transactions data on a minute by minute basis. Sofianos found that profitable arbitrage opportunities were short lived, lasting on average about three minutes, with arbitrage transactions often being initiated when the mispricing series was within the limits of the arbitrage window. Unsurprisingly 70% of arbitrage positions were unwound early following a profitable mispricing reversal. When allowance was made for modest transactions costs there were eleven arbitrage opportunities per day. The sample was characterised by 175 profitable mispricing reversals, an average of one reversal a day. However, some reversals occurred within four minutes, while others took as long as eight days. Sofianos argued that arbitrage transactions were riskier than had previously been suggested because of the practice of "legging" whereby stock and futures transactions are not initiated simultaneously. Of the arbitrage transactions considered 37% were characterised by legging. Tracking risk was also found to be significant with the average number of stocks in the cash leg of the arbitrage transaction being only 280, though 8% of arbitrage trades were established with less than seventy stocks. This practice of using a surrogate basket to initiate the stock side of an arbitrage transaction was found to be marginally more profitable but considerably riskier.

2.32) PRICING OF INDEX FUTURES IN NON-U.S. MARKETS

Bowers and Twite (1985) examined index arbitrage opportunities on a daily basis for the Australian All Ordinaries index futures contract over the period February 16 1983 to December 27 1984. Bowers and Twite partitioned their data set into three distinct sub-periods. In the initial sub-period, consistent with studies in the US, the Australian All Ordinaries index futures contract was found to trade at a discount to its theoretical value. During the intermediate period, ranging from April 1983 to January 1984, while arbitrage opportunities remained, the sign of the deviation switched, with the index futures contract trading at a premium. While in the final period the index futures contract once again reverted to trading at a discount, there was evidence to suggest that investors were exploiting arbitrage opportunities more rapidly than had previously been the case, reflecting the greater experience of market participants in the later period.

Brenner, Subrahmanyan and Uno (henceforth BSU (1989a)) examined the arbitrage relationship between the price of the Nikkei Stock Average (NSA) index traded on the Tokyo stock exchange and the price of the NSA index futures contract traded on the Singapore International Monetary Exchange (SIMEX). BSU employed daily closing prices over the period September 3 1986 to June 7 1988. Consistent with results for the US, deviations of actual futures prices from theoretical prices tended to be large with actual prices generally lower than theoretical prices. Negative deviations were observed on 75.1% of occasions and positive deviations were observed on 24.9% of occasions. Mean negative deviations were found to be three times the size of mean positive deviations.

Many of the deviations from fair value were too large to be explained purely by transaction costs, and BSU considered the possibility of profitable arbitrage after allowing for transactions costs of 1% and 2%. At the 1% transactions cost level, arbitrage was found to be profitable on 41.4% of occasions, of which 91.2% represented underpricing opportunities and 8.8% represented overpricing opportunities. While at the 2% transactions cost level profitable arbitrage opportunities were found to have arisen on only 17.6% of occasions, of which 97.4% represented underpricing opportunities and 2.6% represented overpricing opportunities.

The dominance of negative mispricing was largely accounted for by specific trading restrictions which constrained the arbitrageurs ability to sell stocks short as part of a long futures arbitrage strategy. However, as BSU pointed out the magnitude of mispricing does decrease in size over time, and:

> "Possible explanations for this secular decline in mispricing include the relaxation of legal restrictions on certain investors, creation of better institutional arrangements for short sales, and greater awareness of the possibilities for substitution between stocks and futures contracts" (1989a, p. 381).

While the magnitude of mispricing was found to decline over time, there was a tendency for mispricing to be characterised by persistence, whereby positive or negative mispricing remained positive or negative for several days. Autocorrelation coefficients for all contracts were found to be significant for four days.

Brenner, Subrahmanyan and Uno (1989b) examined deviations from the no arbitrage condition for two Japanese index futures contracts. The pricing efficiency of both the Nikkei Stock Average index futures contract traded on SIMEX and the Osaka Stock Futures 50 (OSF 50) index futures contract traded on the Osaka Securities Exchange (OSE) were considered using daily data over the period June 9 1987 to June 1988. After allowances were made for 1% transactions costs BSU found that the majority of arbitrage opportunities could be profitably exploited. For the OSF 50 contract the mispricing series was overpriced on 56.6% of occasions, of which 68.8% of these opportunities could be profitably exploited, and underpriced on 43.4% of occasions, of which 59.3% of these opportunities could be profitably exploited. For the NSA contract the mispricing series was overpriced on 19.5% of occasions, of which only 11.8% of the overpricing could be profitably exploited, and underpriced on 80.5% of occasions, of which 52.1% of the underpricing could be profitably exploited. Mispricing for both contracts was found to be persistent, and evidence from autocorrelation coefficients suggested that the series were characterised by a strong path dependence.

Yadav and Pope (1990) investigated the pricing efficiency and potential for index arbitrage on the FTSE 100 index futures contract traded on LIFFE. Yadav and Pope employed daily opening and closing prices for the sixteen contracts over the period July 1 1984 to June 30 1988. The data set was partitioned into two sub-samples to evaluate the effects of the financial deregulation which ensued the Big Bang on October 27 1986.

Consistent with studies in the US, Yadav and Pope found that the forward pricing cost of carry model provided a downward biased estimate of actual futures prices. The mispricing series for the near contract indicated that mispricing for the whole sample was large and persistent with the fair value formula frequently being violated. In the pre-Big Bang period the futures price traded at a systematic discount from its theoretical value. Post Big Bang mispricings were still large with the market dominated by frequent mispricing reversals. In the pre-Big Bang period, the market was underpriced on 80% of occasions and overpriced on only 20% of occasions. While in the post-Big Bang period, the market was underpriced on 59% of occasions and overpriced on 41% of occasions. The fact that the chronic discount which characterised the early part of the sample gradually disappeared and resulted in more efficient pricing was according to Yadav and Pope, evidence of both the market maturing and the simultaneous growth in the arbitrage sector.

Yadav and Pope examined mispricing for the next nearest to maturity contract for the four weeks prior to the expiration of the near contract. The absolute magnitude of mispricing for the second nearest to maturity contract was considerably larger than the near contract. Although like the near contract the next nearest to maturity contract was found to be trading at a discount in the pre-Big Bang period and a premium in the post Big Bang period.

Given the evidence of potentially profitable arbitrage opportunities Yadav and Pope attempted to simulate the profitability of the market by using a number of simple trading rules on an ex post and ex ante basis. It was found that significant arbitrage profits could have been generated using these various rules. Consistent with the findings of Merrick (1989), additional profits arising from the unwinding options were found to represent a significant proportion of total profits. Interestingly, prior to Big Bang the additional potential profit was due mainly to delayed unwindings, while post Big Bang most of the additional profit resulted from the early unwinding option. Yadav and Pope found that even when allowing for the most restrictive trading conditions 70% of positions were closed out prior to expiration. According to Yadav and Pope the fact that positions tended to be closed out before maturity indicated that:

> "arbitrage related programme trading may not carry a significant risk of expiration day price, volume and volatility effects on underlying stocks" (1990, p. 594)

Finally, Yadav and Pope found that the absolute size of any mispricing was related to the length of time to maturity. The absolute size of any mispricing decreased as the maturity date approached.

Strickland and Xu (1992) working with hourly data for the period January 4 1988 to December 29 1989 examined the time series properties of the mispricing series for the FTSE 100 index futures contract. Strickland and Xu employed data on both the near contract and the next nearest to maturity contract. They found that for the near contract the futures market was consistently more volatile than the cash market and that frequent arbitrage opportunities prevailed. There was a tendency for mispricing to be negative and persistent. The average mispricing for the entire sample was -0.468% which was comparable to the figure of -0.4% of Yadav and Pope (1990). The mispricing series was generally found to remain within the transactions cost limits of +0.5% and -1.5%. This finding was consistent with the view that when the futures price deviated towards its transaction costs limits arbitrageurs intervened to pull it back towards fair value. However, the absolute size of mispricing is significantly larger for the far contract than the near contract, with a greater number of negative mispricings and less mispricing reversals.

Strickland and Xu examined the profitability of delayed and early unwinding options. A delayed unwinding strategy depended on the relative mispricing between the near and next nearest to maturity contracts. Overall, the absolute values of mispricing are considerably larger for the far contract than the near contract, with the far contract being more underpriced than the near contract. The delayed and early unwinding options were found to be very profitable, and the larger were the transactions costs limits the greater was the contribution that these strategies made to total arbitrage profits. Strickland and Xu also found that the mispricing series was not random but systematically related to the length of time to maturity and accumulated dividend payment. Furthermore, an AR(2) process proved to be a close approximation for the mispricing series, and parameter estimates suggested that the series was stable over time.

Stulz, Wasserfallen and Stucki (1990) considered the pricing efficiency of the Swiss Market Index (SMI) futures contract, an over the counter market composed of Switzerland's twenty four most actively traded shares. This market was interesting because contract expiration occurs only twice a year and compared to other well established futures contracts, the market was characterised by limited liquidity. The sample consisted of SMI daily closing prices extending over the period January 23 1989 to October 20 1989. Stulz et al found that the SMI futures contract was very efficiently priced, with mispricing errors generally being found to lie within transaction cost limits. The largest mispricing of 1.3% was only marginally in excess of transaction costs, and Stulz et al concluded that given the low liquidity and market impact costs that arise from large trades, such opportunities are unlikely to prove profitable.

Ho, Fang and Woo (1992) used minute by minute transactions data to investigate the incidence of arbitrage opportunities on the Hang Seng index futures contract for different maturity contracts on seventeen randomly selected trading days over the period April to July 1991. Ho, Fang and Woo found that arbitrage opportunities were less common than had been suggested by studies using daily data, with 69% of observations being efficiently priced. Where the futures price was found to deviate from its no arbitrage limits it was overpriced on 89% of occasions and underpriced on just 11% of occasions. The high incidence of overpricing resulted from execution problems which were common to the Hong Kong trading system.

Lim (1992b) suggested that previous studies which have investigated index arbitrage in Japanese markets using daily closing prices have been subject to the execution impossibility problem resulting from non-synchronous prices and have overstated the profitability of index arbitrage in these markets. Lim focused on the four contracts: June 1988, September 1988, June 1989 and September 1989 and employed transaction data at five minute intervals for the NSA contract traded on SIMEX for five randomly selected days for each contract. Lim found that mispricing was less common than had been suggested by Brenner, Subrahmanyan and Uno (1989a and 1989b), with the mispricing series fluctuating within the range -1.2 to +1.2% from fair value. Given the relatively tight limits within which the futures mispricing series was held, arbitrage opportunities were found only to be available to well placed market makers. Lim argued that these significantly different conclusions were due to differences in data frequency. Having determined that arbitrage opportunities were rather rare, Lim examined the statistical behaviour of the mispricing series when it lies within the arbitrage window. It was found that many of the statistical properties characterising the relationship between spot and futures prices in US markets - i.e. stale pricing, relative volatility, lagged prices - were not evident in this market.

Lim and Muthuswamy (1993) investigated the potential for index arbitrage on the NSA contract using a modified cost of carry model which allowed for the effect of taxation and provided a more detailed specification of transactions costs. This study extended the data set of Lim (1992b), by employing transactions data at five minute intervals on five randomly selected days for the June 1988, September 1988, September 1989 and March 1991 contracts. Lim and Muthuswamy's results were largely consistent with those of Lim (1992b) with arbitrage opportunities over this period rare. It was suggested that an increase in uncertainty which arose from changes in the market's composition led to greater volatility in spot and futures prices, resulting in a widening of the limits of the no-arbitrage condition. Furthermore, Lim and Muthuswamy found that even if arbitrage opportunities had occurred, it would have been difficult to realise any profits owing to execution lags.

Grunbichler and Callaghan (1994) examined the pricing efficiency of the nearest to maturity DAX index futures contract using transactions data at five and fifteen minute intervals over the period December 1990 to September 1991. Grunbichler and Callahan found that for 90% of the intervals examined the DAX index futures contract traded at a discount. The average level of underpricing was below 0.5% and the majority of overpricing below 1%. After allowance had been made for transactions costs it was doubtful whether any arbitrage opportunities could have been profitably exploited. The tendency for the near DAX index futures contract to be fairly priced was attributed to the unique institutional and market characteristics in the German futures market, such as screen trading and the restrictions on short selling.

Buhler and Kempf (1995) examined the profitability of index arbitrage for the DAX index futures contract for contracts of differing maturities using minute by minute transactions data for the period November 23 1990 to December 17 1992. Buhler and Kempf found that the prices predicted by the cost of carry model did not provide a very close approximation of actual futures prices, and all the relevant futures irrespective of maturity were characterised by significant average underpricing within the range -0.46% to -1.18%. The further the contract was from the expiration date the more underpriced it was found to be. As the futures contract became the near contract mispricing approached zero, reflecting the increase in trading activity.

Buhler and Kempf assumed (after extensive discussions with market participants) that an arbitrageur required an additional risk premium of 0.25% of the index value - in excess of normal transaction costs - before engaging in index arbitrage. Given these wider arbitrage bounds, over the entire sample period arbitrage was triggered on 26.65% of the occasions when the futures contract was underpriced, compared with only 0.163% of the occasions when the futures contract was overpriced.

An examination of the ex ante profitability of these arbitrage triggers found that all long futures arbitrage opportunities were profitable if executed within one minute of the mispricing being identified. Even after allowing for an execution lag of fifteen minutes over 90% of arbitrage opportunities remained profitable. Buhler and Kempf argued that their ex ante arbitrage strategy was considerably more profitable that that reported by Chung (1991) for the US because he took no account of the premium required by arbitrageurs.

2.33) SUMMARY AND IMPLICATIONS

Stock index futures prices have been found to trade at sizeable and sustained deviations from the theoretical values predicted by the cost of carry model, giving rise to profitable arbitrage opportunities. With respect to this review of the empirical literature regarding the related issues of the pricing efficiency of futures contracts and index arbitrage, a number of important points can be highlighted. Firstly, the standard cost of carry forward pricing formula tended to be misspecified leading to biased estimates of the actual futures price. Attempts were made to correct this problem by allowing for the effects of marking to market, differential transaction costs and taxation. Secondly, a large number of the index futures contracts both in the US and elsewhere were characterised by chronic underpricing relative to fair value in the early stages of their trading life. Various explanations were espoused to account for this phenomenon such as a tax timing option and short selling difficulties. However, the suggestion that the market was in a state of "fundamental disequilibrium" owing to the inexperience and lack of knowledge of the relevant traders appears more tenable, especially as the discounts often disappeared in a subsequent period. This indicated that as the market matured pricing inefficiencies have shrunk. Even so, there was evidence to suggest that rather than futures markets being characterised by a steady improvement in efficiency, pricing efficiency fluctuated over time. Thirdly, while the simple buy and hold to maturity strategy was found to provide limited arbitrage opportunities, arbitrage capital constraints and frequent mispricing reversals have given rise to early and delayed unwinding options. These options offered significant transactions costs discounts, and were found to have made an important contribution to overall arbitrage profits, resulting in arbitrage being undertaken while the mispricing series was still within the bounds dictated by the no-arbitrage condition. The tendency for arbitrageurs to exercise the early and delayed unwindings options led to the mispricing series often being characterised by path dependence. Fourthly, the mispricing series was found to be systematically related to accumulated dividend payments and the length of time to maturity. The size and frequency of mispricing was found to fall as the maturity date approached. This finding was consistent with profitability of the delayed unwinding option. In summary, arbitrage was found to be much more complicated in practice than suggested in theory, once execution risk, tracking risk and restrictions to short selling have been accounted for.

In the UK, stock index arbitrage strategies are considerably more difficult to implement than in other markets owing to specific technical and stuctural features which impede trading in equity and index futures markets. In spite of these difficulties, index arbitrage has been positively encouraged in London (ISE (1987)) due to concern over the large pricing differences which exist between spot and futures markets. While research into the pricing efficiency of the FTSE 100 contract relative to the underlying index has been conducted both on a daily and intra-daily basis, to date no research has been undertaken investigating the pricing efficiency of the Mid 250 contract or the potential for index arbitrage within this market. If the Mid 250 contract is to effectively function as an efficient means of risk transfer for lower capitalisation UK stocks then it is important that it be priced according to fair value. However, owing to thin trading in this contract and the illiquid nature of many of its market constituents, there are strong reasons to believe that the Mid 250 contract is likely to be mispriced. While deviations from fair value usually signal the presence of an arbitrage opportunity, the trading impediments which exist in the UK together with the infrequent trading of stocks make index arbitrage extremely difficult in the Mid 250 market. In chapter five, the pricing efficiency and the potential for arbitrage is investigated for both the FTSE 100 and Mid 250 contracts.

2.4) PRICING OF INTRAMARKET AND INTERMARKET SPREADS

The review of literature relevant to chapter five indicates that futures mispricing is an important component of the return on a futures contract, which has relevance for the earlier investigations relating to hedging effectiveness. An alternative test of futures pricing efficiency involves examining spread trading, which by enabling futures traders to allocate risk amongst themselves provides additional hedging opportunities, and contributes to the discussion on the '*economics of arbitrage'*. While much speculative activity in financial futures markets is conducted by the trading of spreads, the price behaviour of spreads has received little attention in the academic literature. This is surprising given that considerable research has been conducted into the pricing of futures contracts relative to their underlying spot instruments; and compared to arbitrage, spread trades tend to be easier and less expensive to execute. Spread trading involves taking both long and short positions in two different but economically related futures contracts in order to profit from pricing relationships that are believed to be temporary.

While this review of the literature is not exhaustive, its purpose is to highlight the range and diversity of spread trading relationships which have been investigated, together with their relative strengths and weaknesses. It will be shown that as a trading strategy, spreading provides essential liquidity to distant contract months, and in doing so underpins the viability of the futures market. The remainder of this section is structured as follows. This review will firstly consider spread trading relationships focusing on traditional agricultural and metallic futures markets, and will then subsequently examine spread trading relationships relevant to financial futures markets.

2.41) SPREAD TRADING IN TRADITIONAL FUTURES MARKETS

Ma (1985) examined the potential for profitable spread arbitrage between the gold and silver futures markets. The pricing relationship underpinning this model was based on the assumption that a short term equilibrium parity existed between the gold and silver markets, and that any deviation from this parity could be profitably exploited. Using daily gold and silver prices based on London fixing quotes over the period January 1972 to October 1984, Ma modelled historical realisations of the gold-silver spread using a moving average model. Employing alternative lag specifications of the moving average model, an ex ante equilibrium spread (parity) was generated and compared to the actual level of the spread parity. If the ex ante spread differed significantly from its current level, a spread was initiated. Ma found that by altering the widths of the confidence interval and the order of the moving average process, ex ante spread arbitrage profit opportunities existed on a daily basis. Although it was possible to make profits on the basis of this rule, excess returns were largely wiped out once allowances had been made for transaction costs.

Monroe and Cohn (1986) investigated the pricing efficiency of the gold futures market relative to the T-bill futures market by constructing an intermarket spread between the two markets. The rationale for this spread was that it was assumed that gold prices of different maturity should reflect some interest rate which was closely related to the T-bill rate. Therefore, gold futures prices should display a strongly defined relationship with the equilibrium T-bill futures price, and any deviation from this relationship was likely to constitute a spread arbitrage opportunity. Using intra-daily transaction data for the gold and T-bill markets from the CME over the period March 1976 to July 1982, Monroe and Cohn explored spread arbitrage opportunities for the three contracts closest to maturity.

Over the entire sample average returns per contract were not found to be sufficient to violate transaction cost limits, which provided evidence that average futures returns were in equilibrium. However, Monroe and Cohn tested the efficiency of the spread by employing a trading strategy based on a 60 day moving average of the difference between the implied gold and T-bill rate. Trades were initiated whenever the spread differential deviated from the moving average by more than one standard deviation. Two liquidating rules were evaluated. The first rule required that the established position be closed out on the next trading day, while the second rule required that the position be held until the spread difference was reversed or contract expiration was reached.

While both strategies generated positive returns, the returns associated with the first exit rule were not sufficient to cover the transaction costs of the typical trader. However, the reversal rule generated profits which were four to five times larger than the initial rule, easily violating transaction costs and providing evidence of market inefficiency. Furthermore, the contribution of the gold leg of the spread to overall returns was found to be consistently larger than the T-bill leg. A finding which is in part accounted for by the thinness of the gold futures market relative to the T-bill market.

Poitras (1987) examined the potential for profitable spread arbitrage using a "golden turtle" strategy which involved taking positions in both a gold intramarket spread and interest rate futures. The strategy involved comparing the implied carry return (ICR) on the gold futures spread with the associated Eurodollar and T-bill rates. For fundamental reasons the differential between the Eurodollar and T-bill rates was larger than the differential between the gold ICR's and Eurodollar rate. Consequently, the gold ICR was weakly bounded from below by the T-bill rate and weakly bounded from above by the Eurodollar rate. Using daily settlement prices for gold futures (COMEX), T-bill and Eurodollar futures (IMM) for the 15 months prior to maturity, over the period April 1982 to March 1985, Poitras devised a trading rule based on the relationship between the three rates. For instance, whenever the gold ICR came within a predetermined number of basis points of either the Eurodollar or T-bill rates, a golden turtle trade was initiated, and was subsequently liquidated when the gold ICR came within a predetermined number of basis points of the other boundary.

The profitability of the golden turtle trading rule depended crucially on the arbitrage triggers adopted, which were calculated as a percentage of the size of the T-bill - Eurodollar differential. Poitras tested both the 25% and 35% triggers. Trades based on the 25% trigger ranged from 2-13 months, with an average of 6.5 months per trade. While trades based on the 35% trigger ranged from 0.25 to 9.5 month, with an average of 2.5 months. Overall this strategy was found to be both profitable and relatively riskless, with only 3 from 38 trades generating losses.

Carter (1989) examined the potential for profitable spread trading opportunities between thin and liquid futures markets for substitutable commodities. This issue is of interest because illiquid markets are likely to be less efficient and characterised by greater price variability. Although some difference in the amount of price variability between the two markets was expected, arbitrage should limit the size of the spreads. This hypothesis was tested by spreading three liquid US contracts against three illiquid Canadian contracts. The spreads investigated were the US long term government bond - Canadian long term government bond spread, the US corn - Canadian barley spread, and the US soyabean - Canadian rapeseed spread. Daily opening and settlement prices were obtained for all six nearby contracts over the period January 1980 to August 1987, from the Chicago Board of Trade, the Winnipeg Commodity Exchange and the Toronto Commodity Exchange.

With respect to the three spread positions, Carter devised a trading rule based on the assumption that the spread price differential was a random variable with a normal distribution, and hence it was possible to calculate the expected size of the spread based on past historical information. Large deviations from this mean value were perceived as profitable spread opportunities, and the trading rule was devised to capture these large price variations. Using this approach, Carter employed samples of 50 and 30 observations to compute Z values, and spread positions were initiated whenever, the absolute Z value was greater than 2.5 (i.e. the expected probability of occurrence was less than 1%) and the position was reversed by an hypothetical liquidating trade whenever the absolute Z value was less than 1.

Overall, the results indicated that only the long term government bond spread proved profitable, with the corn-barley spread and the soyabean-rapeseed spread resulting in small average losses. Carter argued that these losses indicated an absence of arbitrage opportunities between the respective legs of the spreads, and the conclusion that barley and rapeseed markets were as efficient as the corn and soyabean markets cannot be rejected.

Abken (1989) examined the potential profitability of the seasonal behaviour of intramarket heating oil spreads. Using monthly data on the No. 2 heating oil futures contract traded on NYMEX over the period January 1980 to December 1987, Abken found that spread returns tended to narrow and become increasingly negative during winter months when the heating oil futures price structure became characterised by backwardation. Therefore, Abken argued that potential profits existed from exploiting the subsequent reversion in seasonal spread prices.

By seasonally partitioning the sample into summer and winter periods, Abken computed the monthly returns accruing from a long or bull spread. It was found that while average returns on the spread during the winter season were large and significantly positive, returns during the summer season were small and often insignificant. Abken suggested that seasonal variations in the margin requirements led to a reluctance on the part of traders to commit capital, and that the inadequacy of speculative capital during winter months was the most likely cause of this spread return anomaly.

Johnson, Zulauf, Irwin and Gerlow (1991) examined the soy complex crush margin to test for speculative opportunities in the crush spread. This intermarket spread involved taking simultaneous positions in the soybean, soyoil and soymeal futures markets. The net processing (or crushing) margin for the soyabean complex was the difference between, the sum of the soybean and soyoil futures price, and the soybean futures price, minus the cost of crushing. An implied crushing margin of zero was consistent with zero arbitrage profits. A positive margin indicated a normal soybean crush position (long soybeans, short soymeal, short soyoil) should be initiated because profits were expected from processing soybeans. While a negative margin indicated a reverse crush position (short soybeans, long soymeal, long soyoil) should be initiated because processing losses were expected. The profitability of this strategy was tested on an ex ante basis over the period January 1966 to November 1988, using data from Dunn and Hargitt Incorporated, a commercial supplier of futures data.

Johnson et al initiated five hypothetical soy complex trades on a monthly basis, with the trades being subsequently liquidated 9.5, 7.5, 5.5, 3.5 and 1.5 months later, with positions having been taken in the contracts maturing closest to the liquidation date. Over the entire sample period, Johnson et al found that average returns net of transaction costs were positive only for positions held in excess of 5.5 months, with trades being held for less than 5.5 months being characterised by average losses. Therefore, while there was minimal evidence of profit opportunities for spread trading the nearby contracts, profit opportunities existed for trades of distant contracts. Furthermore, the reverse crush trade produced larger average profit and generated profits more frequently than the normal crush trade. Finally, when the sample was partitioned into two-equal sub periods, trading profits were found to be more prevalent in the latter period suggesting inefficiencies had persisted.

Wahab, Cohn and Lashgari (1994) derived a simple no-arbitrage model to estimate the theoretical fair price for the gold-silver spread, to determine the profitability of trading in precious metals. The model represented a no-arbitrage cost of carry model for pricing forward contracts on storable commodities. Using daily spot and futures prices over the period January 1982 to July 1992, Wahab et al found that the spot and futures spread series were cointegrated, and by estimating an error correction model were able to generate forecasts of future spread changes. Where the model indicated a positive change, a long position in gold and a short position in silver was initiated. Conversely, where the model indicated a negative change, a short position in gold and a long position in silver were taken. It was found that trading profits which were positive on a pre-transaction cost basis, became losses once transaction costs were accounted for.

Barrett and Kolb (1996) investigated the pricing behaviour of a range of intramarket and intermarket agricultural spreads to determine whether predictable seasonal patterns in the prices of these commodities gave rise to profit opportunities. Using daily futures data collected from Dunn and Hargitt over the period 1960 to 1990, Barrett and Kolb tested the profitability of spreads consisting of corn, wheat, oat and soyabean futures both in calendar and contract time.

In determining whether agricultural spreads offer investors profitable opportunities, Barrett and Kolb considered whether the mean daily profit arising from each spread trade was significantly different from zero. For the spreads based on calendar time, only 15 of the 189 hypothetical intermarket trades and only 2 of the 150 hypothetical intra market spreads were significant at the 5% level. In addition, for the spreads based in contract time, only 2 of the 42 hypothetical intermarket spreads and 2 of the 35 hypothetical intra market spreads were significant at the 5% level. Barrett and Kolb argued that these results were not considerably different from what chance alone would predict, and did not constitute evidence of a regular seasonal pattern which would give rise to reliable speculative profits. In fact these results were supportive of the hypothesis of market efficiency.

2.42) SPREAD TRADING IN FINANCIAL FUTURES MARKETS

Easterwood and Senchak (1986) examined the profitability of the "turtle trade" which involved testing for spread opportunities between the T-bond and T-bill futures markets. The turtle trade suggested that at any point in time, the three month repurchase (or repo) rate implied by the intermarket T-bond spread comprising of adjacent futures delivery months should be equivalent to the three month T-bill futures rate for the equivalent time period. However, owing to market frictions the two rates had the potential to diverge, and on such occasions spread arbitrage opportunities were likely to exist. Easterwood and Senchak employed daily settlement prices relating to T-bonds and T-bill contracts over the period January 1979 to November 1983 to test the profitability of this strategy.

A hypothetical turtle trade was initiated whenever there was at least a 50 basis point difference between the price of the T-bond spread and the T-bill futures contract, which was then monitored until either of two liquidation conditions had been met. The established position was liquidated when either the absolute difference between the two rates became less than 20 basis points or the "first position day" of the delivery month was reached. This latter condition precluded the possibility of having to take delivery. Overall the strategy was found to realise an average loss of $72 per trade which was not statistically significant. However, individual trades were characterised by considerable variation with trade returns varying from $12,094 to -$11, 581, with a standard deviation of $3,736. Distinguishing between spread type, Easterwood and Senchak found that while bull spread combinations (long the bond spread and short the bill) realised a significant loss of $325 per trade, bear spread trades (short bond spread and long bill contract) realised an average gain of $622 per trade. On average, there was a tendency for bear turtle spreads initiated more than three months from contract maturity to be the most profitable strategy. However, such a strategy accounted for only 27% of all trades undertaken.

Rentzler (1986) studied turtle trades which involved predicting relative price movements between the T-bond spread and T-bill futures and purchasing the investment which offered the highest relative return and selling the investment which offered the lowest relative return. Although the turtle trade represented an arbitrage transaction it was not riskless given the presence of time and grade basis risk. Using daily settlement prices for the T-bond futures (CBT) and T-bill futures (IMM) over the period August 1977 to June 1983, Rentzler employed the 9 months of data before maturity to test the profitability of the trade. When it was considered that the two rates were significantly out of line, positions were taken which would prove profitable if the rates reverted to their recent equilibrium relationship. Where the implied repo rate was considered to be overpriced relative to the T-bill rate a bull turtle trade was initiated which involved a long T-bond spread position and short T-bill futures position. Alternatively, where the implied repo rate was considered to be underpriced relative to the T-bill rate a bear turtle trade was initiated which involved a short T-bond spread and a long T-bill futures position.

In designing the strategy for initiating trades, Rentzler decided that a deviation between the two rates was significant if it was more than k standard deviations from a m day moving average. Where k = 1.5, 2.0, 2.5 and m = 10, 15, 20. The position was then held until there was a significant deviation (measured in terms of k) in the opposite direction. At this point the trade was reversed with a bull (bear) spread becoming a bear (bull) spread. Over the entire sample the trading rule outlined produced consistently large profits even after adjustments had been made for transaction costs. Over two thirds of all trades proved profitable. Furthermore, the profits did not diminish over time and were found to be independent of market conditions, performing well in both bull and bear markets. While all combinations of k and m resulted in positive average profits, those initiated with larger values of k produced the largest average profits. Finally, when distinguishing between the relative positions of the turtle trade it was evident that when k = 2, profits are predominantly generated from bill trades, while when k = 1, profits are predominantly generated from the bond spread leg of the trade.

Billingsley and Chance (1988) provided the first examination of spread trading in the context of index futures markets, by testing the profitability of both intra and intermarket spreads. Using weekly data over the period April 1982 to January 1986, the performance of intramarket spreads comprising of the near and next nearest to maturity S&P 500 contracts and intermarket spreads comprising of the near S&P 500 contract and near NYSE contract were tested to see whether or not they were priced according to their theoretical no arbitrage levels. Both sophisticated spreads which involved undertaking offsetting positions in the respective equity markets, and simple spreads which were based on futures price levels were examined. The sample period was partitioned into sub-periods around September 1983 to detect for any changes in the spread pricing relationship.

With respect to the intramarket spread, over the entire sample period the average spread was found to be correctly priced, being insignificantly different from zero. However, the spread was priced at a significant discount in the earlier period and a significant premium afterwards. When examining spread mispricing on a weekly basis it was found that the spread mispricing violated its transaction cost limits on only 10% of occasions, which was considerably less than the transaction cost violations associated with each specific leg of the spread over the same period. On examining the performance of the simple intra market spread based on weekly futures returns, although the overall mean return was found to be insignificantly different from zero, the spread return did in fact violate transaction cost limits on 31% of occasions. However, the dilemma faced by spread traders was that on an ex ante basis they would not know which legs to buy and which to sell. Furthermore, the standard deviation estimates reported by Billingsley and Chance indicated that through holding an intramarket spread the underlying volatility associated with the individual legs could be reduced by over 90%.

When initiating an intermarket spread between the near S&P500 contract and the near NYSE contract allowance had to be made for the spread ratio applicable to the two legs. The overall mean spread value was found to be a significant 0.258%, indicating that the spread traded at an overall premium. Even so, while the average spread was overpriced on a weekly basis, the degree of mispricing was only sufficient to exceed transaction cost limits on one occasion. As for the simple spreads, the mean spread was positively priced but this was not significant. Finally, while over 50% of these spreads exceeded transaction cost, these opportunities could not be profitably exploited on an ex ante basis, because once again the trader would not know which legs to buy and which to sell.

Allen and Thurston (1988) investigated the wide price discrepancies which were observed between implied forward rates and the corresponding futures rates in the T-bill market. Using T-bill futures prices together with 7, 14, 21, 30 and 90 day term repo rates for the 16 contracts spanning the period December 1982 to September 1986, Allen and Thurston computed spread rates between forward and futures instruments. Their results showed that the differences between the forward and associated futures rate are strongly positive, and have a tendency to persist because financing rates are not low enough to allow traders to completely arbitrage a market without incurring considerable risk.

Yadav and Pope (1992b) examined the potential for intramarket spread trading on the FTSE 100 index futures contract, using intra daily data over the period April 1986 to March 1990. Yadav and Pope employed the forward pricing formula to determine the fair value of the deferred contract which was measured in terms of the nearest to maturity contract. The spread mispricing series was expressed as the log of the ratio of the price of the deferred contract to the fair price of the deferred contract.

Over the entire sample average spread mispricing was not found to be significantly different from zero, with 49.2% of observations being characterised by positive spread mispricing and 50.8% of observations being characterised by negative spread mispricings. On a contract by contract basis, spread mispricing was significantly positive for 7 contracts and significantly negative for 6 contracts, with 3 contracts not being significantly different from zero. Furthermore, neither the average spread mispricing nor the associated standard deviation were found to be characterised by any systematic reduction over time.

Spread mispricing was also found to be persistent, whereby mispricing persisted in a particular direction for extended intervals, as was the case for index arbitrage. Yadav and Pope calculated the degree of persistence through the use of non-parametric runs tests, which measured the average length of a run (or the average frequency of a mispricing reversal). The average length of time between mispricing reversal was 22 trading hours. Overall the run test results demonstrated that:

> "the number of runs is significantly less than the number of runs expected if successive observations were independent; the hypothesis of no persistence being conclusively rejected" (1992b, p. 368).

According to Yadav and Pope the implication of a high degree of persistence was that the early unwinding option was unlikely to be profitable in any subsequent spread arbitrage strategy.

The profitability of the FTSE 100 intermarket spread was examined with respect to two simple trading rules, these were the hold-to-expiration and the early unwinding option trading rules. On an ex post basis spread arbitrage offered a significant number of profitable opportunities for the most favourably placed class of arbitrageurs. In contrast to index arbitrage over 80% of the spread arbitrage positions were held to maturity. Alternatively, on an ex ante basis, while the actual magnitude of spread arbitrage profits had been reduced, over 70% of the arbitrage trades remained profitable when held to maturity. However, the ex post profits generated from the early unwinding option were completely eliminated when this strategy was tested on an ex ante basis. Therefore risky spread arbitrage strategies were likely to be unattractive.

Grinblatt and Jegadeesh (1996) examined the relative pricing of spreads between Eurodollar futures and forward contracts. Daily Eurodollar futures prices (CME) and forward prices implied by the term structure of the spot LIBOR quotations from Data Resources Incorporated were employed over the period April 1982 to December 1992. The sample was partitioned into two sub-periods: April 1982 to June 1987 and July 1987 to December 1992. Over both sub-periods the average yield differential was significantly different from zero, with this average differential being smaller in the second sub-period. Grinblatt and Jegadeesh evaluated a number of different hypotheses that could potentially explain both the futures-forward yield difference, and variations in this relationship over time. The factors considered as possible explanations for the observed yield difference between the forward and futures contract were the issues of marking-to-market, default risk, liquidity risk and market depth, taxation and the structure of futures and forward markets.

The marking-to-market feature is the principal contractual difference between forward and futures contracts, with futures contracts being settled on a daily basis, while forward contracts are settled only at maturity. Grinblatt and Jegadeesh tested the marking-to- market hypothesis but found that it was too small to account for the actual magnitude of observed futures-forward rate differences. The default risk hypothesis suggested that forward contracts should have a risk premium factored into them to cover the inherent default risk of trading in OTC markets, which would lead to forward contracts trading at a premium to futures contracts. However, this hypothesis could not account for either the size or the sign of the yield differential in the early part of the sample. Alternatively, the liquidity risk hypothesis suggested that transaction costs are a function of market liquidity. Therefore, since forward contracts are less liquid than futures contracts, the equilibrium forward rate should be in excess of the equilibrium futures rate to offset the larger market impact costs of trading in the forward market. However, this hypothesis was not corroborated by the evidence, since the Eurodollar futures rate was generally in excess of the forward rate. Finally, tax differences in the forward and futures markets were considered. However, since the effect of taxation was found to be symmetrical with respect to gains and losses, they only affect the scale of payoffs at maturity and not the expected value of the payoff.

Acknowledging the failure of the previous hypotheses, Grinblatt and Jegadeesh argued that the large yield differential could be attributed to market inefficiency. When examining the timing of the flow of information between the forward and futures markets they found that although information was rapidly transferred from the forward to the futures market, there were delays in the speed at which information was transferred from the futures to the forward markets. Therefore, they argued that it was reasonable to assume that the Eurodollar yield differential resulted from relative mispricing owing to a lack of arbitrage activity, and concluded that:

> "The finding that mispricing persisted for many years is surprising in that the conventional wisdom is that a market quickly arbitrages away any mispricing. It appears that market frictions and ignorance may limit the arbitrage activity and prolong the price adjustment process" (1996, p. 1522).

Board and Sutcliffe (1996) investigated the implications that dual listings of stock index futures contracts have for implementing profitable spread trading strategies. Dual listing arises where the same futures contracts are traded simultaneously on different futures exchanges. Board and Sutcliffe employed the no-arbitrage condition to test for deviations from fair value and implemented hypothetical spread trades based on relative mispricing between the different legs of the spread. Using opening and closing prices for the Nikkei index futures contract over the period September 1988 to June 1993, spread profitability was examined with respect to the near Nikkei contract traded on the Osaka and Singapore exchanges, and Singapore and Chicago exchanges respectively. The sample period for the Osaka-Singapore trade was partitioned around October 1990 (the date associated with the onset of Nikkei futures trading on the Chicago exchange) to allow a comparison between the two intermarket spreads.

With respect to the Nikkei spread comprising of positions in both the Osaka and Singapore markets, the mean spread mispricings are much larger in the earlier sub-period than in the later sub-period, a difference which is statistically significant at the 5% level. Board and Sutcliffe suggested that this reduction in the size of spread mispricing could be attributed to a "learning effect". In addition the distribution of spread mispricing was also found to be symmetrical indicating that there was no systematic tendency for spreads to be priced either at a premium or discount. The actual size of spread mispricings were found to be considerably smaller than those reported for spot futures arbitrage (see Brenner, Subrahmanyan and Uno (1989b)). For instance, only on 5.1% of occasions were spread mispricings found to violate the 1% transaction cost limit.

The mispricing series relating to the Osaka - Singapore spread was also found to be characterised by a number of specific time series properties. Firstly, the tendency for mispricing series associated with index arbitrage to converge to zero as maturity approached, was not evident in the spread mispricing series. Board and Sutcliffe argued that because a spread involves offsetting short and long positions, the decline in dividend and interest rate uncertainty which is associated with a time to maturity effect, would be cancelled out. Secondly, although the spot - futures mispricing series was found to be characterised by significant positive autocorrelation, this feature was not present in the spread mispricing series. In fact there was little evidence that spread mispricings have a tendency to persist in one direction over time. This finding is in contrast to Yadav and Pope (1992b) who found that significant spread mispricing runs constituted evidence of persistence. Finally, in the context of index arbitrage the limits of the arbitrage window were often found to be highly asymmetric and path dependent owing to the difficulties associated with the short selling of stock and the option to unwind established positions early. However, these issues do not impede spread trading and consequently the spread mispricing series was found to be largely symmetrical and associated with minimal path dependence.

The second testable spread which Board and Sutcliffe examined was that between the Nikkei futures contract traded in Singapore and Chicago. This spread was complicated by the fact that the respective contract multipliers were denominated in different currencies. To overcome the inherent currency risk associated with this spread is was necessary to forecast the dollar - yen exchange rate at the contract maturity date before the spread was initiated. This additional source of uncertainty together with the fact that the two markets are situated in different time zones implied that the arbitrage window would be larger than that associated with the Osaka-Singapore spread. Spread mispricings associated with the Singapore - Chicago spread were found to be both larger and more frequent than those associated with the Osaka - Singapore spread, with the 1% (2%) transaction cost threshold being violated on 10.5% (2%) of occasions. Finally, the time series properties evident in the Osaka - Singapore spread mispricing series were also evident in the Singapore - Chicago spread mispricing series.

2.43) SUMMARY AND IMPLICATIONS

In summary, spread trading is an essential strategy which is widely employed by traders in futures markets, and arises from perceived anomalies between the relative prices of two or more related futures contracts. Unfortunately, with respect to the spread trading literature the vast majority of previous studies have focused on the examination of the profitability of specific trades, and the theoretical development of spread trading behaviour has been rather limited. While spread trading strategies were traditionally applied to agricultural futures, the strategy has become increasingly more widespread with respect to financial futures. Although there are difficulties in generalising across the various studies, it was often found to be the case that strategies which were profitable on a pre-transaction cost basis, resulted in losses once allowances were made for transaction costs. This finding would tend to reinforce the overall conclusion that futures markets are generally efficient.

While spread trading is vital to the well functioning of any futures market, spread trading activity in index futures markets has received very little attention compared to the literature examining index arbitrage relationships. However, the introduction of the Mid 250 contract in conjunction with the well established FTSE 100 contract provides a unique opportunity to examine both intramarket and intermarket spread trading relationships. Although the FTSE 100 and Mid 250 contracts are technically quite good substitutes, the chapter investigating mispricing suggests that owing to differences in trading volume the Mid 250 is not as efficient as the FTSE 100 contract, and that the far FTSE 100 contract is not as efficiently priced as the near FTSE 100 contract. Therefore, it would seem reasonable to assume that intramarket and intermarket inefficiencies are likely to exist, and these pricing inefficiencies will manifest themselves in spread trading opportunities. Findings of systematic patterns in the relative price movements between the two contracts suggest that subsequent changes are predictable. Whether or not these predicted variations can be profitably exploited through an effective trading rule is an issue which can only be resolved empirically.

2.5) CONCLUSIONS

In conclusion, this chapter has reviewed the empirical literature which relates to important issues regarding *the economics of stock index futures trading* in the UK, and which have been identified as warranting further investigation. While both of these areas have been well researched in the context of US index futures contracts, and work has been forthcoming for the FTSE 100 contract, to date no research has been undertaken in any of these areas with regards to the UK's Mid 250 contract. The main function of the thesis is to help to bridge this gap in the literature, by examining the hedging effectiveness and the pricing efficiency of index futures contracts. Hence the focus of this research is to concentrate on the important aspects relating to the introduction of the Mid 250 contract and the additional benefits, if any, that the introduction of the Mid 250 contract has made to index futures trading in the UK. The findings from each of these investigations will be of interest to investors, market practitioners, regulators and the general public alike.

Endnotes

[1] There is considerable evidence to suggest that the normality assumption is not appropriate in the case of futures contracts. Taylor (1985) finds evidence that returns on futures contracts are characterised by excess kurtosis, which supports the use of the mean Gini approach.

CHAPTER THREE

THE HEDGING EFFECTIVENESS OF THE FTSE 100 AND FTSE MID 250 CONTRACTS: COMPARING THE EX POST AND EX ANTE APPROACHES

3.1) INTRODUCTION

In chapter one it was argued that index futures contracts provide a mechanism for facilitating the transfer of price risk for basis risk and extend the range of portfolio opportunities which are available to investors through hedging. Thus hedging was found to provide the principal justification for the existence of futures markets. The stated purpose of this thesis is to empirically investigate the role and function of UK index futures contracts. Specifically, an important concern is the degree to which the recently introduced Mid 250 contract complements the well established FTSE 100 contract. To resolve this issue, this chapter considers whether the Mid 250 contract provides investors with any additional hedging benefits, in addition to those already provided by the FTSE 100 contract.

As was illustrated in chapter one, the new contract is associated with very thin liquidity and this suggests that while the Mid 250 contract offers new risk reduction opportunities in principle, owing to the low levels of trading volume, its practical significance may be limited, in that it might provide little extra hedging opportunity compared to the FTSE 100 contract. The hedging role of the new contract is investigated by examining whether the Mid 250 contract is an effective means of hedging a range of stock portfolios and comparing its hedging performance with that of the FTSE 100 contract. The chapter offers a number of improvements on previous studies of the hedging role of stock index futures contracts. In particular, a wide range of spot portfolios are used for determining the hedging performance of the two contracts, by utilising not only portfolios which mirror the indexes on which the futures contracts are written but also a spread of investment trust companies. By examining hedging effectiveness over such a range of spot portfolios, it should be possible to determine whether the new futures contract adds substantially to the opportunity set available to investors in terms of hedging effectiveness.

It is evident from the literature review in chapter two that most previous studies have evaluated the hedging effectiveness of index futures contracts by employing an ex post strategy with spot portfolios that mirror the composition of the underlying contract. This may have seriously exaggerated the risk reduction potential of these instruments. Such an approach presumes that the hedger has perfect foresight with respect to the future behaviour of spot and futures series. In reality, investors only have imperfect information sets and in the presence of inter-temporal hedge ratio instability the use of futures contracts to remove market risk is associated with forecasting problems. Therefore, by investigating hedging effectiveness using a dynamic ex ante strategy in conjunction with spot portfolios that do not just replicate market indexes, it is possible to provide a more reliable evaluation of the risk reduction potential of UK index futures contracts.

The remainder of this chapter is structured as follows. In section 3.2) theoretical issues relating to the derivation of the optimal hedge ratio in an ex post and ex ante context are considered. In section 3.3) the research issues being empirically investigated within this chapter are outlined. In section 3.4) data and methodology issues are presented. In section 3.5) the key findings in relation to the use of an ex post hedging strategy are reported, and in section 3.6) the key findings in relation to the use of an ex ante hedging strategy are reported. Finally, in section 3.7) conclusions are drawn.

3.2) THEORETICAL ISSUES

Futures contracts have an important practical role to play by expanding the opportunity set available to investors through the introduction of negative correlation not typically found in spot markets. In the case of stock index futures, the existence of these contracts allows investors to avoid market risk which cannot easily be avoided using spot assets alone due to restrictions on short selling. Traditionally, the management of the market risk associated with an investor's portfolio involves expensive stock selection and market timing decisions. A diversified portfolio which contains excellent stock selection, and would be expected to outperform the market may experience losses during a general downturn. In the past investors were required to liquidate their positions and sell stocks, or acquire put options to insure against market risk. These activities were expensive and often unreliable. However, the onset of trading in stock index futures has provided investors with a reliable and economical method of managing market risk through the act of hedging.

Hedging involves a futures market transaction which is undertaken to reduce the risk associated with some other risky spot market position[1], and it is thought to provide the main justification for the existence of futures markets. According to Daigler (1993):

> "Although speculative interest provides shorter-term volume, speculative activity can be wavering and uncertain, especially since speculators hold a position for only several weeks. Market makers on the floor provide intraday liquidity, but without speculators and hedgers the market makers soon depart to another pit. Likewise, arbitrageurs provide only limited liquidity for the market. Hedgers are the key to the market" (p. 221).

In order to illustrate the mechanics of hedging using index futures contracts we shall assume a perfect capital market in which market imperfections such as taxes, transaction costs and indivisibilities are overlooked. Initially the hedge ratio is assumed to be constant, although the importance of a dynamic hedging strategy will be considered later. Assume an investor holds a fully diversified portfolio of stocks which exactly replicates the market index (e.g. FTSE Mid 250 index). Furthermore, suppose that the current value of the stock portfolio is V_t, the current price of the stock index is S_t and the number of spot index units held is x_S. Therefore, the investor possess $\frac{V_t}{S_t}$ units of the market index. For instance, if the current value of the stock portfolio is £20 million and the current price of the stock index is 4000 points, the investor holds the equivalent of five thousand units of the stock index ($x_S = 5000$). Should the investor wish to adjust the portfolio's exposure to market risk this can be achieved by taking an offsetting position in the futures market. By allowing x_F to become the number of index units traded in the futures market, the hedge ratio becomes:

$$Hedge\ Ratio\ (h) = \frac{x_F \, . \, S_t}{V_t} = \frac{x_F}{x_S} \qquad 3.1)$$

Where the hedge ratio (h) refers to the current value of the stock index sold forward as a proportion of the current value of the portfolio being hedged. The hedge ratio (equation 3.1) is responsible for determining the specific risk and return properties of the hedged portfolio (i.e. a weighted portfolio of the spot and futures positions). Portfolio theory demonstrates that the expected return and variance on the hedged portfolio can be expressed by equations 3.2 and 3.3 respectively.

$$E(R_h) = x_s E(R_S) + x_F E(R_F) \qquad 3.2)$$

$$\sigma^2_{R_h} = x_S^2 \sigma_S^2 + x_F^2 \sigma_F^2 + 2 x_S x_F \sigma_{S,F} \qquad 3.3)$$

Where the expected return on the hedged portfolio $E(R_h)$ is the weighted sum of the expected returns on the spot portfolio ($E(R_S)$) plus the expected returns on the futures contract ($E(R_F)$), σ^2_{Rh} is the variance of the return on the hedged portfolio and $\sigma_{S,F}$ is the covariance between the returns on the futures contract and the returns on the spot portfolio. However, by setting $x_S = 1$ and substituting into equation 3.1, the expected return and variance of the hedged portfolio can be equivalently expressed in terms of equations 3.4 and 3.5 respectively:

$$E(R_h) = E(R_S) + h\, E(R_F) \qquad 3.4)$$

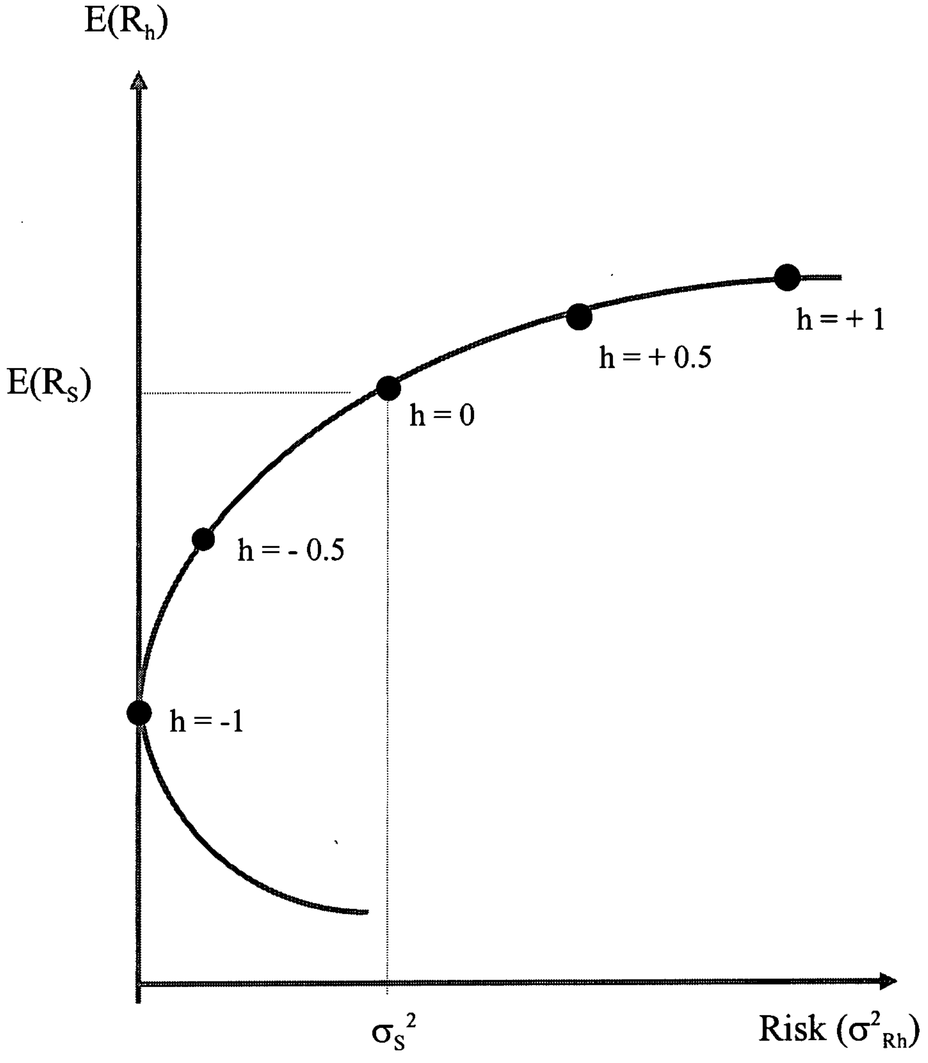
$$\sigma^2_{R_h} = \sigma^2_S + h^2\sigma^2_F + 2\,h\,\sigma_{S,F} \qquad 3.5)$$

Changes in the hedge ratio are responsible for determining the level of risk and return on the hedged portfolio. Figure 3.1 which illustrates the Portfolio possibility frontier for the hedged portfolio, shows that by adjusting the hedge ratio associated with the hedged portfolio the hedger can attain any of a range of portfolios. Changes in the hedge ratio alter the weights which the investor attaches to their spot and futures market positions. In figure 3.1, where h = 0 the futures market makes no contribution to the investors portfolio, and the risk-return combination is determined purely by the spot portfolio. However, the investor has the opportunity to alter the risk and return characteristics of their spot portfolio by establishing a position in the futures market and adopting a non-zero hedge ratio.

All points along the portfolio possibility frontier to the left of the unhedged stock portfolio involve taking a short position and selling futures contracts against the established stock portfolio. Since selling futures contracts involves assuming a negative hedge ratio, then with regards to equation 3.5 and 3.4 the hedged spot portfolio will be associated with a simultaneous reduction in risk and return. Alternatively, all points along the portfolio possibility frontier to the right of the unhedged portfolio involve taking a long position and buying futures contracts against the established spot portfolio. Since buying futures contracts involves assuming a positive hedge ratio, then with regards to equation 3.4 and 3.5 the hedge portfolio will be associated with a simultaneous increase in risk and return[2]. Given that the investor's stock portfolio is assumed to exactly mirror the Mid 250 index, the

Figure 3.1)

Portfolio Possibility Frontier for the Hedged Portfolio



returns achieved from selling the futures contract will be perfectly inversely correlated with the returns on the spot position. Since the spot and futures markets are assumed to move in perfect tandem, a rise (fall) in the price of the Mid 250 index would be exactly offset by a fall (rise) in the price of the futures contract. Therefore, where h = -1 a perfect hedge is achieved, with the hedged portfolio associated with zero risk and a rate of return equal to the riskless rate of interest. Although the investor's choice of hedge ratio will depend on their specific risk preferences, in no case should a hedge ratio in excess of -1 be chosen.

In practice, spot and futures positions rarely move in 'lock step' and a perfect hedge is generally unattainable, resulting in the risk minimising hedge ratio diverging from -1. In fact, hedging effectiveness is imperfect whenever the composition of the investor's stock portfolio differs from the stock index underlying the futures contract or where basis risk exists. The basis receives a great deal of attention in the futures literature and refers to the difference between the spot price of an instrument and the respective futures price of the instrument. Basis risk measures the volatility of this relationship over time. Changes in the basis are measured as:

$$\begin{aligned}\Delta\, Basis &= (P_t^S - P_{t-1}^S) - (P_t^F - P_{t-1}^F) \\ &= (P_t^S - P_t^F) - (P_{t-1}^S - P_{t-1}^F)\end{aligned} \qquad 3.6)$$

Where P^S_t and P^S_{t-1} refer to the price of the spot instrument in time periods t and t-1 respectively, and P^F_t and P^F_{t-1} refer to the price of the futures contract in time periods t and t-1 respectively. Although basis risk introduces uncertainty into hedging decisions, fortunately this uncertainty still tends to be less than the outright price risk of being unhedged in spot market operations. As Castelino (1990) argues:

> "by deciding to hedge the hedger relieves himself of the burden of predicting price levels (of the spot market) in exchange for predicting price differences (between futures and cash, the basis)" (p. 272).

Basis risk arises from various sources, each of varying importance, and according to Figlewski (1984a) is a more significant problem for stock index futures contracts than for other financial futures contracts. Firstly, the unhedged spot portfolio held by the hedger is unlikely to be identical in composition to the market index on which the contract is written, and therefore the hedged portfolio will be associated with an unsystematic risk component. The size and composition of the spot portfolio to be hedged is therefore of particular relevance in hedging decisions. Secondly, an index portfolio will typically make dividend payments, while the index futures contract will only track the capital value of the stock index. Since index futures can only hedge the risk associated with stock price movements, the risk arising from uncertain dividend payments will remain, and constitute a source of basis risk in the hedged portfolio. Where dividend payments are stochastic they may result in potentially unhedgeable variations in return. Even so, Figlewski (1984a) argues that dividend risk is not of great significance and it has typically been ignored by subsequent researchers[3]. Thirdly, while the futures price must equal the index price at maturity, at any point before maturity the futures price has the potential to deviate from the index price, which introduces an additional source of basis risk which impairs hedging effectiveness. Merrick (1988b) demonstrates that the reversal of an initial contract mispricing by arbitrageurs has important implications for the return on the hedged portfolio. Although the activities of arbitrageurs largely determine the degree to which the futures price and the index price can diverge, difficulties in assembling the stock side of the arbitrage transaction limit the extent to which index arbitrage transactions can be executed. Issues relating to the pricing of index futures contracts will be explored in more detail in chapter six. Finally, "noise" which derives from a multitude of sources and manifests itself in temporary distortions in the spot and futures price relationship is the principal source of basis risk. The cumulative effect of these alternative sources of noise is considerable, but is often indistinguishable from other sources of basis risk. However, Figlewski (1984a) argues that noise as a proportion of total risk should fall as hedge duration increases. Therefore, longer duration hedges should be associated with less risk than shorter duration hedges. In addition the duration of the hedge should also influence the size of the hedge ratio, with longer duration hedges resulting in hedge ratios that are larger in absolute magnitude. This relationship exists because basis risk as a proportion of total risk should fall over larger intervals. Thus any noise in the spot and futures price series should reduce over time, with the correct economic relationship between spot and futures prices prevailing over the long term. The duration effect is a directly testable hypothesis which can only be resolved empirically.

Cross hedging arises where an investor wishes to hedge the market risk associated with a spot portfolio for which no underlying futures contract exists. Since cross hedging involves hedging the market risk of a portfolio by initiating a position in an economically related futures contract, the choice of the optimal hedging vehicle becomes an important issue[4]. According to Castelino et al (1991) the choice of the optimal hedging vehicle for a cross hedge will depend on the degree of correlation between the unhedged spot portfolio and the instrument underlying the futures contract. It is this source of uncertainty that makes the cross hedge riskier than hedging the underlying instrument. The extent to which the spot and futures positions track one another will determine the success of the hedge. Furthermore, in the absence of full convergence between the spot and futures instruments at contract maturity, a hedged portfolio held until maturity will not be riskless. In this sense, cross hedging risk is the unsystematic risk associated with the spot portfolio.

Investors may also favour using a composite hedge or combination of different futures contracts to hedge a spot portfolio (see Anderson and Danthine (1981) and Sutcliffe (1993)). For instance, a portfolio of UK stocks might be hedged using a mixture of different futures contracts (e.g. FTSE 100 and Mid 250 index futures contracts). The principal benefit accruing from using a composite hedge, is that the hedged portfolio is likely to be associated with lower risk than in the case of a single hedge. While the variance associated with the hedged position using a single futures contract is given in equation 3.5, the variance associated with the composite hedge (σ^2_{CH}) using two futures contracts (e.g. FTSE 100 and Mid 250 contract) is:

$$\begin{aligned}\sigma^2_{CH} &= \sigma^2_S + h^2_{100}\,\sigma^2_{100} + h^2_{250}\,\sigma^2_{250} + 2h_{100}\,\sigma_{S,100} \\ &\quad + 2h_{250}\,\sigma_{S,250} + 2h_{100}\,h_{250}\,\sigma_{100,250}\end{aligned} \qquad 3.7)$$

Where σ^2_S , σ^2_{100} , σ^2_{250} refer to the variance of returns on the unhedged spot portfolio, the variance of returns on the FTSE 100 contract and the variance of returns on the Mid 250 contract. $\sigma_{S,100}$, $\sigma_{S,250}$, $\sigma_{100,250}$ refer to the covariance of returns between the unhedged spot portfolio and the FTSE 100 contract, the covariance of returns between the unhedged spot portfolio and the Mid 250 contract and the covariance of returns between the FTSE 100 and Mid 250 contracts respectively. Finally, h_{100} and h_{250} refer to the hedge ratios associated with the FTSE 100 contract and Mid 250 contract respectively.

Successful hedging involves replacing price risk in the spot market with basis risk. However, given the lack of any uniform view as to what motivates the hedger, a variety of hedging models have evolved, each offering a different interpretation for this phenomenon. Together these models capture a broad spectrum of opinion with regard to the function of hedging, and the implications for hedging will be different depending on which theory the hedger subscribes to. Consideration is given to four models of hedging which have been widely adopted by previous research: the traditional one to one hedge; the Working model of hedging; the minimum variance hedge and the beta hedge[5].

The traditional (also referred to as the classical or naive) model is the earliest and most simple model of hedging, and stresses the risk-avoidance potential of futures markets. Hedgers are assumed to take futures positions that are equal in magnitude but opposite in sign to the established spot market position. The traditional model rather naively assumes that the spot and futures prices are perfectly positively correlated, and that the price risk in the spot market will be completely offset by movements in the futures market, producing a riskless hedged position which rewards investors with the risk-free rate of return. Proponents of this view claim that even where spot and futures prices are less than perfectly positively correlated, price movements are to a large degree random in character and therefore need not be considered. However, because spot and futures markets are not perfectly correlated, the traditional hedge cannot guarantee to be a risk minimising position. In fact in the case of a cross hedge, use of the traditional strategy has the potential to result in a hedged portfolio which is riskier than the unhedged spot portfolio.

The Working (1953) model challenges the traditional view of hedging as a risk minimising activity and suggests that hedgers operate much like speculators with their principal motivation for hedging being expected profit maximisation, with risk reduction at best a secondary consideration. Working argues that:

> "the basic idea that complete effectiveness of hedging depends on parallelism of movements of spot and futures prices is false, and an improper standard by which to test the effectiveness of hedging. The effectiveness of hedging intelligently used with commodity storage depends on *inequalities* between the movements of spot and futures prices and on reasonable predictability of such inequalities" (1953, pp. 547-549).

Working's view of hedging has been perceived as amounting to speculating on changes in the basis, with the size of the basis on the hedge initiation date and the predicted value at the hedge lifting date playing a crucial role in the decision of whether to hedge or not. According to Working, hedgers with a long position in the spot market will only hedge if the initial basis is negative, because as the spot price rises relative to the futures price over the life of the hedge, the hedge will prove profitable.

Both the traditional and Working models of hedging evolved before the onset of modern portfolio theory and do not reflect the observed diversity and sophistication which characterises users of futures markets. As Anderson and Danthine (1981) argue:

> "The set of futures market participants is far more diverse than the traditional dichotomy of hedgers and speculators suggests." (1981, p.1184))

The minimum variance approach to hedging has attempted to reconcile the earlier views of hedging by subsuming them as special cases, within the context of portfolio theory. The minimum variance strategy was developed by Johnson (1960), who argues:

> “In general, hedging activity appears to be motivated by the desire to reduce risk, as described in traditional theory, but levels of inventory held appear to be not independent of expected hedging profits as emphasised by Working. Furthermore, that an individual may hold a mix of hedged and speculative positions in response to his expectations concerning *absolute* price changes is a practice not well explained in either traditional or in Working’s theory ... In fact the very distinction between hedging and speculation is

> fuzzy; when the trader takes market positions on the basis of expectations concerning *relative* price changes, he is speculating insofar as he is not betting on a 'sure thing' " (p. 142).

The Johnson strategy seeks to minimise the variance of returns on the hedged spot portfolio (equation 3.5). To find the hedge ratio which minimises the risk on the hedged portfolio, we differentiate the variance of the hedged portfolio with respect to h and set the result equal to zero

$$\frac{\partial \sigma_{Rh}^2}{\partial h} = 2h\sigma_F^2 + 2\sigma_{S,F} = 0 \qquad 3.8)$$

or

$$h = -\frac{\sigma_{S,F}}{\sigma_F^2} = h^* \qquad 3.9)$$

Where equation 3.9 refers to the minimum variance hedge ratio (henceforth MVHR), which is the proportion of the spot portfolio to be hedged when the hedger's goal is to maximise risk reduction. The negative sign attached to the MVHR refers to the fact that most long spot positions are best hedged by taking a short position in the futures market. The greater is the covariance between the returns in the spot and futures market relative to the variance of returns in the futures market, the greater this hedged proportion should be. The MVHR only equates to the traditional hedge where the returns on the spot and futures markets are perfectly correlated with identical variances.

In order to determine the effectiveness of the hedge it is necessary to compare the variance of the hedged portfolio to the variance of the unhedged spot portfolio. By substituting equation 3.9 into equation 3.5, the variance of the hedged portfolio where the MVHR is employed becomes:

$$\begin{aligned}\sigma^2_{Rh*} &= \sigma^2_S + \frac{\sigma_{S,F}{}^2}{\sigma^2_F} - \frac{2\sigma_{S,F}{}^2}{\sigma^2_F} \\ &= \sigma^2_S - \frac{\sigma_{S,F}{}^2}{\sigma^2_F}\end{aligned} \qquad 3.10)$$

Given that the coefficient of correlation between the spot and futures returns is $\rho = \dfrac{\sigma_{S,F}}{\sigma_S \, \sigma_F}$, it follows that the variance on the hedged portfolio can be expressed as

$$\sigma^2_{Rh*} = \sigma^2_S \, (1 - \rho^2) \qquad 3.11)$$

The greater is the correlation between the spot and futures returns, the smaller is the amount of price risk associated with the hedged portfolio. At the limit where $\rho^2 = 1$, the return on the hedged portfolio is riskless. The ex post effectiveness (e) of the MVHR is measured by the coefficient of determination (ρ^2), and can be expressed as

$$e = \left[1 - \frac{\sigma^2_{Rh*}}{\sigma^2_S}\right] = 1 - (1 - \rho^2) = \rho^2 \qquad 3.12)$$

As Figlewski (1984a) has shown, the ex post MVHR can be estimated by regressing spot portfolio returns against futures returns using historical information. When this is achieved the coefficient of determination coincides with Johnson's measure of hedging effectiveness (e).

Where the investor's spot portfolio is hedged using a single futures contract, generating the hedge ratio which minimises the risk on the hedged portfolio is a relatively simple procedure. To extend the analysis, and calculate the risk minimising hedge ratios for a composite hedge where a single spot portfolio is hedged by two or more futures contracts, is rather more complicated. In the case of a spot portfolio which is jointly hedged by two futures contracts, the MVHR can be determined by differentiating the variance of the hedged portfolio with respect to both of the futures contracts separately. In relation to the variance of the composite hedge in equation 3.7, which refers to a hedged portfolio comprising of a UK spot portfolio and futures market positions in the FTSE 100 and Mid 250 contracts, the MVHR's can be calculated by differentiating equation 3.7 with respect to h_{100} and h_{250} respectively, and setting each of the derivatives equal to zero:

$$\frac{\partial \sigma^2_{CH}}{\partial h_{100}} = 2\, h_{100} \sigma^2_{100} + 2\sigma_{S,\,100} + 2\, h_{250} \sigma_{100,250} = 0 \qquad 3.13)$$

$$\frac{\partial \sigma^2_{CH}}{\partial h_{250}} = 2\, h_{250} \sigma^2_{250} + 2\sigma_{S,250} + 2\, h_{100} \sigma_{100,250} = 0 \qquad 3.14)$$

To isolate terms containing h_{100} and $h_{250,}$ equations 3.13 and 3.14 can be equivalently expressed as equations 3.15 and 3.16 respectively:

$$h_{100}\sigma^2_{100} + h_{250}\sigma_{100,250} = -\sigma_{S,100} \qquad 3.15)$$

$$h_{250}\sigma^2_{250} + h_{100}\sigma_{100,250} = -\sigma_{S,250} \qquad 3.16)$$

Firstly, to determine the MVHR in relation to the FTSE 100 contract, we multiply equation 3.15 by $\frac{\sigma^2_{250}}{\sigma_{100,250}}$:

$$h_{100}\frac{\sigma^2_{100}\sigma^2_{250}}{\sigma_{100,250}} + h_{250}\sigma^2_{250} = -\frac{\sigma_{S,100}\sigma^2_{250}}{\sigma_{100,250}} \qquad 3.17)$$

To eliminate the influence of $h_{250,}$ we subtract equation 3.16 from equation 3.17:

$$h_{100}\frac{\sigma^2_{100}\sigma^2_{250}}{\sigma_{100,250}} - h_{100}\sigma_{100,250} = -\frac{\sigma_{S,100}\sigma^2_{250}}{\sigma_{100,250}} + \sigma_{S,250} \qquad 3.18)$$

To eliminate the term in the denominator of equation 3.18 we multiply through by $\sigma_{100,250}$:

$$h_{100}\sigma^2_{100}\sigma^2_{250} - h_{100}\sigma^2_{100,250} = -\sigma_{S,100}\sigma^2_{250} + \sigma_{S,250}\sigma_{100,250} \qquad 3.19)$$

Factorising equation 3.19 for h_{100} :

$$h_{100}(\sigma^2_{100}\sigma^2_{250} - \sigma^2_{100,250}) = -\sigma_{S,100}\sigma^2_{250} + \sigma_{S,250}\sigma_{100,250} \tag{3.20}$$

Finally, to determine the MVHR for the FTSE 100 contract we divide through by the multiple of h_{100} :

$$h_{100} = \frac{-\sigma_{S,100}\sigma^2_{250} + \sigma_{S,250}\sigma_{100,250}}{\sigma^2_{100}\sigma^2_{250} - \sigma^2_{100,250}} = h^*_{100} \tag{3.21}$$

Secondly, to determine the MVHR for the Mid 250 contract, we repeat the transformations outlined above, by multiplying equation 3.16 by $\frac{\sigma^2_{100}}{\sigma_{250,100}}$.

$$h_{250}\frac{\sigma^2_{250}\sigma^2_{100}}{\sigma_{250,100}} + h_{100}\sigma^2_{100} = -\frac{\sigma_{S,250}\sigma^2_{100}}{\sigma_{250,100}} \tag{3.22}$$

To eliminate the influence of $h_{100,}$ we subtract equation 3.15 from equation 3.22:

$$h_{250}\frac{\sigma^2_{250}\sigma^2_{100}}{\sigma_{250,100}} - h_{250}\sigma_{100,250} = -\frac{\sigma_{S,250}\sigma^2_{100}}{\sigma_{250,100}} + \sigma_{S,100} \tag{3.23}$$

To eliminate the term in the denominator of equation 3.23 we multiply through by $\sigma_{250,100}$:

$$h_{250}\sigma^2_{250}\sigma^2_{100} - h_{250}\sigma^2_{250,100} = -\sigma_{S,250}\sigma^2_{100} + \sigma_{S,100}\sigma_{250,100} \tag{3.24}$$

Factorising equation 3.24 for h_{250} :

$$h_{250}(\sigma^2_{250}\,\sigma^2_{100} - \sigma^2_{250,100}) = -\sigma_{S,250}\,\sigma^2_{100} + \sigma_{S,100}\,\sigma_{250,100} \qquad 3.25)$$

Finally, to determine the MVHR for the Mid 250 contract we divide through by the multiple of h_{100} :

$$h_{250} = \frac{-\sigma_{S,250}\,\sigma^2_{100} + \sigma_{S,100}\,\sigma_{250,100}}{\sigma^2_{250}\,\sigma^2_{100} - \sigma^2_{250,100}} = h^*_{250} \qquad 3.26)$$

The MVHR for the FTSE 100 contract when used in combination with the Mid 250 contract, and the MVHR for the Mid 250 contract when used in combination with the FTSE 100 contract are expressed in equations 3.21 and 3.26 respectively. It is clear that the covariance between the FTSE 100 contract and Mid 250 contract enters both equations, and where the covariance is found to be zero, both equations collapse to the standard MVHR for the single futures contract.

Using the MVHR as the basis for a hedging strategy implicitly assumes that the investor is infinitely risk averse, in that they are willing to give up an infinite amount of expected return in exchange for an infinitely small reduction in risk. While such an assumption concerning the risk-return trade off is clearly unrealistic, it has the advantage of providing an unambiguous benchmark against which to assess hedging performance[6] and it has therefore been widely adopted in previous research.

Hedging models based on the beta coefficient which emanates from the capital asset pricing model (CAPM) framework have been found to generate powerful hedge ratios. The beta coefficient gauges the volatility (or systematic risk) associated with a spot portfolio measured in terms of the volatility associated with the market portfolio. The market portfolio to be employed in determining the value of the beta is not the true market portfolio, but rather the stock index which underlies the futures contract. In using the beta coefficient to hedge the spot portfolio, the number of futures contracts to be held for a full hedge needs to be adjusted with respect to the portfolio beta. Clearly, the traditional hedge ratio and the beta ratio are identical when the portfolio to be hedged is identical in composition to the spot index which underlies the futures contract. However, where the composition of the spot portfolio and index differ then the beta hedge ratio will deviate from unity, being greater than unity for portfolios that out-perform the market, and less than unity for portfolios that under-perform the market. The beta hedge ratio is measured as:

$$h_\beta = -\frac{\sigma_{S,I}}{\sigma_I^2} \qquad 3.27)$$

Where the beta hedge ratio (h_β) is equal to the negative of the covariance of the returns on the unhedged spot portfolio and the spot index ($\sigma_{S,\ I}$), divided by the variance of returns on the spot index (σ^2_I). Peters (1986) demonstrates that the beta coefficient is unlikely to be an optimal hedge ratio, since it only takes into account market risk, and risk which arises from futures price volatility is often overlooked. Where the portfolio to be hedged is the underlying spot index, the beta hedge will equal unity, and by comparing the MVHR with unity, a direct comparison can be made between h* and the beta hedge. Furthermore, in practice the beta hedge ratio has been found to be larger than the minimum variance hedge ratio, and therefore like the traditional hedge ratio is often associated with the problem of overhedging.

From the preceding theoretical discussion, it is apparent that in evaluating the effectiveness of stock index futures as hedging instruments it is necessary to consider the extent of risk reduction which these contracts permit. Furthermore, the value of the beta and minimum variance hedge ratios need to be determined, together with the effect that hedge duration, spot portfolio composition and hedge ratio stability have on hedging effectiveness.

In order to estimate the optimal hedge ratio which minimises risk it is necessary to assume that the hedger possesses perfect foresight and knows the future values of the covariance and variance relationships in equation 3.9 at the point when the hedge is initiated. In reality this is not the case, and in the presence of basis risk the relationship between the spot and futures prices has a tendency to change leading to hedge ratio instability. Thus the ex post hedge ratio generated in one period may be inappropriate for use in a subsequent period, leading to a discrepancy between ex post and ex ante effectiveness. Where hedge ratios are generated on an ex ante basis the covariance relationship in equation 3.9 has the potential to vary considerably leading to hedge ratio variability. This problem becomes most acute where the underlying spot portfolio represents a cross hedge. Under these circumstances the hedger must determine the optimal ex ante hedge ratio with respect to expectations conditioned by historical information.

3.3) EMPIRICAL INVESTIGATION

In this chapter the ex post and ex ante hedging effectiveness of the FTSE 100 and Mid 250 index futures contracts are investigated for a diverse range of spot portfolios. The empirical section is structured into two stages, with the first stage examining hedging effectiveness within an ex post framework, and the second stage examining hedging effectiveness within an ex ante framework. As was earlier demonstrated futures contracts play an important practical role by expanding the investor opportunity set through the introduction of negative correlation not typically found in spot markets. In this section we investigate whether the new contract is effective for hedging a range of stock portfolios and compare its hedging performance with that of the FTSE 100 contract. In addition to providing the first test of the hedging effectiveness of the new contract, this section offers improvements on previous studies of stock index futures hedging. In particular, a wide range of spot portfolios are used for assessing hedging performance, by using not only portfolios which mirror indexes underlying futures contracts, but also a spread of investment trust companies (henceforth ITCs). Examining hedging effectiveness over such a range of spot portfolios makes it possible to determine whether the new contract adds substantially to investors' opportunity sets by markedly enhancing hedging performance. Additional features are that this study provides the first analysis of daily hedging using UK futures and, also investigates the effectiveness of using a 'synthetic' FTSE 350 index futures contract (comprising of various weighted combinations of the FTSE 100 and Mid 250 contract) to hedge.

Specifically, this first stage of the empirical investigation addresses shortcomings of previous work conducted into ex post hedging effectiveness in a number of important ways:

- the first assessment of hedging effectiveness of the Mid 250 contract is presented. In addition, comparisons are made between the performance of this contract and that of the FTSE 100 contract for a number of different portfolios. Given that one aim of the introduction of the new contract is to enable more effective hedging of small capitalisation stocks, this is clearly important.
- in addition to assessing hedging performance for spot portfolios mirroring broad indexes, cross hedging performance is analysed by examining the hedging of actual spot portfolios held by professional managers in the form of ITCs. Since returns on ITCs represent the returns on professionally managed, well diversified, portfolios, evaluation of hedging effectiveness in relation to these portfolios provides new insights into the capabilities for hedging actual portfolios.
- consideration is given here not only to the hedging effectiveness of the FTSE 100 and Mid 250 when used separately, but also to their use in combination.
- the first investigation of hedging effectiveness of stock index futures in the UK over short periods is provided, by examining daily hedges.

While the hedging effectiveness of stock index futures contracts has been thoroughly investigated, the great majority of these studies are limited in that they focus solely on the issue of ex post hedging effectiveness. Ex post hedging effectiveness presumes that the hedger has perfect foresight with respect to the future behaviour of spot and futures prices, and therefore the hedger is able to estimate the optimal hedge ratio for the subsequent period on the basis of this information. In reality, investors only have imperfect information sets and in the presence of hedge ratio instability the use of futures contracts to remove market risk is associated with forecasting problems. Previous studies of hedging effectiveness which adopt an ex post approach are likely to have tended to overstate the extent to which stock index futures are able to eliminate market risk.

The second stage of the empirical investigations undertaken in this chapter extends the work on ex post hedging effectiveness of UK index futures, by employing an ex ante strategy for both the FTSE 100 index futures contract and the Mid 250 contracts, with respect to the same range of spot portfolios used in the ex post analysis. It is clear from the literature review in chapter two that work into ex ante hedging effectiveness has been largely confined to currency and interest rate futures, and where the ex ante effectiveness of index futures has been examined, research focuses on the use of spot portfolios which mirror the underlying futures contract. Furthermore, no examination has been conducted into the hedging effectiveness of the Mid 250 contract on an ex ante basis. Specifically, with respect to ex ante hedging effectiveness the following issues will be addressed:

- the ex ante hedging performance of the FTSE 100 and Mid 250 index futures will be examined. Consideration will be given to the use of both direct hedges and a varied range of cross hedges. The cross hedges involve portfolios comprising of both broad based stock indexes and actual spot portfolios typically held by small investors, in the form of investment trust companies.

- how the ex ante hedging effectiveness compares with the ex post benchmark. This is an important issue because a high degree of ex post hedging effectiveness is meaningless if the hedger cannot attain similar levels of effectiveness on an ex ante basis.
- consideration is given to whether there is an optimal window size (i.e. estimation period) for estimating the ex ante MVHR, and whether the window size affects hedge ratio stability.

4.4) DATA AND METHODOLOGY

Hedging performance is examined for the FTSE 100 and Mid 250 index futures contracts traded on LIFFE by using spot and futures return data over the period 25 February 1994 (date of introduction of the Mid 250 index future) to 20 December 1996. Thirty-seven spot portfolios comprising of five indexes and thirty-two investment trust companies (henceforth ITC) are used. The five market indexes are the FTSE-100, the Mid 250, the FTSE-350 (comprising the largest 350 companies), the FT All Share (FTALLSH) and the FT Investment Trust (FTIT) index. ITC's were chosen because they represent managed diversified portfolios which are similar in composition to those held by private investors, and the recent growth in the number of these funds traded indicates that they are a popular route for undertaking capital investment. Therefore, it is of interest to determine whether there is the potential for reducing the market risk of these portfolios through the use of index futures. Seven categories of ITCs are used[7]:

(i) General funds: at least 80% of the assets are in UK registered companies;

(ii) Capital Growth funds: at least 80% of the assets are in UK registered companies, with stocks chosen to accentuate capital growth;

(iii) Income Growth funds: at least 80% of their assets are in UK equities whose policy is to accentuate income growth;

(iv) High Income funds: at least 80% of assets are in equities and convertibles; the aim is to achieve a yield in excess of 125% of that of the FT Actuaries All-Share Index;

(v) Smaller Company (SC) funds: at least 50% of assets are in smaller and medium sized companies;

(vi) Venture and Development Capital (VDC) funds: a significant portion of the trusts' portfolio is invested in securities of unquoted companies; and

(vii) Property funds: at least 80% of the assets of these funds are in listed property equities.

For each of the first six categories returns on five ITCs are used to analyse hedging effectiveness. In the case of Property funds, only two ITCs are used due to a lack of appropriate funds with sufficiently long returns series. To alleviate problems resulting from thin trading in these funds, only ITC's with a market capitalisation in excess of £20 million at the beginning of the period under investigation are included. The funds provide a broad range of portfolios, which differ in terms of objectives and composition. In particular, the Smaller Company funds and the Venture and Development Capital funds represent investments in relatively low capitalisation stock. Hedging such funds is expected to be less effective with the FTSE-100 contract, given the composition of the underlying index. It is therefore of interest to determine if this is the case and whether the Mid 250 contract adds markedly to hedging performance for such portfolios.

The first stage of the empirical analysis focusing on ex post hedging effectiveness employs both daily and weekly hedges, while the second stage of the analysis which investigates ex ante hedging effectiveness employs only weekly hedges. Hedge durations of longer than a week are not considered due to problems of sample size. In all cases the futures contract nearest to maturity is used. After removing non-trading days the daily series consists of 715 observations and the weekly series 147 observations. The returns series for each spot portfolio and each futures contract refers to the logarithmic price change. Logarithmic price changes are used since they minimise any non-stationarities which arise from changes in price levels. Returns are calculated as follows:

$$R_t = \log\left(\frac{P_t}{P_{t-1}}\right) \qquad 3.28)$$

Where R_t is the daily or weekly return on either the spot or futures position and P_t is the price at time t. Price is the daily or weekly closing price. All data was obtained from *Datastream*.

In the first stage of this empirical analysis which focuses on ex post hedging effectiveness three hedging strategies are considered. First, the traditional hedge is examined. Second, the MVHR, as shown in equation 3.9 is used. The MVHR can be estimated by regressing spot returns on futures returns using historical information, where h* is the negative of the slope coefficient, b, in the following equation:

$$RS_t = a + bRF_t + e_t \qquad 3.29)$$

Where RS_t is the return on the spot portfolio in time period t, RF_t is the return on the futures contract in time period t, e_t is an error term and a, b are regression parameters, where -b is the MVHR, h* [8].

Third, given that cross hedges are being considered, we use the beta hedging strategy. The beta hedge ratio is calculated as the negative of β in the following equation:

$$RS_t = \alpha + \beta RIND_t + \varepsilon_t \qquad 3.30)$$

Where $RIND_t$ is the return on the index underlying the futures contract, ε_t is an error term and all other terms are as previously defined.

Consideration is given to mean and standard deviation of returns on the unhedged and the hedged positions. The effectiveness of each of the hedges is measured in terms of the degree of risk reduction and is calculated as:

$$\text{Risk reduction} = \frac{\sigma_u - \sigma_h}{\sigma_u} \text{ x } 100 \qquad 3.31)$$

Where σ_u is the standard deviation of returns on the unhedged (i.e. spot) position and σ_h is the standard deviation of returns on the hedged position. The risk reduction statistic expressed in equation 3.31 refers to the percentage reduction in risk associated with the unhedged spot portfolio which is achieved through hedging.

The effectiveness of the three strategies is investigated using the FTSE 100 and the Mid 250 contracts individually. In addition, for the MVHR a composite hedging strategy is examined, where the two futures contracts are combined into a 'synthetic' FTSE 350 index futures contract. Returns on the synthetic contract are the weighted average of returns on the FTSE 100 and Mid 250 contracts, with the weights attached to the two contracts varying from 2:-1 to -1:2. Weights always sum to 1 and change at intervals of 0.25. Thus, 13 composite hedges are considered for each of the thirty-seven spot portfolios. In relation to the issues being investigated this panel approach has a number of advantages over the alternative approach of choosing composite hedges for each contract individually as shown in equations 3.21 and 3.26. Firstly, the panel approach is much simpler to implement with a single hedge ratio being estimated for the synthetic contract rather than hedge ratios being estimated for each of the individual contracts. In doing so the approach alleviates the indivisibility problem that would inevitably arise. Secondly, the composite hedge ratios shown in equations 3.21 and 3.26 are considerably more complicated than the traditional MVHR, and there is the potential for the individual variance and covariances to be characterised by instability over time. Thirdly, by creating various weighted 'synthetic' FTSE 350 contracts, the panel approach provides a detailed picture of the impact on hedging effectiveness arising from changes in the contribution made by the Mid 250 contract to the composition of the 'synthetic' hedge. This is an important issue given that one of the objectives of this thesis is to investigate what are the additional benefits from using the Mid 250 contract.

The second stage of the empirical analysis investigates ex ante hedging effectiveness, using the Johnson (1960) minimum variance strategy, employing hedges of one week duration. The ex ante hedging effectiveness of UK index futures contracts in managing the market risk inherent in the UK stock market is examined, and compared with evaluations of hedging effectiveness using the ex post approach[9]. While the static ex post MVHR's used in this stage are estimated using equation 3.29, the ex ante MVHR's are based on a dynamic strategy where hedge ratios are estimated using a rolling regression (or moving window) procedure.

The ex ante MVHR is estimated using equation 3.29 for the first w observations (where w refers to the window size), and as the window moves over the sample the equation is subsequently re-estimated for each group of w consecutive observations by dropping the most obsolete data point and replacing it by a new data point. In this manner, historical information ranging from observation t to observation t+w was used to generate the hedge ratio to be used in period t+w+1. Window sizes of three and six month duration (i.e. thirteen and twenty-six observations respectively) were employed to reflect the three and six month contract cycle. For instance, when using a twenty-six week window the hedge ratio employed in week 93 was estimated on the basis of information contained within the range of observations 67 to 92. By utilising different window sizes it is possible to evaluate the impact which different amounts of historical information have on hedge ratio stability, and in turn on hedging effectiveness. In comparing the performance of the ex post and ex ante strategies, hedging effectiveness is evaluated over the sample period extending from observation 28 to observation 147. The initial 27 observations are excluded from the comparison because they are used to estimate the first ex ante hedge ratio which the

26 week window requires. Therefore, this approach results in 120 ex ante hedge ratios for each spot portfolio.

The empirical findings are reported in the subsequent sections. In section 3.5 the results relating to the issues investigated with respect to ex post hedging effectiveness are discussed, while in section 3.6 the results corresponding to work undertaken with regards to ex ante hedging effectiveness are considered.

3.5) RESULTS: EX POST HEDGING EFFECTIVENESS

The success of any direct hedging strategy is dependent on the amount of basis risk which underpins the relationship between the futures contract and its underlying spot market. Therefore, before investigating the issues outlined in the previous section it is useful to consider how basis risk has evolved for both contracts over the sample period. Figures 3.2 and 3.3 illustrate the basis at daily intervals for the FTSE 100 and the Mid 250 markets respectively.

In figure 3.2, the basis for the FTSE 100 can be seen to fluctuate within the range of 33.4 to -41.4 with an average of -8.3 basis points and a standard deviation of 11.8. Similarly in figure 3.3 the basis for the Mid 250 was found to fluctuate within the range of 34.9 to -45.9 with an average of -9.71 basis points and a standard deviation 13.50. In both markets the basis was positive on 24% of occasions and negative on 76% of occasions. From this information it can be seen that the basis risk associated with the Mid 250 market is greater than that associated with the FTSE 100 market, which is consistent with the view that the Mid 250 is likely to be a more noisy

Figure 3.2)
The Basis Associated with the FTSE 100 Contract:
(February 1994 - December 1996)

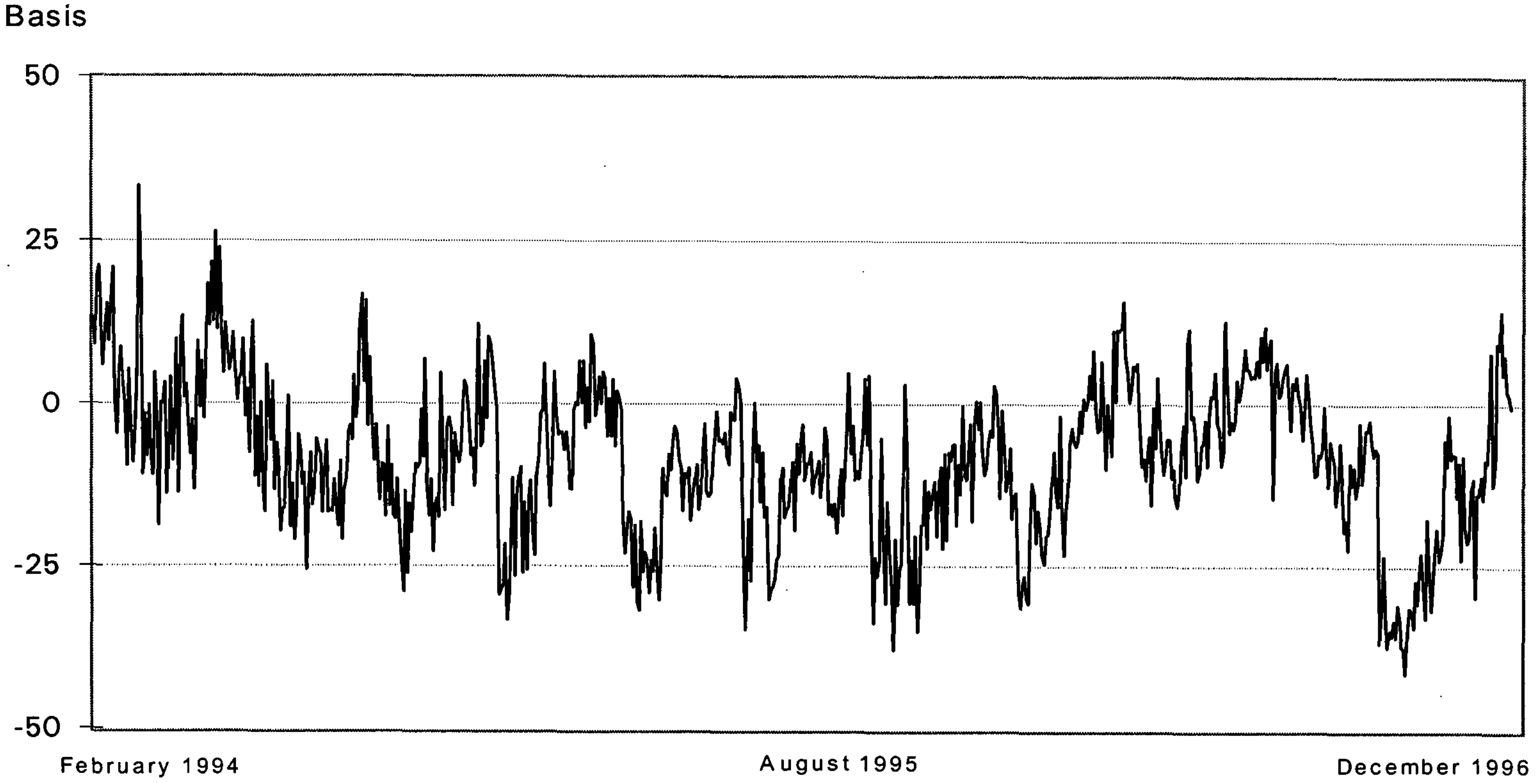
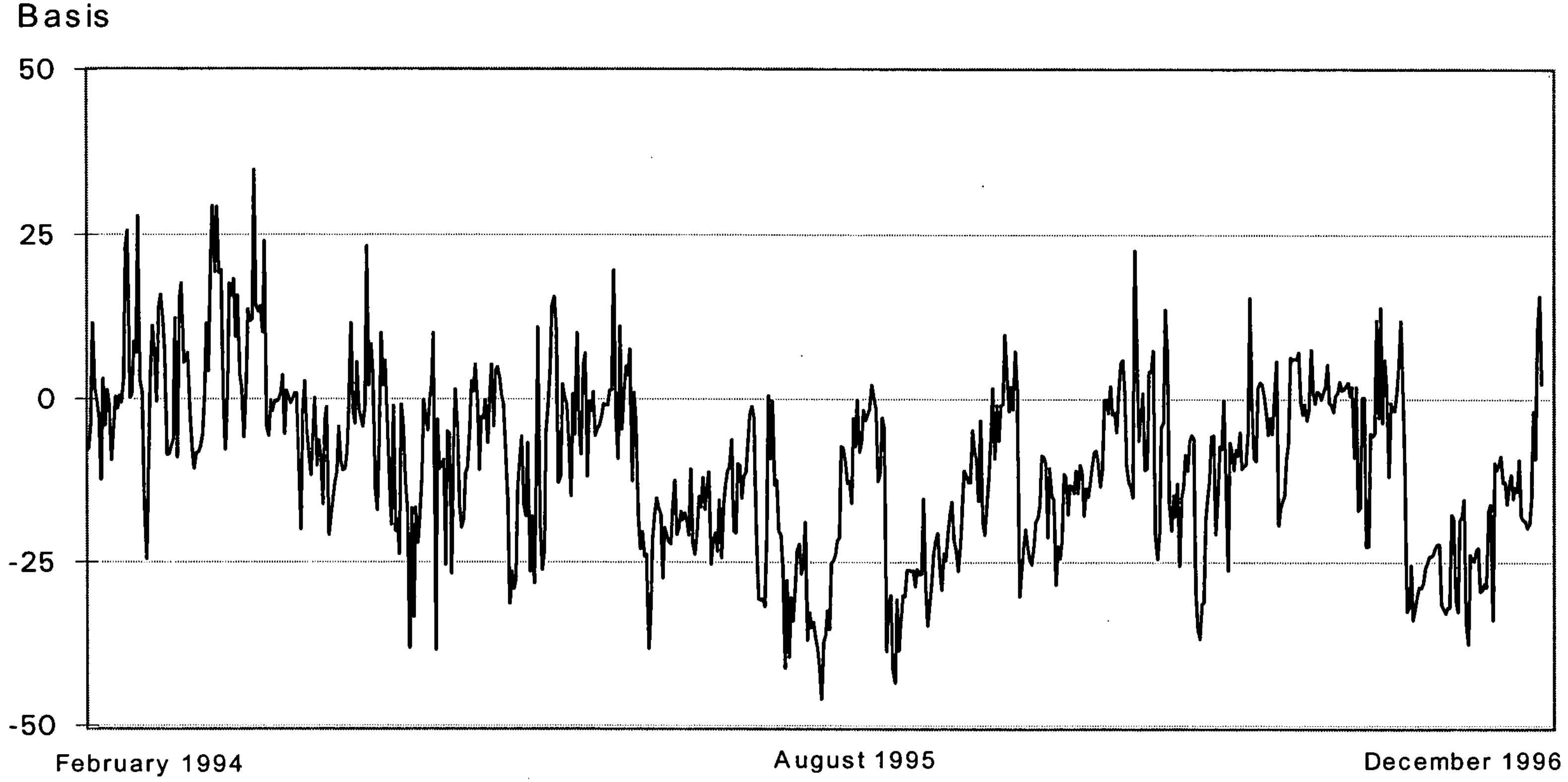


Figure 3.3)
The Basis Associated with the FTSE Mid 250 Contract:
(February 1994 - December 1996)



market. This would suggest that hedging effectiveness is likely to be greater for the FTSE 100 contract with respect to its underlying spot market than for the Mid 250 contract.

The empirical analysis begins by investigating whether the new contract adds markedly to the ability to hedge broad based spot portfolios. Therefore, the reduction in risk achieved by the FTSE 100 and Mid 250 contract when the spot portfolio is an index is examined first. The five indexes described above are considered. Results using traditional and beta hedge strategies for daily and weekly hedge durations are presented in tables 3.1 and 3.2 respectively. For each table panel A shows the mean and standard deviation of returns for spot portfolios[10]; panel B shows results when hedging with the FTSE 100 contract; and panel C shows results when using the Mid 250 contract. In panels B and C the hedge ratio, mean and standard deviation of returns and percentage reduction in the standard deviation from the unhedged position are shown.

In relation to daily data, table 3.1, panel A shows that the five spot portfolios differ considerably in terms of their risk-return profiles over the sample period. For example, the FTSE 100 index gave an annual mean return of 7.7%, with a standard deviation of returns of 10.9%, compared to figures for the Mid 250 of 4.5% and 7.0% respectively. In terms of hedging, the traditional hedge is very effective when the spot portfolio is that which underlies the contract under consideration, as expected. For example, panel B shows that hedging the FTSE 100 spot index with the FTSE 100 contract achieves risk reduction of over 64%, while using the Mid 250 contract to hedge the Mid 250 index achieves risk reduction of 45.2% (see panel C). These

Table 3.1)
The Hedging Effectiveness of the FTSE 100 and FTSE Mid 250 Contracts: Daily Data.

Spot Portfolio	Hedge Ratio	Mean Return	S. D. of Returns	Decrease in S.D.*
A) Unhedged				
FTSE 100		7.669	10.912	
FTSE 250		4.464	6.999	
FTSE 350		6.937	9.737	
FTALLSH		6.579	9.218	
FTIT		1.691	8.138	
B) Hedging with the FTSE 100 contract				
Traditional hedge				
FTSE 100	1.000	-0.146	3.924	64.038
FTSE 250	1.000	-3.351	9.296	-32.816
FTSE 350	1.000	-0.878	4.805	50.651
FTALLSH	1.000	-1.236	5.220	43.372
FTIT	1.000	-6.124	9.112	-11.971
Beta hedge				
FTSE 100	1.000	-0.146	3.924	64.038
FTSE 250	0.503	0.533	5.005	28.491
FTSE 350	0.888	-0.003	3.755	61.436
FTALLSH	0.838	0.030	3.658	60.320
FTIT	0.586	-2.889	5.884	27.689
C) Hedging with the FTSE Mid 250 contract				
Traditional hedge				
FTSE 100	1.000	3.293	6.938	36.422
FTSE 250	1.000	0.087	3.834	45.225
FTSE 350	1.000	2.560	5.681	41.651
FTALLSH	1.000	2.202	5.312	42.376
FTIT	1.000	-2.686	5.506	32.337
Beta hedge				
FTSE 100	1.223	2.317	7.064	35.264
FTSE 250	1.000	0.087	3.834	45.225
FTSE 350	1.172	1.808	5.875	39.657
FTALLSH	1.123	1.664	5.489	40.454
FTIT	0.961	-2.515	5.410	33.520

* This measures the percentage of the standard deviation of returns of the unhedged portfolio that is removed by hedging.

Table 3.2)
The Hedging Effectiveness of the FTSE 100 and FTSE Mid 250 Contracts: Weekly Data.

Spot Portfolio	Hedge Ratio	Mean Return	S. D. of Returns	Decrease in S.D.*
A) Unhedged				
FTSE 100		7.687	11.169	
FTSE 250		4.474	9.276	
FTSE 350		6.953	10.469	
FTALLSH		6.594	10.033	
FTIT		1.695	9.027	
B) Hedging with the FTSE100 contract				
Traditional hedge				
FTSE 100	1.000	-0.020	2.500	77.613
FTSE 250	1.000	-0.466	7.398	20.254
FTSE 350	1.000	-0.122	3.266	68.800
FTALLSH	1.000	-0.172	3.679	63.328
FTIT	1.000	-0.851	7.222	19.991
Beta hedge				
FTSE 100	1.000	-0.020	2.500	77.613
FTSE 250	0.695	-0.134	5.606	39.566
FTSE 350	0.932	-0.048	2.752	73.711
FTALLSH	0.890	-0.052	2.820	71.896
FTIT	0.678	-0.501	5.270	41.621
C) Hedging with the FTSE Mid250 contract				
Traditional hedge				
FTSE 100	1.000	0.458	5.717	48.811
FTSE 250	1.000	0.012	2.610	71.868
FTSE 350	1.000	0.356	4.523	56.794
FTALLSH	1.000	0.306	4.188	58.264
FTIT	1.000	-0.373	4.789	46.952
Beta hedge				
FTSE 100	1.008	0.453	5.720	48.800
FTSE 250	1.000	0.012	2.610	71.868
FTSE 350	1.006	0.352	4.527	56.755
FTALLSH	0.976	0.321	4.160	58.534
FTIT	0.843	-0.278	4.424	50.994

* As table 3.1.

results indicate the new contract is not as effective at hedging its underlying index as is the more established contract, using the traditional strategy. The new contract is also less effective at hedging the FTSE 350 and FTALLSH indexes. Given the composition of the FTSE 350 and the FTALLSH indexes, these results are not surprising.

Results for other cross hedges are of more interest. First, panel B shows that the FTSE 100 contract was not effective at hedging either the Mid 250 or the FTIT indexes using the traditional hedge. For both hedges the standard deviation of returns is higher and mean returns lower for the hedged position than for the unhedged position. In contrast, the Mid 250 contract offers an effective means by which to cross-hedge. Table 3.1, panel C demonstrates that using this contract for a traditional hedge, when the spot portfolio is the FTSE 100, achieves risk reduction of over 36%. Similarly, risk reduction in relation to the FTIT spot portfolio is almost one third.

Now consider the beta hedge. The traditional and beta hedges are identical when the spot portfolio is that underlying the contract. For cross-hedging, the FTSE 100 contract is superior when hedging the FTSE 350 and FTALLSH (risk reduction of 61.4% and 60.3% respectively for the FTSE 100 contract, compared to 39.7% and 40.5% respectively for the Mid 250 contract). However the Mid 250 contract again is superior for cross-hedging other indexes. The FTSE 100 contract achieves risk reduction of below 29% when the spot portfolio is the Mid 250 or the FTIT. In contrast, for the FTSE 100 and FTIT spot portfolios, the Mid 250 index achieves risk reduction in excess of one third with the beta strategy. The results suggest that for daily hedging the new contract provides an important additional hedging vehicle for some broadly diversified portfolios.

Table 3.2 shows results for traditional and beta weekly hedges. Results are very similar to those for daily data, although the new contract's value is more marked. When the spot portfolio is that underlying the contract, risk reduction is substantial with both futures (over 70%), as in previous studies for the FTSE 100 (see Holmes (1995, 1996)). Thus, hedging effectiveness improves as hedge duration rises. For cross hedges, the new contract again achieves superior risk reduction for the FTIT (47% compared to 20% for the FTSE 100 contract).

Tables 3.3 and 3.4 report daily and weekly results respectively for the mean and standard deviation of returns using the MVHR. Results relate to the same spot portfolios as in tables 3.1 and 3.2. For convenience panel A again shows details of unhedged positions. Panels B and C show results for hedging with the FTSE 100 and Mid 250 contracts respectively. Panel D reports results for the 'synthetic' FTSE 350 contract. Results are reported for the optimal combination of the two contracts[11]. The optimal combinations of the FTSE 100 and Mid 250 contracts for daily data for the four spot portfolios are 0.75:0.25 (FTSE 100), 0:1 (Mid 250), 0.75:0.25 (FTSE 350), 0.75:0.25 (FTALLSH) and 0.25:0.75 (FTIT). Thus, for example, in constructing a synthetic futures which minimises the return variance when hedging the FTIT portfolio, the optimal mix involves a weighting of 0.25 in the FTSE 100 contract and 0.75 in the new contract.

Table 3.3)
Hedging Effectiveness Using the MVHR Strategy: Daily Data.

Spot Portfolio	Hedge Ratio	Mean Return	S. D. of Returns	Decrease in S.D.*
A) Unhedged				
FTSE 100		7.669	10.912	
FTSE 250		4.464	6.999	
FTSE 350		6.937	9.737	
FTALLSH		6.579	9.218	
FTIT		1.691	8.138	
B) Hedging with the FTSE100 contract				
FTSE 100	0.803	1.392	2.960	72.873
FTSE 250	0.391	1.411	4.781	31.682
FTSE 350	0.710	1.390	2.943	69.776
FTALLSH	0.669	1.352	2.912	68.409
FTIT	0.451	-1.831	5.616	30.994
C) Hedging with the FTSE Mid250 contract				
FTSE 100	1.050	3.072	6.927	36.521
FTSE 250	0.766	1.111	3.343	52.242
FTSE 350	0.985	2.625	5.681	41.656
FTALLSH	0.941	2.463	5.290	42.614
FTIT	0.779	-1.718	5.209	35.991
D) Composite hedges**				
FTSE 100	0.924	1.245	2.882	73.591
FTSE 250	0.766	1.111	3.343	52.242
FTSE 350	0.823	1.211	2.609	73.206
FTALLSH	0.777	1.173	2.555	72.281
FTIT	0.743	-2.201	4.892	39.890

* As table 3.1.

**Results are reported for the optimal combination of FTSE-100 and FTSE-Mid 250 contract in terms of maximum risk reduction. The optimal combinations are 0.75:0.25, 0:1, 0.75:0.25, , 0.75:0.25 and 0.25:0.75 respectively.

Table 3.4)
Hedging Effectiveness Using the MVHR Strategy: Weekly Data.

Spot Portfolio	Hedge Ratio	Mean Return	S. D. of Returns	Decrease in S.D.*
A) Unhedged				
FTSE 100		7.687	11.169	
FTSE 250		4.474	9.276	
FTSE 350		6.953	10.469	
FTALLSH		6.594	10.033	
FTIT		1.695	9.027	
B) Hedging with the FTSE100 contract				
FTSE 100	0.882	0.108	2.026	81.860
FTSE 250	0.601	-0.032	5.483	40.895
FTSE 350	0.819	0.075	2.367	77.390
FTALLSH	0.781	0.066	2.473	75.356
FTIT	0.595	-0.411	5.166	42.765
C) Hedging with the FTSE Mid250 contract				
FTSE 100	0.985	0.467	5.715	48.827
FTSE 250	0.918	0.062	2.483	73.228
FTSE 350	0.970	0.374	4.514	56.885
FTALLSH	0.938	0.344	4.144	58.696
FTIT	0.809	-0.257	4.411	51.134
D) Composite hedges**				
FTSE 100	0.959	0.139	1.975	82.317
FTSE 250	0.918	0.062	2.483	73.228
FTSE 350	0.900	0.094	1.794	82.863
FTALLSH	0.861	0.082	1.844	81.623
FTIT	0.795	-0.344	4.173	53.775

* As table 3.1.

** Results are reported for the optimal combination of FTSE-100 and FTSE-Mid 250 contract in terms of maximum risk reduction. The optimal combinations are 0.75:0.25, 0:1, 0.75:0.25, 0.75:0.25 and 0.25:0.75 respectively.

Table 3.3, panel B shows the FTSE 100 contract greatly reduces risk for the FTSE 100 (72.9%), FTSE 350 (69.8%) and FTALLSH (68.4%) spot portfolios for daily hedges. For the other portfolios risk reduction of only about 30% is achieved. The Mid 250 contract is less successful at reducing risk for the FTSE 100, FTSE 350 and FTALLSH spot portfolios, as expected, given that the FTSE 100 dominates these indexes by market capitalisation. However, for the other portfolios the new contract is superior for hedging. Risk reduction of 52% and 36% is achieved for the Mid 250 and FTIT spot portfolios. Thus, for portfolios with smaller capitalisation the new contract is a significant additional hedging facility.

Results in relation to the construction of a synthetic futures are very interesting (see panel D). In all cases, the optimal combination involves some use of the new contract, while for the Mid 250 spot portfolio the FTSE 100 contract should not be used. Thus, even for the FTSE 100 spot portfolio, the introduction of the new contract adds to hedging effectiveness[12].

Again, hedge performance improves as hedge duration rises to a week. However, the main results are unchanged: for the FTSE 100, FTSE 350 and FTALLSH portfolios, the FTSE 100 contract provides higher risk reduction than the Mid 250 contract, with the new contract superior for other spot portfolios. Optimal combinations for the synthetic contract reported for weekly hedges are the same as for daily data. Thus, the new contract improves hedging effectiveness even when the spot portfolio is that underlying the FTSE 100 contract.

We now examine the hedging effectiveness of the two contracts when the spot portfolios are ITCs. Rather than report results for each of the thirty-two portfolios, we report average results for each category of ITCs. Results using traditional and beta hedge strategies for daily and weekly hedge durations are presented in tables 3.5 and 3.6 respectively. The format of the tables is similar to tables 3.1 and 3.2, with three panels in each table. However, in addition to showing the average risk reduction for each category of investment trust, the maximum and minimum standard deviations for each category are shown. Panel A in both tables 3.5 and 3.6 demonstrates that the spot portfolios vary substantially in terms of mean and standard deviations of returns. Thus, the thirty-two portfolios under consideration cover a broad range of spot portfolios, providing an opportunity for a thorough assessment of true hedge effectiveness.

Results for the daily cross hedges in table 3.5, panel B shows that the FTSE 100 contract was not effective at hedging any of the categories of ITC's using the traditional hedge. In all cases the standard deviation of returns is higher and mean returns lower for the average hedged portfolio than for the average unhedged position. While the results in panel C show that using the traditional strategy in relation to the Mid 250 contract results in a small reduction of risk for three of the seven ITC categories, the overall extent of risk reduction is still very poor. Owing to the low covariance relationship between the futures contracts and ITC's, the traditional strategy of assuming an hedge ratio equal to unity results in severe over-hedging.

Table 3.5)
Hedging Investment Trust Portfolios Using the FTSE 100 and FTSE Mid 250 Contracts: Daily data.

	Average	Average	Standard Deviation of Returns			
	Hedge Ratio	Mean Return	Minimum	Maximum	Average	Decrease*
A Unhedged portfolio						
General		5.905	8.652	13.975	10.676	
Capital Growth		3.362	8.260	12.525	9.556	
Income Growth		0.553	7.665	11.925	9.879	
High Income		-5.079	8.927	13.897	10.681	
Small Company		1.880	6.744	12.409	9.743	
Venture / Development		11.535	6.708	9.603	8.111	
Property		-7.579	13.497	13.884	13.691	
B) Hedging with the FTSE100 contract						
Traditional hedge						
General	1.000	-1.910	9.621	12.290	11.417	-9.856
Capital Growth	1.000	-4.453	12.022	14.635	13.514	-44.392
Income Growth	1.000	-7.262	11.129	13.471	12.366	-29.466
High Income	1.000	-12.894	13.091	15.443	13.865	-31.952
Small Company	1.000	-5.935	13.122	14.429	13.736	-46.924
Venture / Development	1.000	3.720	12.178	14.312	13.504	-69.996
Property	1.000	-15.394	16.136	18.138	17.137	-25.093
Beta Hedge						
General	0.597	1.241	7.828	11.559	8.954	15.660
Capital Growth	0.322	0.849	8.060	11.766	9.044	5.143
Income Growth	0.450	-2.962	7.298	10.891	8.838	9.968
High Income	0.372	-7.985	8.576	13.131	10.113	5.267
Small Company	0.313	-0.564	6.660	11.171	9.264	4.449
Venture / Development	0.223	9.794	6.649	9.397	7.834	3.210
Property	0.278	-9.748	13.107	13.848	13.477	1.578
C) Hedging with the FTSE Mid 250 contract						
Traditional hedge						
General	1.000	1.529	7.649	10.848	8.552	19.168
Capital Growth	1.000	-1.015	8.250	11.645	9.631	-1.867
Income Growth	1.000	-3.823	7.905	10.819	8.891	8.047
High Income	1.000	-9.456	9.327	12.597	10.320	2.591
Small Company	1.000	-2.496	8.827	10.934	10.006	-5.275
Venture / Development	1.000	7.159	8.697	10.299	9.386	-17.723
Property	1.000	-11.956	13.089	14.351	13.720	-0.170
Beta Hedge						
General	1.002	1.519	7.308	10.954	8.411	20.888
Capital Growth	0.621	0.646	7.540	11.383	8.690	8.905
Income Growth	0.815	-3.013	7.135	10.617	8.350	14.792
High Income	0.692	-8.107	8.402	12.524	9.690	9.149
Small Company	0.586	-0.682	6.478	10.899	8.968	7.532
Venture / Development	0.425	9.674	6.502	9.113	7.655	5.340
Property	0.649	-10.417	12.750	13.550	13.150	3.971

* The decrease in the S.D. of returns relates to a comparison of the average S.D. of returns for the hedged position with that of the unhedged position

Table 3.6)
Hedging Investment Trust Portfolios Using the FTSE 100 and FTSE Mid 250 Contracts: Weekly data.

	Average	Average	Standard Deviation of Returns			
	Hedge Ratio	Mean Return	Minimum	Maximum	Average	Decrease*
A) Unhedged portfolio						
General		5.919	10.870	13.604	11.816	
Capital Growth		3.370	10.403	13.546	11.568	
Income Growth		0.554	9.992	14.124	11.894	
High Income		-5.091	10.764	15.406	12.785	
Small Company		1.885	8.890	14.456	11.990	
Venture / Development		11.561	7.961	10.857	9.347	
Property		-7.596	16.393	17.599	16.996	
B) Hedging with the FTSE100 contract						
Traditional hedge						
General	1.000	-0.265	7.402	11.235	10.024	14.549
Capital Growth	1.000	-0.619	11.485	14.496	13.069	-13.801
Income Growth	1.000	-1.009	9.230	13.071	11.449	2.842
High Income	1.000	-1.792	11.271	14.662	13.010	-2.673
Small Company	1.000	-0.825	11.432	13.748	12.922	-10.566
Venture / Development	1.000	0.517	11.486	14.265	12.740	-38.430
Property	1.000	-10.373	16.161	17.661	16.911	0.216
Beta Hedge						
General	0.721	0.038	6.883	9.955	8.868	24.710
Capital Growth	0.455	-0.027	9.358	12.045	10.515	8.967
Income Growth	0.617	-0.593	8.264	11.135	9.807	17.390
High Income	0.575	-1.330	9.628	13.707	11.281	11.830
Small Company	0.507	-0.289	8.599	12.674	10.680	10.511
Venture / Development	0.307	1.270	7.507	9.961	8.705	6.574
Property	0.594	-1.699	15.621	15.773	15.712	7.420
C) Hedging with the FTSE Mid 250 contract						
Traditional hedge						
General	1.000	0.212	6.928	9.971	8.389	28.970
Capital Growth	1.000	-0.141	8.961	12.143	10.820	5.926
Income Growth	1.000	-0.531	8.069	10.403	9.402	20.436
High Income	1.000	-1.314	9.554	13.354	11.209	11.980
Small Company	1.000	-0.347	9.053	12.366	10.653	9.788
Venture / Development	1.000	0.995	9.794	11.404	10.432	-12.989
Property	1.000	-8.411	15.174	15.604	15.389	9.293
Beta Hedge						
General	0.894	0.277	6.921	9.962	8.251	30.204
Capital Growth	0.631	0.084	8.770	11.768	9.952	13.806
Income Growth	0.819	-0.421	7.864	10.076	9.059	23.575
High Income	0.739	-1.155	9.218	13.231	10.752	15.986
Small Company	0.721	-0.177	8.063	12.211	10.022	16.159
Venture / Development	0.416	1.350	7.291	9.732	8.491	8.907
Property	0.863	-1.578	15.179	15.211	15.195	10.480

* As table 3.5.

With respect to the beta strategy, for all categories of ITC's, hedging with the FTSE 100 and Mid 250 contracts results in hedge ratios which are less than unity and more effective than the traditional strategy. However, the risk reduction achieved is only a fraction of that achieved when the spot portfolios are broad based market indexes. While hedging effectiveness is greater for the Mid 250 contract than the FTSE 100 contract in relation to all the ITC's, the differences are small. For instance, in relation to daily hedges, average risk reduction is below 10% for all but 1 of the 7 categories of ITC's when cross hedges comprise the FTSE 100 contract, and below 10% for all but 2 of the 7 categories when cross hedges comprising the Mid 250 contract are used.

Table 3.6 shows results for traditional and beta weekly hedges with respect to the ITC's. While the results are very similar to those for daily data, all hedges are characterised by improvements in risk reduction as we move from a daily to a weekly basis. Thus, hedging effectiveness improves as hedge duration rises. The Mid 250 contract also dominates the FTSE 100 contract in terms of risk reduction and mean returns in relation to every ITC category, with respect to both traditional and beta strategies. This result is interesting since it indicates that where the spot portfolio consists of lower capitalisation stocks the Mid 250 contract provides an unequivocally more effective hedge.

Finally, tables 3.7 and 3.8 report the results for ITC's for daily and weekly MVHR's respectively. The format of the tables is similar to tables 3.3 and 3.4, with four panels in each table. However, as in tables 3.5 and 3.6, in addition to showing average risk reduction for each category of ITC, maximum and minimum standard deviations for each category are also shown. As can be seen in table 3.7, panels B and C, in all cases average standard deviation of returns are lower and average mean returns are higher with a MVHR strategy, than is the case for either the traditional or beta strategy. Furthermore, the Mid 250 contract produces hedges that are associated with lower risk and higher mean returns than compared to using the FTSE 100 contract. The same is true for weekly hedges (see table 3.8), providing strong evidence in support of the usefulness of the Mid 250 contract for hedging actual spot portfolios.

However, while the results show the superiority of the Mid 250 contract for hedging these spot portfolios, risk reduction is far less than when spot portfolios are broad based market indexes. For example, for daily hedges (table 3.7), in no case does average risk reduction exceed 22% for the ITC portfolios and even when using the Mid 250 contract, average reduction is below 10% for 5 categories. This compares with risk reduction for broad market indexes of 36% to 52% when the Mid 250 contract is used and up to 73% for the FTSE 100 contract. The results for Smaller Companies funds and Venture and Development Capital funds are particularly weak, suggesting that while the new contract relates to an index covering smaller companies, it is still not suitable for hedging portfolios comprising very low value stocks. Results for weekly hedges are markedly better. In only one case is average risk reduction below 10% when using the Mid 250 contract (three when using the FTSE 100 contract) and average risk reduction of almost one third is achieved for the General funds using the new contract.

Table 3.7)
Hedging Investment Trust Portfolios Using the MVHR strategy: Daily Data.

	Average	Average	Standard Deviation of Returns			
	Hedge Ratio	Mean Return	Minimum	Maximum	Average	Decrease*
Spot Portfolio						
A) Unhedged portfolio						
General		5.905	8.652	13.975	10.676	
Capital Growth		3.362	8.260	12.525	9.556	
Income Growth		0.553	7.665	11.925	9.879	
High Income		-5.079	8.927	13.897	10.681	
Small Company		1.880	6.744	12.409	9.743	
Venture / Development		11.535	6.708	9.603	8.111	
Property		-7.579	13.497	13.884	13.691	
B) Hedging with the FTSE100 contract						
General	0.459	2.319	7.726	11.299	8.771	17.342
Capital Growth	0.237	1.512	7.988	11.688	8.966	5.961
Income Growth	0.343	-2.131	7.254	10.802	8.721	11.101
High Income	0.278	-7.252	8.537	13.014	10.036	5.972
Small Company	0.211	0.233	6.645	10.995	9.222	4.789
Venture / Development	0.159	10.293	6.614	9.350	7.785	3.789
Property	0.186	-9.036	12.995	13.821	13.408	2.088
C) Hedging with the FTSE Mid250 contract						
General	0.832	2.263	7.229	10.809	8.297	21.953
Capital Growth	0.497	1.186	7.465	11.334	8.629	9.556
Income Growth	0.658	-2.325	7.060	10.535	8.252	15.788
High Income	0.571	-7.580	8.334	12.465	9.639	9.643
Small Company	0.478	-0.213	6.447	10.818	8.925	7.975
Venture / Development	0.332	10.084	6.472	9.075	7.615	5.821
Property	0.490	-9.725	12.660	13.511	13.086	4.445
D) Composite hedges+						
General	0.804	1.919	7.216	10.544	8.142	23.277
Capital Growth	0.490	1.115	7.465	11.334	8.610	9.752
Income Growth	0.625	-2.573	7.060	10.458	8.205	16.216
High Income	0.562	-7.633	8.334	12.465	9.636	9.666
Small Company	0.473	-0.315	6.429	10.689	8.896	8.233
Venture / Development	0.328	10.118	6.469	9.075	7.614	5.830
Property	0.507	-9.427	12.660	13.412	13.036	4.802

* As table 3.5.

\+ The optimal combinations of the FTSE-100 and Mid 250 contract ranges from 0.25:0.75 to -0.5 to 1.5. For no portfolio did the weight given to the Mid 250 contract fall below 0.75.

Table 3.8)
Hedging Investment Trust Portfolios Using the MVHR Strategy: Weekly Data.

	Average	Average	Standard Deviation of Returns			
	Hedge Ratio	Mean Return	Minimum	Maximum	Average	Decrease*
Spot Portfolio						
A) Unhedged portfolio						
General		5.919	10.870	13.604	11.816	
Capital Growth		3.370	10.403	13.546	11.568	
Income Growth		0.554	9.992	14.124	11.894	
High Income		-5.091	10.764	15.406	12.785	
Small Company		1.885	8.890	14.456	11.990	
Venture / Development		11.561	7.961	10.857	9.347	
Property		-7.596	16.393	17.599	16.996	
B) Hedging with the FTSE100 contract						
General	0.623	0.144	6.785	9.865	8.784	25.429
Capital Growth	0.381	0.053	9.290	12.004	10.471	9.343
Income Growth	0.532	-0.501	8.228	11.014	9.746	17.882
High Income	0.486	-1.234	9.583	13.660	11.226	12.262
Small Company	0.435	-0.211	8.591	12.633	10.640	10.837
Venture / Development	0.259	1.322	7.485	9.930	8.684	6.794
Property	0.509	-1.606	15.585	15.766	15.676	7.632
C) Hedging with the FTSE-Mid 250 contract						
General	0.864	0.295	6.920	9.960	8.243	30.279
Capital Growth	0.586	0.111	8.754	11.762	9.941	13.910
Income Growth	0.785	-0.400	7.852	10.074	9.052	23.639
High Income	0.705	-1.135	9.215	13.227	10.746	16.031
Small Company	0.672	-0.147	8.060	12.205	10.009	16.263
Venture / Development	0.391	1.365	7.290	9.725	8.486	8.953
Property	0.776	-1.525	15.153	15.190	15.171	10.618
D) Composite hedges+						
General	0.853	0.216	6.268	9.617	8.036	31.974
Capital Growth	0.588	0.120	8.596	11.706	9.868	14.525
Income Growth	0.779	-0.439	7.750	10.055	8.960	24.431
High Income	0.693	-1.179	9.215	13.205	10.728	16.182
Small Company	0.673	-0.147	7.902	12.174	9.971	16.662
Venture / Development	0.385	1.348	7.290	9.708	8.439	9.450
Property	0.773	-1.538	15.110	15.136	15.123	10.905

* As table 3.5.

+ The optimal combinations of the FTSE-100 and FTSE-Mid 250 contract ranges from 0.5:0.5 to -0.75 to 1.75. For no portfolio did the weight given to the FTSE-Mid 250 contract fall below 0.5.

Results for the optimal synthetic futures show minor improvement over results for the Mid 250 contract. In all cases the optimal combination involves using the Mid 250 contract[13] again supporting the view that the new contract has an important role to play, especially in relation to hedging portfolios which are not broadly diversified.

3.6) RESULTS: EX ANTE HEDGING EFFECTIVENESS

In this section the empirical results relating to the ex ante performance of both futures contracts are reported. All the tables are organised in the same fashion and consist of four panels of results. For each table, panel A reports the mean and standard deviation of return for each of the unhedged spot portfolios; panel B reports the MVHR ex post hedging effectiveness results, establishing a comparative benchmark; panel C reports the results for the ex ante hedge resulting from a window size of 13 weeks; panel D reports the results for the ex ante hedge resulting from a window size of 26 weeks.

Firstly, hedging effectiveness is examined where the underlying spot portfolios are market indexes. In table 3.9, the results are reported for the FTSE 100 contract. The results show that the FTSE 100 contract achieves considerable levels of risk reduction (both in an ex post and ex ante context) when the underlying spot portfolios consist of broad based stock indexes. With respect to panel B, the FTSE 100 contract eliminates 81.1% of the risk associated with the underlying spot index. While the levels of risk reduction for the related cross hedges are not as great, they are still considerable: for the Mid 250, FTSE 350, FTALLSH and FTIT indices, the FTSE 100 contract reduces risk by 35.9%, 76.5%, 74.2% and 38% respectively. With respect to these cross hedging results it is evident that the FTSE 100 contract produces the most effective hedges for those indexes which are dominated by large capitalisation stocks, and least effective hedges for those stocks dominated by smaller capitalisation stocks. Even so, in order to reduce this risk the hedger has to sacrifice considerable mean returns on all stock indexes.

More importantly, panels C and D in table 3.9 demonstrate that the hedger can achieve similar levels of risk reduction by employing the dynamic ex ante hedging strategy based on the moving window procedure. For the ex ante strategy utilising a 13 week window the hedger can achieve in excess of 95% of the risk reduction levels attained by the static ex post strategy for all five spot indexes. When the window size is extended to 26 weeks there is a marginal improvement, with risk reduction approaching the ex post benchmark for all reported stock indexes. These findings indicate that hedge ratio instability is not a serious problem for ex ante hedging effectiveness when both the spot and futures instruments are liquid instruments. Where both the instruments are relatively well traded, this would result in a strong and uniform covariance relationship between spot and futures returns (see equation 3.9), leading to relative hedge ratio stability. This is confirmed by examining the hedge ratio stability statistics in panel C and D for the 13 and 26 week windows. These figures clearly show that there is a positive relationship between hedge ratio stability and the proportion of the ex post hedging effectiveness which the ex ante strategy manages to achieve. For instance, an ex ante hedging strategy which utilises a 26 week window produces more stable hedge ratios and a greater level of risk reduction than an ex ante hedging strategy which utilises a 13 week window. This point is demonstrated graphically in figures 3.4a which plots the stability of the direct and cross hedges associated with the FTSE 100 index future for a 13 and 26 week

Table 3.9)
Ex Ante Hedging Effectiveness of the FTSE-100 Contract: Stock Market Indexes

	Average Hedge Ratio	Average Mean Return*	S.D. of Returns*	Decrease in S.D.**	Stability of Hedge Ratio+
A) Unhedged					
FTSE100		10.1972	9.9917		
FTSE250		7.0408	8.3699		
FTSE350		9.4796	9.3254		
FTALLSH		9.1728	8.9389		
FTIT		2.8652	8.3166		
B) Ex Post Hedging					
FTSE100	0.8854	1.2064	1.8886	81.0962	
FTSE250	0.5798	1.1544	5.3643	35.9099	
FTSE350	0.8179	1.1700	2.1943	76.4698	
FTALLSH	0.7793	1.2584	2.3068	74.1892	
FTIT	0.5889	-3.1148	5.1552	38.0142	
C) Ex Ante Hedging - 13 Week Window					
FTSE100	0.8862	1.3364	1.9910	80.0715	0.3065
FTSE250	0.5617	1.7160	5.5324	33.9026	0.7377
FTSE350	0.8144	1.4040	2.2917	75.4255	0.3425
FTALLSH	0.7744	1.4976	2.3999	73.1565	0.3519
FTIT	0.5885	-3.1668	5.2562	36.7994	0.8343
D) Ex Ante Hedging - 26 Week Window					
FTSE100	0.8826	1.2792	1.9391	80.5933	0.1687
FTSE250	0.5780	1.0868	5.4350	35.0623	0.4060
FTSE350	0.8150	1.2168	2.2398	75.9807	0.1853
FTALLSH	0.7748	1.3156	2.3515	73.6954	0.1875
FTIT	0.5965	-3.5828	5.2136	37.3128	0.4911

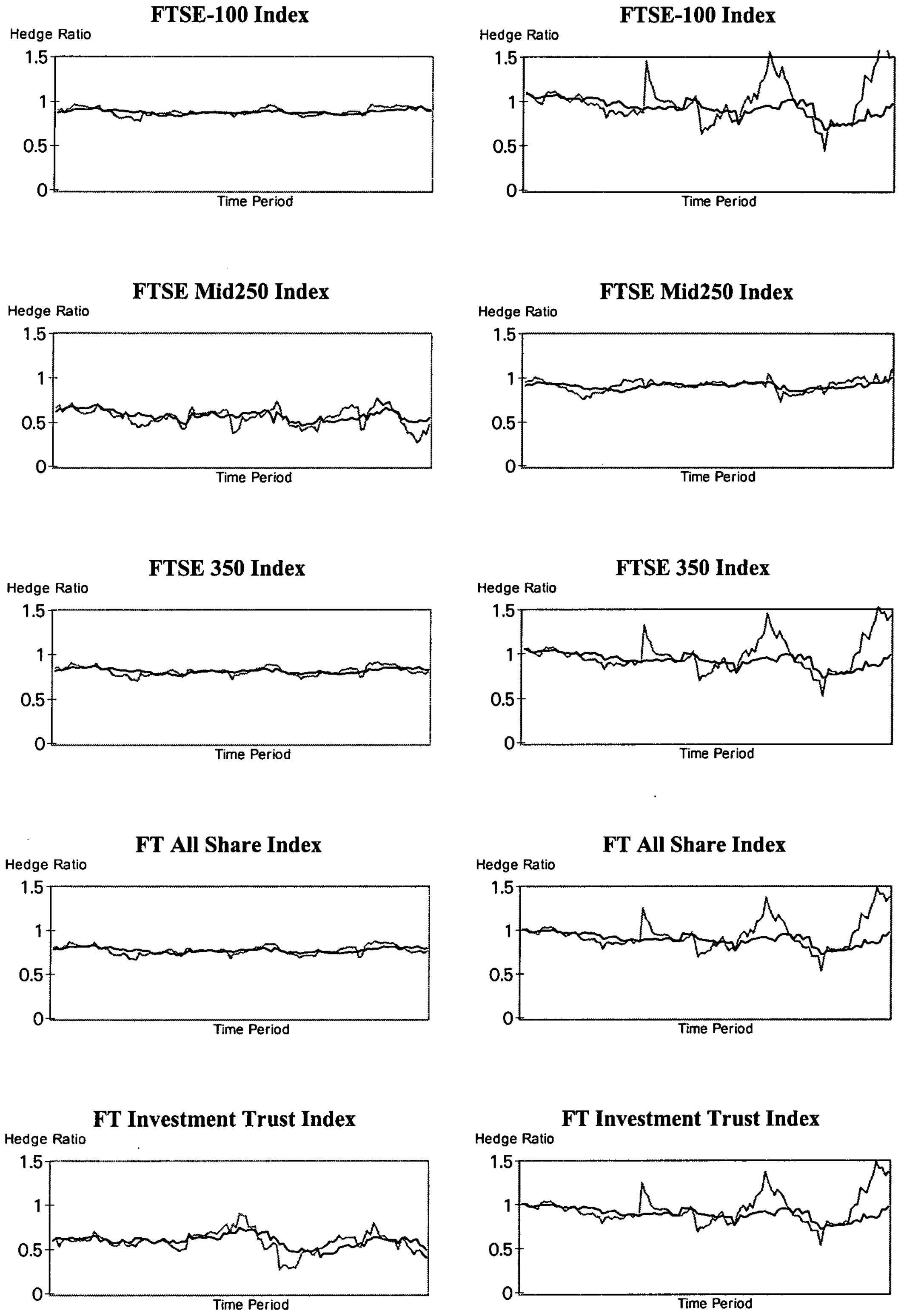
* All mean and standard deviation statistics have been annualised to improve their readability.

** This measures the percentage of the standard deviation of return of the unhedged position that is removed by hedging, and is calculated as:

$$\text{Risk reduction} = \frac{\sigma_u - \sigma_h}{\sigma_u} \times 100$$

+ This refers to the variability of the ex ante hedge ratio series measured in terms of the standard deviation of the series.

Figure 3.4 -Ex Ante Hedge Ratio Stability: Stock Indexes*



a) FTSE-100 Index Futures Contract

b) Mid250 Index Futures Contract

* Each plot illutrates the stability of ex ante hedge ratios estimated on the basis of 13 and 26 week windows over the period September 1994 to December 1996. Where the lighter series refers to hedge ratios estimated on the basis of a 13 week window and the darker series refers to the hedge ratios estimated on the basis of a 26 week window.

window respectively. The ex ante hedge ratios which are estimated on the basis of a larger window size are all characterised by greater stability. As Holmes (1995) argued this was to be expected, since when using a larger window the weight attached to outliers is reduced and a more representative hedge ratio is generated.

In table 3.10 the ex post and ex ante hedging effectiveness of the Mid 250 contract is reported for the same five spot indexes. Once again the results show that when the underlying spot portfolios are market indexes, the risk reduction achieved on both an ex ante and ex post basis is substantial. With respect to the ex post strategy (panel B), the Mid 250 contract eliminates 72.5% of the risk associated with its underlying spot index. While this level of risk reduction is not as great as the direct FTSE 100 hedge it is still considerable. For the cross hedges with the FTSE 100, FTSE 350, FTALLSH and FTIT indexes, the Mid 250 contract reduces risk by 42%, 50.9%, 53% and 46.4% respectively. As was previously found, the FTSE 100 index futures contract is more effective at eliminating risk on indexes which are dominated by large capitalisation stocks, and the Mid 250 contract is more effective at eliminating risk on indexes which are dominated by low capitalisation stocks. Furthermore, the mean returns on these cross hedges were also greater than those associated with the FTSE 100 contract.

The ex ante hedging effectiveness for the Mid 250 contract with respect to the market indexes is reported in panels C and D. Once again, ex ante hedging effectiveness was found to be a function of the window size employed, with the 26 week window resulting in hedge ratios that were more stable, and more effective in reducing risk

Table 3.10)

Ex Ante Hedging Effectiveness of the Mid250 Contract: Stock Market Indexes

	Average Hedge Ratio	Average Mean Return	S.D. of Returns	Decrease in S.D.	Stability of Hedge Ratio
A) Unhedged					
FTSE100		10.1972	9.9917		
FTSE250		7.0408	8.3699		
FTSE350		9.4796	9.3254		
FTALLSH		9.1728	8.9389		
FTIT		2.8652	8.3166		
B) Ex Post Hedging					
FTSE100	0.9290	3.7180	5.7920	42.0287	
FTSE250	0.9182	0.6344	2.3032	72.4816	
FTSE350	0.9270	3.0108	4.5790	50.8988	
FTALLSH	0.9002	2.8964	4.2034	52.9739	
FTIT	0.8013	-2.7196	4.4550	46.4271	
C) Ex Ante Hedging - 13 Week Window					
FTSE100	1.0008	2.8288	6.1294	38.6549	1.6593
FTSE250	0.9154	0.4108	2.3883	71.4658	0.4680
FTSE350	0.9819	2.2568	4.8307	48.2017	1.3189
FTALLSH	0.9481	2.2984	4.4182	50.5756	1.2331
FTIT	0.8143	-1.6484	4.6966	43.5221	1.0896
D) Ex Ante Hedging - 26 Week Window					
FTSE100	0.9320	4.6800	5.9340	40.6072	0.7110
FTSE250	0.9100	0.5980	2.3386	72.0603	0.2315
FTSE350	0.9273	3.7492	4.6908	49.6988	0.5524
FTALLSH	0.8972	3.6140	4.2978	51.9237	0.4846
FTIT	0.7938	-2.3244	4.5343	45.4757	0.5286

than those associated with a 13 week window. For instance, the standard deviation of the ex ante hedge ratio series relating to the Mid 250 direct hedge fell from 0.468 for a 13 week hedge to 0.2315 for a 26 week hedge, with hedging effectiveness increasing from 71.5 % to 72.1%. Compared to the FTSE 100 contract, the Mid 250 contract does not achieve the same proportion of ex post risk reduction when employing an ex ante strategy. This discrepancy can be accounted for by the fact that hedges underpinned by the Mid 250 contract are characterised by greater inter-temporal hedge ratio instability, reflecting the illiquid nature of this contract. The instability associated with the hedge ratio series relating to the Mid 250 contract is illustrated in figures 3.4b. Compared to the relevant hedges for the FTSE 100 contract in figures 3.4a the Mid 250 contract is clearly characterised by greater hedge ratio instability. The instability is particularly acute for cross hedges, where the covariance relationship is weaker and characterised by greater variability. For instance, the ex ante hedge ratio series resulting from the cross-hedge between the FTSE 100 contract and the Mid 250 index is significantly more stable than that corresponding to the cross hedge between the Mid 250 contract and the FTSE 100 index, both with respect to the 13 and 26 week window. Overall, the results in table 4.9 and 4.10 suggest that when the underlying spot portfolio is a well diversified market index, with a composition similar to the index futures contract, the degree of risk reduction achieved by both the static ex post and dynamic ex ante hedging strategies are substantial and of a similar magnitude.

Hitherto, both the ex ante hedging strategies have focused on specific cases where the spot portfolio consists of market indexes. However, Holmes and Amey (1995) have demonstrated that by evaluating hedging effectiveness using spot portfolios that are very similar in composition to the index futures contract, the potential for risk reduction was likely to be overstated. Likewise, the results from the first stage of this empirical analysis suggest that ex post hedging effectiveness for spot portfolios which differ significantly in composition from the associated index futures contract are significantly less than previous studies have suggested. In order to address these problems and provide a more representative evaluation of the risk reduction potential of these contracts, the ex ante hedging effectiveness of the FTSE 100 and Mid 250 contracts is examined where the associated spot portfolios consist of investment trust companies. As in the earlier section, rather than reporting the results for each of the funds individually, the average results for each category are reported. The results for the FTSE 100 and Mid 250 contracts are reported in tables 3.11 and 3.12 respectively.

In panels B, C and D of tables 3.11 and 3.12 the standard deviation of returns for the hedged spot portfolios are shown. The standard deviations are lower on both an ex post and ex ante basis in every fund category for the Mid 250 than for the FTSE 100 contract, indicating that cross-hedges using the Mid 250 contract are associated with lower basis risk. This finding is hardly surprising, given that like the Mid 250 contract these portfolios tend to be dominated by low capitalisation stocks.

While the ex post results in tables 3.11 and 3.12 show that the Mid 250 contract dominates the FTSE 100 contract in terms of the risk reduction when ITC's are used, the degree of risk reduction is only a fraction of that achieved when the spot portfolios are market indexes. For instance, with respect to the Mid 250 contract only the general category of ITC's achieves risk reduction in excess of 25%, and the majority of categories achieve risk reduction of less than 15%. These results reflect the relatively weak covariance relationship that exists been both contracts and the respective ITC's. Even so, ex ante hedging effectiveness can be regarded as quite effective, with a large proportion of the ex post reduction in risk being achieved using an ex ante strategy. This is despite the fact that the stability statistics indicate that the ex ante hedge ratio series associated with ITC's are several times larger than those associated with the cross-hedges based on market indexes, indicating greater hedge ratio instability. As Benet (1990) suggested, possible reasons for the difference in performance with regards to minor cross-hedges were, greater and more variable basis risk which is inherent in cross-hedges, and the weaker economic relationship between the futures contract and the vehicle to be hedged. These problems manifest themselves in a volatile covariance relationship. Given the low and unstable covariance relationship between the ITC's and the respective futures contract, the static traditional strategy of adopting a hedge ratio equal to unity would result in serious mishedging. It is evident in figures 3.5 and 3.6 that for all ITC categories, the optimal ex ante hedge ratio rarely equates to unity, and indeed has the potential to deviate considerably from this value.

As with the ex ante hedging results associated with the market indexes, the level of ex ante risk reduction associated with ITC's for both contracts can be seen to be a function of the window size employed. For instance, as the window size increases from 13 to 26 weeks, the ex ante hedge ratio series stabilises producing more effective hedges, which results in greater risk reduction. This point is illustrated in

Table 3.11)
Ex Ante Hedging Effectiveness of the FTSE-100 Contract: Investment Trust Categories

	Average Hedge Ratio	Average Mean Return	S.D. of Returns	Decrease in S.D.*	Stability of Hedge Ratio
A) Unhedged					
General		9.6616	11.0734		
Capital Growth		6.0580	11.0914		
Income Growth		1.8200	11.2219		
High Income		-5.5744	12.7990		
Small Company		5.4964	11.0452		
Venture/Development		12.0172	9.2576		
Property		-2.0228	16.1045		
B) Ex Post Hedging					
General	0.6290	3.2708	8.4983	23.1495	
Capital Growth	0.3788	2.2100	10.1561	8.2035	
Income Growth	0.5372	-3.6348	9.4473	15.5963	
High Income	0.4860	-10.5092	11.5637	9.8850	
Small Company	0.4098	1.3312	9.9859	9.2375	
Venture/Development	0.3227	8.7360	8.5120	7.9895	
Property	0.5022	-7.1240	14.9349	7.3903	
C) Ex Ante Hedging - 13 Week Window					
General	0.6119	3.6816	8.7600	20.6421	1.6845
Capital Growth	0.3750	2.1372	10.6530	3.8426	1.8576
Income Growth	0.5146	-3.0576	9.7984	12.4972	1.8417
High Income	0.4701	-10.3012	12.0324	6.1904	2.3299
Small Company	0.4052	1.2012	10.5888	3.6743	1.9953
Venture/Development	0.3034	8.1796	8.8646	4.2625	1.7386
Property	0.4885	-8.5124	15.9870	0.8703	3.0489
D) Ex Ante Hedging - 26 Week Window					
General	0.6234	3.1148	8.6476	21.8453	1.1668
Capital Growth	0.3665	2.2932	10.3876	6.2005	1.1177
Income Growth	0.5301	-3.7752	9.7249	13.0686	1.1704
High Income	0.4714	-10.5664	11.7527	8.5331	1.5446
Small Company	0.4160	0.9620	10.2672	6.6895	1.1430
Venture/Development	0.3047	8.3824	8.6216	6.8470	1.2107
Property	0.5001	-7.0252	15.2536	5.4195	1.8309

* The decrease in the S.D. of returns relates to a comparison of the average S.D. of returns for the hedged position with that of the unhedged position on a category by category basis.

Table 3.12)

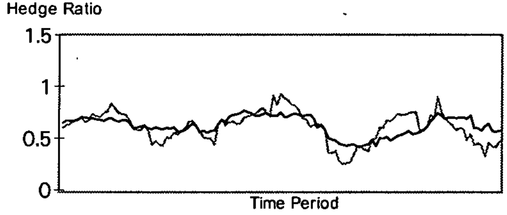
Ex Ante Hedging Effectiveness of the Mid 250 Contract: Investment Trust Categories

	Average Hedge Ratio	Average Mean Return	S.D. of Returns	Decrease in S.D.	Stability of Hedge Ratio
A) Unhedged					
General		9.6616	11.0734		
Capital Growth		6.0580	11.0914		
Income Growth		1.8200	11.2219		
High Income		-5.5744	12.7990		
Small Company		5.4964	11.0452		
Venture/Development		12.0172	9.2576		
Property		-2.0228	16.1045		
B) Ex Post Hedging					
General	0.8629	3.6400	8.0454	27.5594	
Capital Growth	0.6022	1.8616	9.6218	13.0926	
Income Growth	0.7901	-3.6868	8.7954	21.3930	
High Income	0.7228	-10.6132	11.0791	13.7292	
Small Company	0.6571	0.9100	9.3643	14.9601	
Venture/Development	0.4729	8.7152	8.2654	10.7153	
Property	0.8581	-8.0080	14.0566	12.8864	
C) Ex Ante Hedging - 13 Week Window					
General	0.8568	5.9332	8.3389	24.8036	2.4511
Capital Growth	0.5964	1.9396	10.0970	9.1159	2.9825
Income Growth	0.8027	-2.4804	9.1884	17.9125	2.5974
High Income	0.7539	-8.6944	11.3517	11.6227	3.8327
Small Company	0.6294	3.4112	10.1640	7.4545	2.6544
Venture/Development	0.4383	9.2196	8.6028	7.1126	2.6046
Property	0.8412	-5.7616	14.8354	8.0196	3.9726
D) Ex Ante Hedging - 26 Week Window					
General	0.8269	4.6540	8.2106	26.1099	1.4170
Capital Growth	0.5610	2.6676	9.9463	10.3073	1.7472
Income Growth	0.7730	-2.0072	8.9706	19.8064	1.7408
High Income	0.6985	-8.6112	11.1116	12.5943	2.3414
Small Company	0.6597	1.2220	9.6045	12.7629	1.3643
Venture/Development	0.4314	8.3460	8.3541	9.7994	1.5518
Property	0.8446	-8.1952	14.3912	10.8138	2.4914

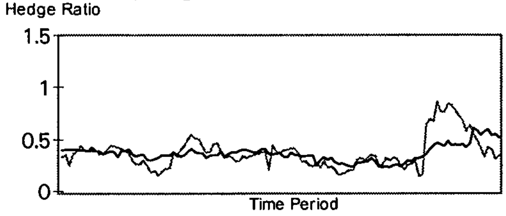
Figure 3.5)*

Ex Ante Hedge Ratio Stability: FTSE 100 Contract and Investment Trust Companies

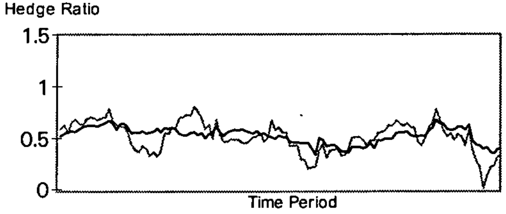
a) General Funds



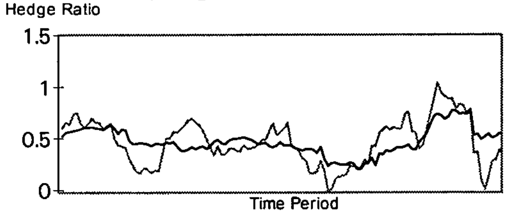
b) Capital Growth Funds



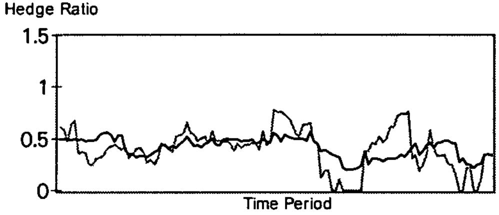
c) Income Growth Funds



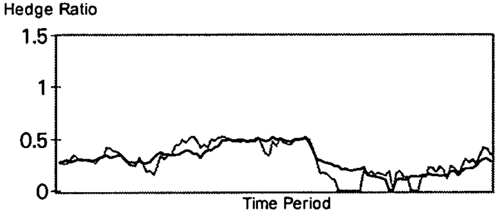
d) High Income Funds



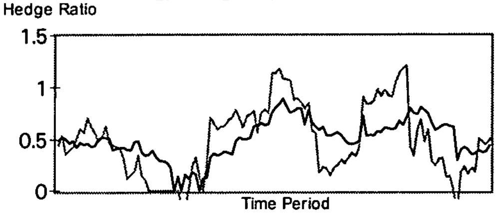
e) Small Company Funds



f) Venture/Development Funds



g) Property Funds

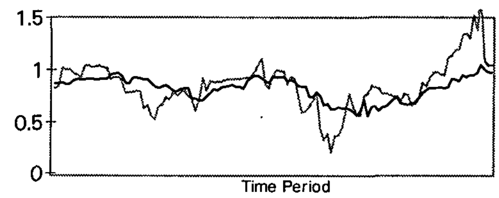


* As Figure 3.4

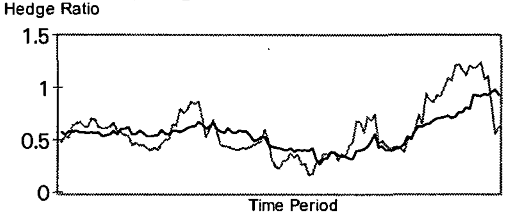
Figure 3.6)*

Ex Ante Hedge Ratio Stability: Mid250 Contract and Investment Trust Companies

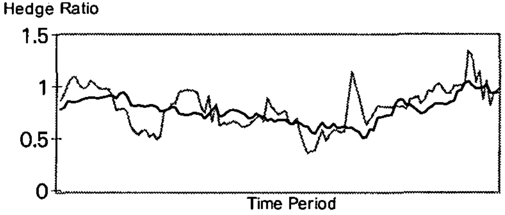
a) General Funds



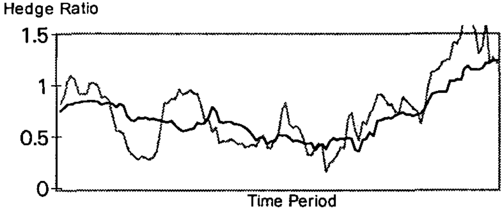
b) Capital Growth Funds



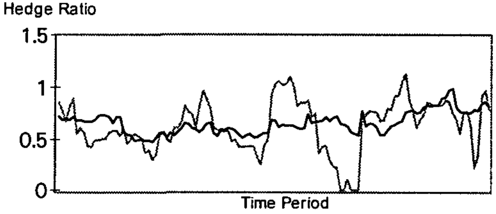
c) Income Growth Funds



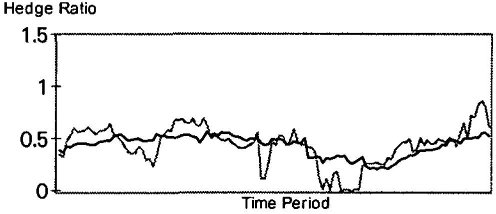
d) High Income Funds



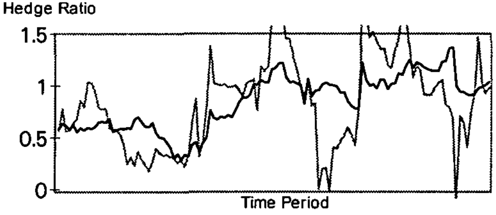
e) Small Company Funds



f) Venture/Development Funds



g) Property Funds



* As Figure 3.4

figures 3.5 and 3.6 for the FTSE 100 and Mid 250 contracts[14]. Each plot clearly shows that for all investment trust categories, as the window size increases the ex ante hedge ratios become smoother and converge towards the ex post hedge ratio, resulting in an improvement of the level of risk reduction. Even so, ex ante hedge ratios for the FTSE 100 contract in figure 3.5 are significantly less variable than those for the Mid 250 contract in figure 3.6 reinforcing the point made earlier that hedge ratio stability is also a positive function of futures market liquidity.

3.7) SUMMARY AND CONCLUSION

In conclusion, this chapter provides the first assessment of hedging performance of the Mid 250 futures contract. Given the low level of trading in this contract and the results from chapter three hedging effectiveness may be limited. The chapter also provides the first examination of hedging effectiveness of stock index futures when the spot portfolio to be hedged is an actual portfolio, rather than a broad market index or a portfolio specifically constructed for the purposes of research.

Results demonstrate that in spite of low trading volume, the Mid 250 contract provides an important additional hedging instrument. The findings in relation to hedging broad market indexes show the superiority of the new contract over the FTSE 100 contract in relation to spot portfolios mirroring the Mid 250 and the FTIT indexes. When considering actual spot portfolios in the form of ITC's, the results clearly demonstrate the benefits to be gained from using the new contract. In all cases, the average standard deviation of returns is lower when the Mid 250 contract is used as compared to the use of the FTSE 100 contract.

Results also show that previous studies of hedging effectiveness have greatly exaggerated the risk reduction which can be achieved. While previous studies for the UK have found risk reduction of 60% to 80%, the findings in this chapter show that for many portfolios, including those comprising smaller stocks, risk reduction of below 20% is achieved. Thus, while the new contract does significantly add to the ability to hedge risk, for many portfolios there is still no satisfactory means by which to achieve substantial risk reduction.

For ex ante hedge ratios estimated by means of a moving window, it was found that where the underlying spot portfolios were broad based market indexes, the levels of risk reduction achieved were of a similar magnitude to those achieved using the ex post strategy. For these portfolios inter-temporal hedge ratio instability did not appear to strongly adversely affect hedging performance. Furthermore, it was found that the FTSE 100 contract provided the most effective hedge for portfolios dominated by large capitalisation stocks, and the Mid 250 contract provided the most effective hedge for stocks dominated by low capitalisation stocks.

Where the spot portfolios to be hedged consisted of investment trust companies, ex ante hedging effectiveness was found to be poor, and the presence of significant hedge ratio instability resulted in levels lower than those achieved when using the ex post strategy. In these circumstances the degree of hedge ratio instability dictated the proportion of ex post risk reduction which could be attained on an ex ante basis. Even so, it was found that this problem could be alleviated by enlarging the window size used for estimating hedge ratios. When larger window sizes were employed ex ante hedge ratios were found to stabilise, converging towards the ex post benchmark, and maximising risk reduction.

It is evident that previous studies which have evaluated the hedging effectiveness of index futures contracts by employing an ex post strategy with spot portfolios that mirror the composition of the underlying contract have seriously exaggerated the risk reduction potential of these instruments. Hedging effectiveness can only be truly examined by using an ex ante strategy in conjunction with spot portfolios that do not replicate market portfolios.

While the evidence presented in this chapter indicates that the Mid 250 contract is an effective hedging vehicle, the Mid 250 contract is characterised by greater basis risk and produces a less effective hedge than the FTSE 100 contract when the spot portfolio to be hedged is the underlying index. The presence of greater basis risk indicates less effective tracking between the Mid 250 spot and futures market than compared with the FTSE 100 contract and is consistent with the findings in chapter one of the contract being very illiquid, with trading volume being sporadically concentrated around the rollover period. Furthermore, difficulties with trading the Mid 250 contract at times other than the rollover period, owing to high market impact costs, also call into question the feasibility of adopting a dynamic hedging strategy as a way of addressing the difficulties associated with hedge ratio instability. In adopting a dynamic hedging strategy account has to be taken of the additional transaction cost which are incurred from frequently adjusting the futures position. Thus the investor has to offset the benefits of improved risk reduction from using a dynamic hedging strategy against the additional costs of adopting an imperfect static hedge.

While the findings in chapter three demonstrate that in terms of risk reduction the MVHR generates the most effective hedges, this approach makes no attempt to differentiate between different categories of risk averse investors, with risk aversion assumed to be absolute. However, in chapter four, the hedging effectiveness of the FTSE 100 and Mid 250 contracts is further investigated using hedge ratios estimated within an Extended Mean Gini framework, where explicit account is taken of the impact that changes in risk aversion have on hedging decisions. This approach provides another perspective on hedging with the FTSE 100 and Mid 250 contracts

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Endnotes

[1] Specific types of hedges initiated in futures markets are the *inventory* and *anticipatory* hedges. An inventory (or cash and carry) hedge refers to where an investor has possession of the spot instrument, and by hedging is attempting to guarantee a future price today. Alternatively, an anticipatory hedge (or selective hedge) is initiated by an investor who is not in possession of the spot instrument but is concerned with locking-in to a price today for some unanticipated future period.

[2] The outcomes suggested with regard to the choice of short and long positions in the futures markets assumes that the ex ante capital market line is positively sloping.

[3] Linter (1956) considered the historical pattern of dividends, and found that dividends were a function of earnings and past dividends. Linter demonstrated that although dividends were often a constant proportion of earnings, companies were reluctant to raise current dividends to levels which could not be sustained in the future, leading to stable dividend payments over time.

[4] Figlewski (1984a) suggests that in the context of hedging with index futures, invariably all hedging will involve a cross hedge, with the composition of the spot portfolio being hedged differing from the portfolio underlying the futures contract.

[5] Hedge ratios computed within an Extended Mean Gini (EMG) framework have also been widely used in relation to index futures markets. An examination of hedge ratios generated within the EMG framework, together with the impact that risk aversion has on hedging behaviour is considered separately in chapter four.

[6] Traditionally, hedging strategies have focused on risk reduction, which while recognising the service a futures market provides in facilitating risk reduction, ignores the cost it often imposes measured in terms of expected return. Although attempts have been made to incorporate expected returns into hedging decisions to develop risk-return measures of hedging effectiveness (see Howard and D' Antoniou (1984), Chang and Shanker (1987), Howard and D' Antoniou (1987), Lindahl (1991)), the addition of an additional effectiveness criterion requires the inclusion of subjective assessments in relation to investor preferences. For instance, the model developed by Howard and D' Antoniou (1984) only applies to investors who seek to maximise the ratio of excess returns to standard deviation, and its practical implementation is complicated by the ex ante estimation of five hedging parameters.

[7] The definitions of these categories of ITC's are taken from the Association of Investment Trust Companies' monthly report.

[8] In the remainder of the chapter the hedge ratio will be referred to as a positive number for convenience, even though in practice hedging an established spot position is likely to require selling futures.

[9] The ex post MVHR's used in the second stage of this analysis use only a subset of the sample period used in the initial stage. Therefore, ex post MVHR's and measures of hedging effectiveness differ slightly from the earlier results.

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[10] All mean and standard deviation figures reported in the tables and the text have been annualised to allow more convenient comparison between hedges of different durations.

[11] The optimal combinations identified using daily and weekly hedges for each of the thirty-seven spot portfolios are reported in full in appendices 1 and 2 respectively.

[12] This finding can, in part, be explained by the fact that the composition of the two cash indexes is revised on a regular basis reflecting changes in market capitalisation. When changes are made some stocks move out of the FTSE 100 index into the Mid 250 index and other make the move in the opposite direction.

[13] In relation to the composition of the optimal 'synthetic' FTSE 350 contract which is used to hedge the ITC's, 84.4% (96.9%) of all weekly (daily) hedges consist of portfolios that comprise either entirely of the Mid 250 contract or portfolios formed from adjacent categories. See appendices 1 and 2.

[14] Figures 3.5 and 3.6 understate the true volatility of the ex ante hedge ratio series associated with investment trust portfolios because of the averaging process which takes place when calculating instability on a category by category basis.

CHAPTER FOUR

THE HEDGING EFFECTIVENESS OF THE FTSE 100 AND FTSE MID 250 CONTRACTS: USING AN EXTENDED MEAN GINI FRAMEWORK

4.1) INTRODUCTION

It was previously established that hedging provides the main justification for the existence of futures trading. In chapter three the hedging effectiveness of the FTSE 100 and Mid 250 contracts was investigated for a broad range of spot portfolios comprising of both market indexes and professionally managed portfolios. The results from that chapter indicate that where the underlying spot portfolios are broad based market indexes risk reduction is considerable for both contracts. Hence, despite being characterised by very low trading volume, the Mid 250 contract has an important role to play as an hedging facility, especially in relation to UK portfolios comprising of medium or small sized stocks.

Traditionally, the futures hedging literature has focused on the risk minimising minimum variance approach pioneered by Stein (1961) and Johnson (1960) as a means of generating the optimal hedge. However, it is now well recognised that mean variance analysis is based on rather restrictive assumptions and that the MVHR is only applicable to the infinitely risk averse investor. In response to these difficulties the extended mean Gini approach has been proposed as an alternative framework for analysing hedging decisions. The extended mean Gini approach offers greater flexibility in determining the optimal hedge ratio by allowing for differentiated risk aversion in the hedging model. Unlike the minimum variance approach the extended mean Gini framework is also consistent with the rules of stochastic dominance. This approach will be employed in this chapter to provide another perspective on hedging with the FTSE 100 and Mid 250 contracts

The remainder of this chapter is structured as follows. In section 4.2 theoretical issues relating to the derivation of the mean Gini coefficient and extended mean Gini coefficient are presented, together with a discussion of the advantages which both of these approaches have over the established mean variance approach. In section 4.3 the empirical investigation to be undertaken in relation to the application of the extended mean Gini framework and the hedging effectiveness of the FTSE 100 and Mid 250 contracts is outlined. Research issues are also presented. In section 4.4 data and methodological issues are considered. In section 4.5 the main empirical findings are reported. Finally, in section 4.6 concluding remarks are made.

4.2) THEORETICAL ISSUES

Although mean variance analysis represents one of the most important developments in the evolution of modern financial theory, it is founded on specific assumptions including that returns are either normally distributed or that the investor's utility function is quadratic. Owing to these restrictive assumptions, the mean variance approach has the potential to arrive at a solution which is inconsistent with the investor's assumed objective of expected utility maximisation, and alternative approaches to modelling risk and return have been espoused. The mean Gini (MG) approach was initially proposed as a measure of income inequality in the area of welfare economics, but owing to many of its desirable features it has recently been successfully applied to the theory of finance, with it being used as a more flexible framework for evaluating risk. While the Gini coefficient is similar to the variance in that it selects portfolios that are efficient within risk and return space, unlike the mean variance approach, the MG approach succeeds in selecting portfolios that are consistent with rules of stochastic dominance, and can be viewed as constituting an index of the variability for a random variable.

Given that the MG coefficient is consistent with risk averse behaviour for a wide range of probability distributions it has been found to be a more appropriate measure of dispersion than the variance. Shalit and Yitzhaki (1984) define the mean Gini coefficient (Γ) as follows:

$$\Gamma = \int_a^b [1-F(R)]dR - \int_a^b [1-F(R)]^2\, dR \qquad 4.1)$$

or for finite values of a as:

$$\Gamma = E(R) - a \int_a^b [1-F(R)]^2\, dR \qquad 4.2)$$

Where F(R) represents the cumulative probability function of risky prospect R, E(R) is the expected value of the risky prospect R and it is assumed there exists values of a $\geq -\infty$ and $b \leq \infty$, such that F(a) = 0 and F(b) = 1. However, in financial applications the most commonly applied version of the Gini coefficient is

$$\Gamma = 2\, Cov\,(R, F(R)) \qquad 4.3)$$

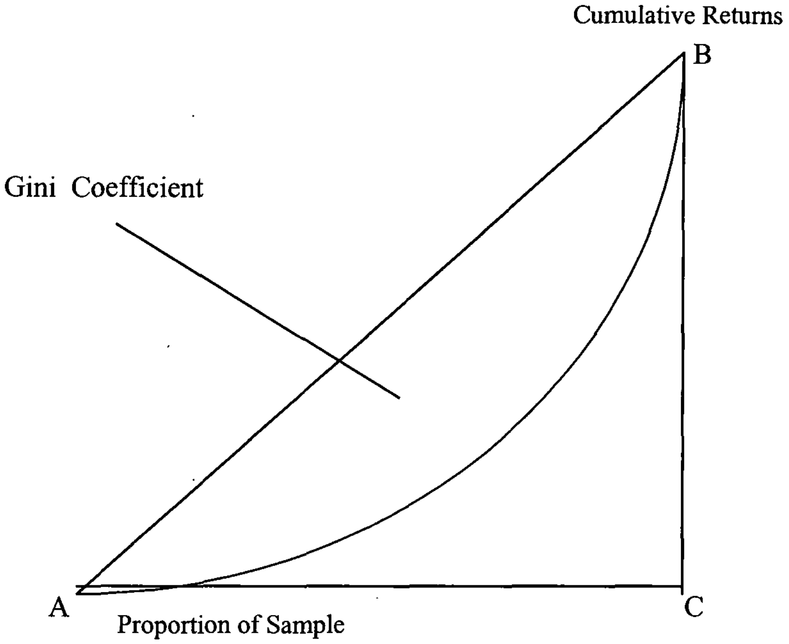
i.e. the MG coefficient is equal to twice the covariance between realisations of the variable R and its cumulative probability distribution. As Shalit and Yitzhaki (1989) point out, this representation of the Gini mirrors the variance, apart from the fact that the cumulative probability distribution is used rather than the return itself. By employing the cumulative probability distribution the MG coefficient attaches greater weight to the least favourable return realisations, and in doing so focuses on down side risk rather than risk in general. A graphical representation of equation 4.3 is provided by the Lorenz Curve in figure 4.1. In constructing a Lorenz curve, the return realisations on the variable R are plotted against their cumulative value (F(R)). All the return realisations are ranked in terms of their size, with the first realisation constituting the smallest return and the final realisation constituting the largest return - referred to as '*the parade of dwarfs*'.

In Figure 4.1 the Lorenz curve is applicable to a financial context, where the proportion of the total realisations are measured on the horizontal axis and the cumulative return from that proportion of the return realisation being measured on the vertical axis. The line AB represents a line of complete equality (i.e. analogous to a risk free asset), and provides a visible "benchmark" measure of dispersion. As the Lorenz curve becomes more convex to the origin the degree of dispersion increases.

The size of the Gini coefficient is calculated as a ratio of the area between the Lorenz curve and the line of equality AB, to the area ABC. The standard Gini coefficient assumes values ranging between zero and one, with the degree of dispersion becoming greater as the size of the Gini coefficient approaches one.

Figure 4.1)

Lorenz Curve in a Financial Context.



The use of the mean Gini approach has been advocated in preference to the mean variance approach as a measure of dispersion because it possesses a number of desirable statistical properties. Firstly, while the mean variance approach requires returns to be normally distributed for a consistent ranking of alternative prospects, the mean Gini approach makes no such assumptions about normality of the underlying probability distribution of returns or the quadraticity of the utility function, and allows for the construction of efficient portfolios that are included in the first and second order stochastic dominance portfolios. Hence, the mean Gini coefficient provides a consistent ranking of risky alternatives whenever mean variance analysis fails. However, where returns are normally distributed the mean

Gini and mean variance efficient sets are identical to one another, indicating that the mean variance approach is a special case of the mean Gini approach. Secondly, while the variance cannot be observed, the Gini coefficient by definition of being expected absolute distance between two return realisations provides a more intuitive measure of investment risk, which can be gauged by the slope of the Lorenz curve. Thirdly, the Gini coefficient can also be extended into a wider family of statistics - the *extended mean Gini (EMG) coefficients* - which enable researchers to take account of the strength of the investor's degree of risk aversion and explicitly allow for the fact that risk averse investors are largely concerned only with 'down side' risk. As Hanoch and Levy (1969) argue:

> "The identification of riskiness with variance, or with any other single measure of dispersion, is clearly unsound. There are many obvious cases, where more dispersion is desirable, if accompanied by an upward shift in the location of the distribution, or by an increasing positive asymmetry" (p. 344).

The theory of stochastic dominance on which the MG approach is underpinned is the only theory of choice under uncertainty that provides a ranking of risky prospects that is consistent with risk averse behaviour for a broad range of probability distributions. Yitzhaki (1982) demonstrates that by using only the mean and Gini coefficient as summary statistics for a risky prospect it is possible to derive the necessary conditions for stochastic dominance, and thereby enable the investor to discard from their efficient set any prospect that is deemed stochastically inferior to the preferred prospect.

A risky investment prospect is said to stochastically dominate another risky investment prospect if an investor receives larger cash flows in every (ordered) state of the world. Yitzhaki (1983) shows that for the mean Gini approach to be consistent with the rules of stochastic dominance, the following two propositions which represent necessary and sufficient conditions must be satisfied.

Proposition 1: Let R_X and R_Y be risky prospects, with Γ_X and Γ_Y representing the riskiness of each prospect measured in terms of the mean Gini coefficient. Where the conditions $E(R_X) \geq E(R_Y)$ and $E(R_X) - \Gamma_X \geq E(R_Y) - \Gamma_Y$ are *necessary* conditions for R_X to dominate R_Y according to *the first and second order stochastic dominance rules*.

Proposition 2. Let R_X and R_Y be two risky prospects with equal expected return. Assume also that the cumulative distributions $F_X(R)$ and $F_Y(R)$ intersect at most once. Then $E(R_X) - \Gamma_X \geq E(R_Y) - \Gamma_Y$ is a *sufficient* condition for R_X to dominate R_Y according to the stochastic dominance rules.

With respect to the propositions, the *necessary* conditions for second order stochastic dominance hold for any probability distribution. While the *sufficient* conditions only hold for families of cumulative probability distributions that intersect at most once, (e.g., the normal, lognormal, uniform and Gamma distributions). In relation to proposition one, the first necessary condition simply states that an essential requirement for prospect R_X to dominate R_Y, is that the mean of the distribution R_X must be at least equal to the mean of the distribution of R_Y. Additionally, the second condition is related to the Gini coefficient, and states that if R_X dominates R_Y, the mean of distribution R_X minus the MG coefficient for R_X is not less than the mean of the distribution R_Y minus the MG coefficient for R_Y. In other words, the expected return on prospect X is not less than the expected return on prospect Y. On the basis of these two conditions, Shalit and Yitzhaki (1984) suggest that proposition one provides researchers

> "with a two-parameter instrument that can be used to discard from the efficient set the stochastically inferior alternatives" (p. 1453).

While proposition one provides necessary conditions for stochastic dominance for any distribution, the sufficient conditions which are embodied in proposition two (the second efficiency criterion) are weaker, in that they relate only to cumulative probability distributions that intersect at most once. Under these circumstances, where the probability distribution is not normal, the mean variance approach fails to provide a consistent ranking of risky alternatives, but the efficient mean Gini set is identical to the efficient stochastic dominance set. However, owing to the difficulties in practically implementing the rules of stochastic dominance, Yitzhaki (1982) argues that the real appeal of the MG approach is that it captures the desirable feature of stochastic dominance, together with the implementative simplicity of mean variance analysis, without any of their adverse affects, and therefore the:

> "MG approach may thus be viewed as a compromise with some of the merits of the other two" (p. 178).

While the mean Gini framework provides an alternative and more robust assessment of risk than the mean variance framework, an important weakness of this approach, is that like the mean variance approach it assumes that there is only one class of risk averse investors. However, in reality there are a multitude of risk averse investors and an framework which is capable of capturing this phenomenon while retaining the desirable properties of the MG approach is the extended mean Gini family of coefficients.

The extended mean Gini coefficient was proposed by Yitzhaki (1983) as an alternative measure of dispersion to the simple mean Gini, in the analysis of investment risk. The extended mean Gini (EMG) is similar in structure and application to the mean Gini coefficient, except that it is capable of distinguishing between different classes of investors by explicitly incorporating a risk aversion parameter (v) which takes account of the impact that risk aversion has on portfolio evaluation decisions. The extended mean Gini is equivalent to equation 4.1 except that the risk aversion parameter v replaces two as the exponent of the function:

$$\Gamma(v) = \int_a^b [1 - F(R)]\, dR - \int_a^b [1 - F(R)]^v\, dR \tag{4.4)}$$

and for finite values of a:

$$\Gamma(v) = E(R) - a - \int_a^b [1 - F(R)]^v\, dR \tag{4.5)}$$

Where v represents a parameter assuming a value between one and infinity. The parameter v which reflects the degree of risk aversion, provides the link between the extended mean Gini coefficient and the investor's attitude towards risk. As in the case of the standard Gini coefficient (equation 4.3), the extended mean Gini of a variable R is expressed in terms of the covariance between ranked returns on variable R and its cumulative probability distribution. For practical purposes the extended mean Gini coefficient (Γ(v)) takes the form of the following expression:

$$\Gamma(v) = -v\, Cov\,(R, (1 - F(R))^{v-1}) \qquad 4.6)$$

As Shalit and Yitzhaki argue the:

> "extended Gini is simply a 'weighted' covariance between the variate and 1 minus its cumulative distribution raised to the power of v-1. The higher v becomes the more risk averse is the investor since he or she is attributing a larger weight to the worst realisations of the distribution" (1984, p. 1462)

The importance of the extended mean Gini coefficient has been demonstrated by Yitzhaki (1983) who proved that the parameter v represents a relative index of risk aversion for the entire spectrum of investors, and Γ(v) denotes a risk premium that needs to be deducted from the expected value of the distribution. Yitzhaki (1983) shows that the certainty equivalent (C.E.) of a distribution is equal to the mean of the distribution minus the extended mean Gini (EMG) coefficient:

$$C.E. = E(R) - \Gamma(v) \qquad 4.7)$$

Thus the certainty equivalent value of the distribution is determined by the risk aversion parameter v. As investor risk aversion increases (i.e. the parameter v rises) the higher is the risk premium required by investors, and the lower is the certainty equivalent of the risky prospect. Hence, investors who are strongly risk averse are willing to pay a larger premium to offset risk. While the simple mean Gini coefficient (where v=2) serves as a "benchmark measure" of risk aversion, it can easily be subsumed into the broader extended mean Gini framework. The extended mean Gini approach provides a mechanism for ranking investors into different categories in relation to risk averse behaviour For instance, where:

V = 1: Risk neutral behaviour

V= 2: Weakly risk averse behaviour

V = 10: Moderate risk averse behaviour

V > 25: Strongly risk averse behaviour

V = ∞: Maximin behaviour

It can be seen in equation 4.6 that higher ranked returns will have lower complements of the cumulative probability distribution function, and raising them to a power greater than one will drive them towards zero. Therefore, as v increases in value more emphasis is placed on the lower end of the distribution and attention is focused on the worst return realisations. Kolb and Okunev (1993) suggest that this feature is:

> "intuitively appealing because one expects more risk averse

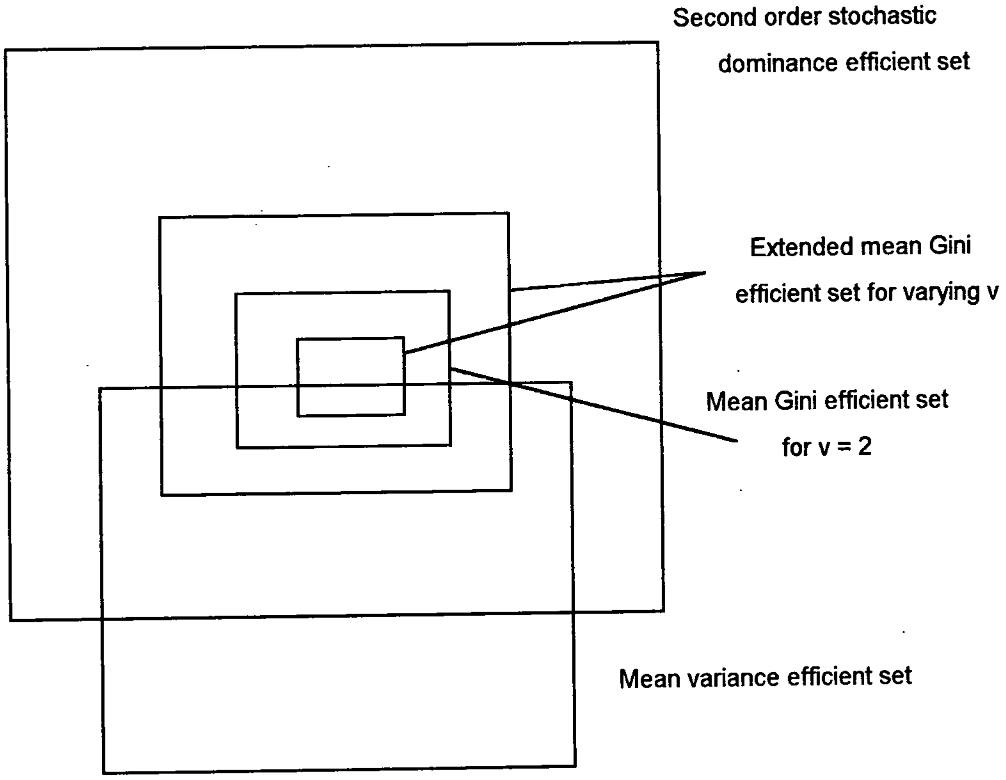
> investors to give attention to the probability of suffering the worst outcomes. The mean variance approach by contrast weights all outcomes equally" (p. 601).

By assuming different values of the extended mean Gini risk aversion parameter v, it is possible to construct a variety of efficient portfolio sets in mean Gini space. While these extended mean Gini portfolios are similar in construction to mean variance portfolios, they have substantial advantages over the variance, in that they are all encompassed in the second order stochastic dominance efficient set. In figure 4.2 this relationship between the mean Gini, extended mean Gini, second order stochastic dominance and mean variance efficient sets is illustrated in terms of a Venn diagram. The efficient set refers to the set of risky prospects within that set that are not dominated by the appropriate rule. As is clearly evident in figure 4.2, because the mean variance efficient set is not always consistent with the second order stochastic dominance set, there are some mean variance portfolios that would never be chosen by risk averse investors.

Shalit (1995) suggests that the EMG approach provides a justified alternative to the minimum variance approach in developing hedge ratios for two further reasons. Firstly, the EMG approach is superior to the minimum variance approach because it allows the development of capital market equilibrium that satisfies the necessary and sufficient conditions for second order stochastic dominance. Secondly, Shalit argues that the minimum variance approach of generating hedge ratios through OLS ignores the assumption of independence between the explanatory variable (i.e. futures series)

Figure 4.2)

Composition of Extended Mean Gini Efficient Set



Source: Hodgson and Okunev (1992), pp. 214.

and the residual term. Shalit points out that owing to the possibility of misspecification in the regression model there are considerable reasons for inferring a dependency between the futures series and the residual series, and this has a tendency to result in biased parameter estimates. However, while the futures series and the residual series may be characterised by dependency, given that the EMG approach is based on the ranked return series, independence between the two series is more likely in the case of the EMG approach.

4.3) EMPIRICAL INVESTIGATION

This chapter extends the work undertaken on hedging effectiveness in chapter three, by investigating the effectiveness of hedge ratios generated within an extended mean Gini framework with respect to both the FTSE 100 and Mid 250 contracts. In relation to the literature review in chapter two there are a number of points worthy of restating in relation to the issues considered in this chapter. Firstly, the EMG approach is superior to the established minimum variance approach, in the sense that while the MVHR allows consideration of only one optimal hedge ratio which is appropriate only for infinitely risk averse investors, the EMG approach can be used to generate a range of hedge ratios which are applicable for different categories of risk averse investors. The EMG approach thereby captures the observed diversity in hedging behaviour. Secondly, while previous studies have applied the EMG approach to both traditional and financial futures contracts (including index futures), surprisingly to date no work has been undertaken examining the robustness of this approach in the presence of cross hedges. It is of interest to determine whether the 'step function' which has been found to characterise the relationship between the optimal hedge ratio and the level of risk aversion for a direct hedge is also applicable when the spot portfolio differs in composition to the index underlying the futures contract.

In this section some of the limitations of previous studies which employ the EMG approach to hedging are addressed in relation to UK index futures contracts. Specifically the following issues are addressed:

- the hedging performance of hedge ratios generated within an EMG framework are examined for both the FTSE 100 contract and the Mid 250 contract. Consideration is given not only to direct hedges, but also to a range of cross hedges with spot portfolios comprising of related market indexes. This is an important issue because cross hedges have been found to be riskier than direct hedges, and it is reasonable to expect them to be more sensitive to changes in risk aversion.
- the hedging effectiveness of the EMG hedge ratio is compared with the ex post MVHR. Since the minimum variance strategy is often treated as a universal benchmark in the literature, by comparing the two strategies for different levels of risk aversion, it should be possible to provides insights as to whether the minimum variance strategy truly warrants such a prominent position.

5.4) DATA AND METHODOLOGY

The hedging effectiveness of the FTSE 100 and Mid 250 index futures contracts is investigated by comparing hedge ratios generated within the EMG framework with the respective ex post minimum variance hedge ratios. The spot portfolios to be hedged include the same range of stock market indexes employed in chapter three. Specifically, the five indexes are the FTSE 100 index, the FTSE Mid 250 index, the

FTSE 350 index, the FT All Share Index and the FT Investment Trust index. Unlike previous studies using the EMG approach this is the first to take account of cross hedging risk. Hedging effectiveness is examined over the period 25 February 1994 (the date of the introduction of the Mid 250 contract) to 31 July 1995 using hedges of one week duration. The weekly return series for each spot index and futures contract is calculated as the logarithmic price change, and consists of 74 observations. All data is obtained from *Datastream*.

Both the EMG approach and the MV approach to hedging seek to determine the hedge ratio which will minimise the risk associated with the hedge portfolio, with risk measured in terms of the extended Gini coefficient and variance respectively. The return on the hedged portfolio (R_h) is expressed as:

$$R_h = R_s + h R_f \qquad 4.8)$$

Where R_s is the return on the spot portfolio, R_f is the return on the futures contract and h is the hedge ratio.

By using the procedure employed by both Hodgson and Okunev (1992) and Kolb and Okunev (1992), the hedge ratio which minimises the EMG coefficient (h^{EMG}) can be determined. Firstly, the return on the hedged portfolio (equation 4.8) is substituted into the EMG coefficient (equation 4.6) to obtain:

$$\Gamma(v) = -v\,Cov(R_s + h^{EMG} R_f ,(1-F(R_h))^{v-1}) \qquad 4.9)$$

By expanding equation 4.9 with respect to the different elements of the hedged portfolio we achieve:

$$\Gamma(v) = -v\,Cov(R_s,(1-(F(R_h))^{v-1}) - v\,h^{EMG}\,Cov(R_f,(1-F(R_h))^{v-1}) \qquad 4.10)$$

Further by differentiating equation 4.10 with respect to h^{EMG} we obtain:

$$\frac{\partial\Gamma(v)}{\partial h^{EMG}} = -v\;Cov(R_f,\,(1-F(R_h))^{v-1}) - \frac{v\,h^{EMG}\,\partial Cov(R_f,(1-F(R_h))^{v-1})}{\partial h^{EMG}} \qquad 4.11)$$

Finally, by setting the partial derivative in equation 4.11 to zero, the global minimum extended mean Gini hedge ratio becomes:

$$h^{EMG} = \frac{-Cov(R_f,(1-F(R_h))^{v-1})}{\left(\dfrac{\partial Cov(R_f,(1-F(R_h))^{v-1})}{\partial h^{EMG}}\right)} \qquad 4.12)$$

It is clear from equation 4.12, that the hedge ratio which minimise the extended mean Gini coefficient is a direct function of the risk aversion parameter v. Hence, different categories of risk averse investors will have different optimal hedge ratios. However, for the risk neutral investor who is characterised by a risk aversion parameter equal to one, the extended mean Gini hedge ratio in equation 4.12 collapses to zero, and the return on the hedged portfolio in equation 4.8 equates to the return on the spot asset only.

Empirically estimating equation 4.12 is rather complicated, owing to difficulties in evaluating the denominator of the expression. However, Hodgson and Okunev (1992) suggest a more simple approach which involves estimating the extended mean Gini hedge ratio through a process of iteration. The iterative procedure involves assigning some arbitrary value to h^{EMG} and calculating the returns on the hedged portfolio. Once the returns on the hedged portfolio have been determined using equation 4.8, they are ranked in ascending order from the lowest to the highest return realisation.The complement of the cumulative probability density function (1 - $F(R_h)$) is then proxied by the series:

$$(1 - F(R_h))^{v-1} = \frac{(T - Rank(R_h))^{v-1}}{T} \qquad 4.13)$$

Where T refers to the number of sample observations and Rank (R_h) refers to the ranked value of the hedged return. Equation 4.13 explicitly takes account of the different levels of investor risk aversion by weighing lower return realisations more heavily than higher return realisations. The EMG coefficient can then be calculated for different levels of v by using equation 4.6. The process of iterations continues by varying the value of h^{EMG} until the minimum value of the extended mean Gini coefficient for a given level of risk aversion has been achieved. Using the iterative procedure outlined, the hedge ratios which minimise the size of the EMG coefficients are determined for each of the ten hedged portfolios, using risk aversion parameters ranging from two to eighty - at increments of one. By using values of the risk aversion parameter (v) which are greater than unity only risk averse investors are considered. Hence, it is possible to determine whether the optimal EMG hedges are a function of risk aversion.

The ex post minimum variance hedge ratio is determined by employing the Johnson (1960) approach, where the minimum variance hedge ratio is estimated using OLS, by regressing spot returns $(S_t - S_{t-1})$ against futures returns $(F_t - F_{t-1})$ as in equation 4.14:

$$(S_t - S_{t-1}) = \alpha + \beta (F_t - F_{t-1}) + \varepsilon_t \qquad t = 1, 2, \dots, T. \qquad 4.14)$$

Where the regression parameter β represents the MVHR, and the parameter ε_t represents the residual term.

In relation to the minimum variance approach to hedging no attempt is made to explicitly accommodate risk aversion, rather risk aversion is deemed to be absolute with the hedger being prepared to forsake an infinite amount of return, in order to reduce risk over the sample period by an infinitely small amount. However, in the case of the EMG approach to hedging, risk aversion is relative, with the risk averse hedger increasingly concerned with downside risk, and limiting the portfolio's exposure only to the risk associated with the worst return realisations (i.e. declines in the value of the hedged portfolio.). Hence, the optimal EMG hedge ratio is that which minimises the hedger's exposure to the least desirable subset of observations rather than all the observations contained within the sample. Greater volatility, insofar as it is associated with an increase in returns, is not thought to be undesirable by the hedger operating within an EMG framework. The impact that risk aversion has on the hedged return weightings in both the mean variance and EMG frameworks is indicated in table 4.1.

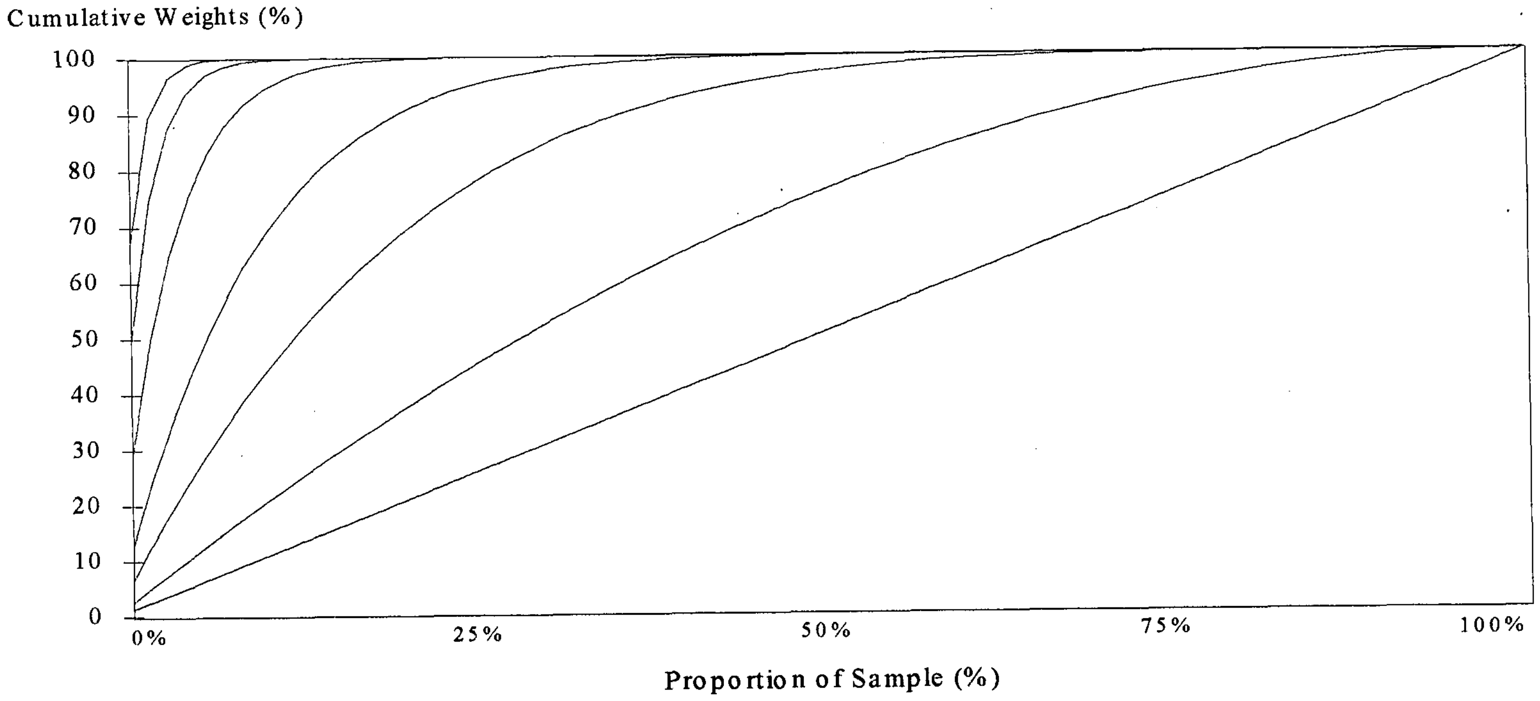
In relation to table 4.1, the cumulative percentage weights associated with different proportions of the worst return realisations within the sample are reported for different categories of risk averse investors. The sub-samples range from the worst 1% of return realisations, to the worst 100% of return realisations (i.e. the whole sample). For instance, the hedger who employs the mean variance approach adopts a uniform weighting system, whereby all observations are weighted equally. Hence, the minimum variance hedging strategy attaches the same importance to the worst 50% of observations as it does to the most favourable 50% of observations. Clearly such an approach would seem at odds with investment behaviour in practice. In contrast, the EMG approach attaches a greater weight to less favourable hedged returns than to more favourable hedged returns. For instance, the mean Gini approach (which assumes v=2) attaches 2.7% of the total portfolio weight to the worst 1% of return realisation and 75.3% of the total portfolio weight to the worst 50% of return realisations. In comparison, a moderately risk averse investor (v= 5) attaches 6.6% of the total portfolio weight to the worst 1% of return realisations, and 97% of the total portfolio weight to the worst 50%. Finally, a strongly risk averse investor (v=80) attaches 99% of the total portfolio weight to the worse 5% of realisations. In other words, the strongly risk averse investor ignores 95% of all observations when making hedging decisions. This indicates that the EMG approach to hedging is extremely sensitive to the presence of outliers.

The figures relating to the return weightings reported in table 4.1 are illustrated in terms of portfolio concentration functions in figure 4.3. While the mean variance

Table 4.1)
Impact of Risk Aversion on Return Weightings

R.A.P.	Proportion of Worst Return Realisations (%)											
	1%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
MV	1	5	10	20	30	40	50	60	70	80	90	100
v=2	2.7	10.59	20.58	36.65	52.8	64.98	75.34	84.97	91.45	96.11	99.22	100
v=3	4.03	15.45	29.23	49.58	67.57	79.27	87.76	94.17	97.5	99.23	99.93	100
v=4	5.33	20.06	36.93	59.87	77.72	87.73	93.92	97.74	99.27	99.85	99.99	100
v=5	6.62	24.41	43.8	68.06	84.69	92.74	96.98	99.12	99.79	99.97	100	100
v=10	12.8	42.86	68.42	89.8	97.66	99.47	99.91	99.99	100	100	100	100
v=25	29.01	75.33	94.4	99.67	99.99	100	100	100	100	100	100	100
v=50	49.61	93.92	99.69	100	100	100	100	100	100	100	100	100
v=80	67.08	98.93	100	100	100	100	100	100	100	100	100	100

Figure 4.3)
Impact of Risk Aversion on Return Weightings.



weights are illustrated by a diagonal linear function, it is clear that for the EMG weights as risk aversion increases the portfolio concentration function becomes more concave indicating that the hedger is attaching an increasingly greater weight to an increasingly smaller sample of observations. At the limit, as $v \to \infty$ the portfolio concentration function will converge to the north-west corner of the plot, as the hedger attaches the total portfolio weight to the worst return realisation. In other words, the hedger becomes a maximin investor, and ranks the risky prospects according to the worst possible outcome, and then selects the least worst realisation.

In assessing the hedging effectiveness of the FTSE 100 contract and Mid 250 contract using the mean variance and EMG approaches, consideration will be given to both mean returns and degree of risk reduction associated with the hedged portfolio. Where the percentage risk reduction achieved from hedging each of the spot indexes within the EMG and mean variance frameworks respectively is calculated as:

$$Risk\,\mathrm{Re}duction\ (\%RR) = \left(1 - \frac{EMG\ (or\, S.D.)\ of\ hedged\ returns}{EMG(or\ S.D.)\ of\ unhedged\ returns}\right) \times 100 \qquad 4.15)$$

5.5) EMPIRICAL RESULTS

Owing to the fact that as risk aversion increases, the EMG approach focuses more strongly on a specific sub-sample of returns, the way in which the returns on the individual spot and futures series are dispersed would seem to have an important bearing on the relationship between risk aversion and hedge ratio stability. For this reason table 4.2 reports statistics relating to the distribution of weekly returns on both futures contracts and all five stock indexes. There are a number of worthwhile points to make. Firstly, while there is considerable variation between the risk and return profiles for each of the series, all spot and futures series appear to be normally distributed. Secondly, the returns on both futures contract are more volatile, and associated with a more extreme range, than compared to those for the individual stock indexes. Of the individual stock indexes, the Mid 250 index has the least number of negative returns, and its returns are dispersed within the narrowest range.

The hedging effectiveness of using the FTSE 100 and Mid 250 contracts in relation to the various cross hedges, within both the EMG and minimum variance frameworks is reported in tables 4.3 and 4.4 respectively, and depicted in figure 4.4. Tables 4.3 and 4.4 present hedge ratios statistics for a selection of risk aversion parameters, together with hedged portfolio returns and the degree of risk reduction associated with the FTSE 100 contract and Mid 250 contracts. Consistent with previous studies there are a number of important findings which can be reported with respect to the relationship between the optimal hedge ratio and the investor's degree of risk aversion.

Firstly, hedge ratios for low levels of risk aversion (v = 2 to 3) are very close to the risk minimising MVHR. This relationship exists for all the hedges associated with both the FTSE 100 and Mid 250 contracts. For instance, the MVHR associated with the direct hedges for the FTSE 100 contract and Mid 250 contract is 0.84 and 0.90 respectively, while when v = 3 the respective EMG hedge ratios are 0.86 and 0.90 respectively. This pattern is also consistent across all the cross hedged portfolios.

Table 4.2)
Summary Statistics - Dispersion of returns*.

							Dispersion of Returns (R_t)							
Series	Obs.	Mean	S.D.	Abs. Avg	Max	Min	Rt > 0	Rt < 0	Rt < -1	Rt < -2	Rt < - 3	Rt < -4	Rt < -5	Skewness
FTSE100 Contract	74	0.0818	2.1231	1.631	4.9621	-5.9744	38	36	20	11	6	2	2	-0.3009
FTSE250 Contract	74	-0.0234	1.6523	1.2698	4.2097	-5.3738	36	38	17	7	3	2	1	-0.4814
FTSE100 Index	74	0.0752	1.8314	1.4397	4.3769	-5.2821	35	39	19	9	3	2	1	-0.378
FTSE250 Index	74	-0.0342	1.5368	1.1824	3.8122	-4.4318	39	35	17	7	3	1	0	-0.3618
FTSE350 Index	74	0.05	1.7287	1.3397	4.2494	-4.9552	35	39	19	8	3	2	0	-0.3615
FTALLSH Index	74	0.0401	1.6563	1.2789	4.0487	-4.7506	35	39	18	8	2	2	0	-0.3737
FTIT Index	74	-0.0293	1.4636	1.1439	4.2406	-4.3199	37	37	17	5	2	1	0	-0.1013

* All returns have been multiplied by 100 to improve readability.

Table 4.3)
Hedging Effectiveness Using the EMG Approach: FTSE 100 Contract

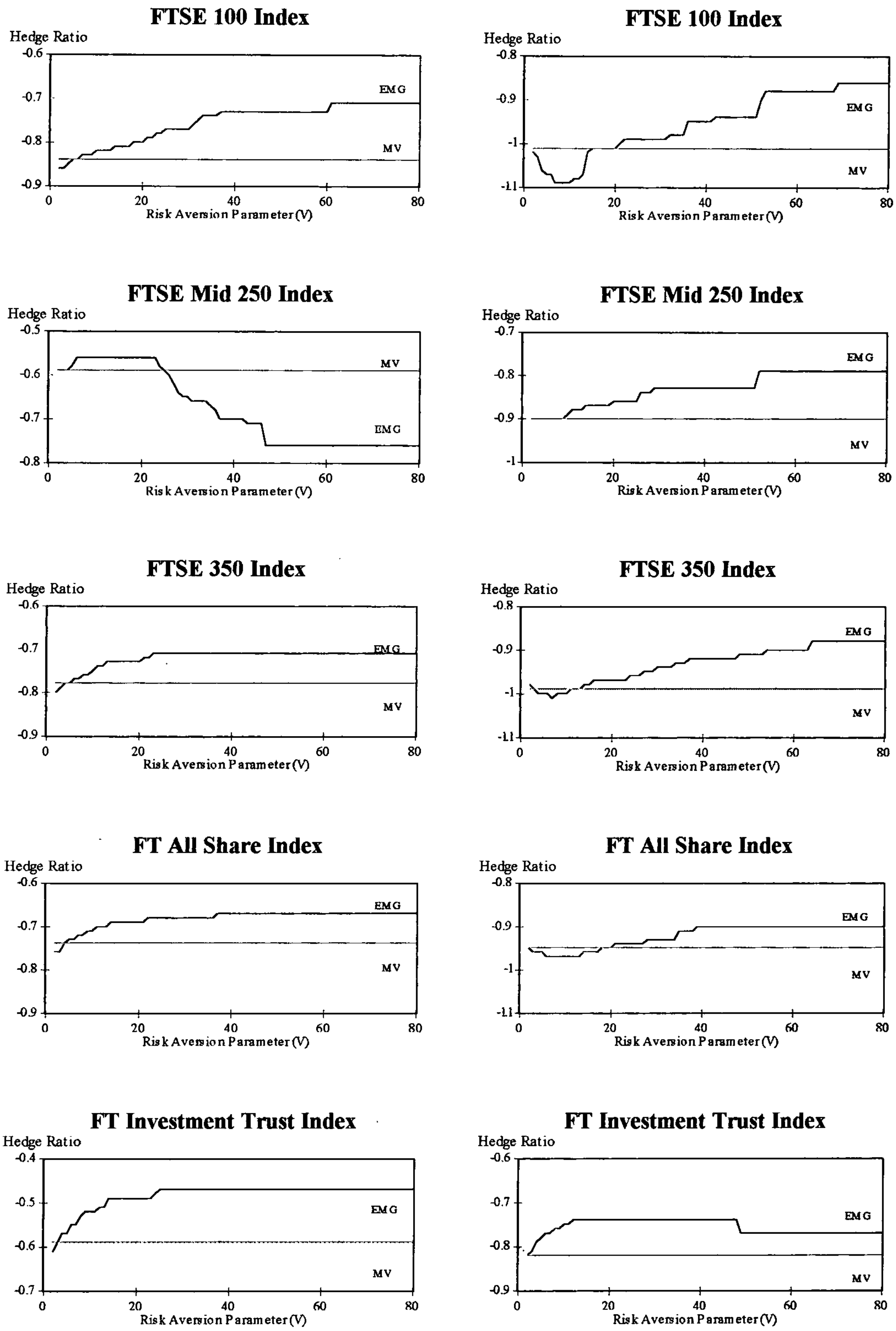
Hedged Portfolio:	Risk Aversion Parameter (V)												
	MV	V=2	V=3	V=4	V=5	V=10	V=20	V=30	V=40	V=50	V=60	V=70	V=80
FTSE 100 Index													
H.R.	0.84	0.86	0.86	0.85	0.84	0.82	0.80	0.77	0.73	0.73	0.73	0.71	0.71
Return	0.0067	0.0050	0.0052	0.0055	0.0061	0.0077	0.0095	0.0126	0.0154	0.0156	0.0156	0.0170	0.0170
% RR	76.02	79.01	78.15	77.30	76.55	73.95	71.00	69.36	68.59	68.03	67.38	66.91	66.44
FTSE Mid 250 Index													
H.R.	0.59	0.59	0.59	0.59	0.58	0.56	0.56	0.65	0.70	0.76	0.76	0.76	0.76
Return	-0.0824	-0.0863	-0.0862	-0.0860	-0.0853	-0.0837	-0.0838	-0.0909	-0.0957	-0.1004	-0.1005	-0.1005	-0.1005
% RR	41.60	42.16	40.17	39.13	38.57	38.14	38.23	38.23	38.71	39.07	39.31	39.42	39.40
FTSE 350 Index													
H.R.	0.78	0.80	0.79	0.78	0.78	0.75	0.73	0.71	0.71	0.71	0.71	0.71	0.71
Return	-0.0140	-0.0152	-0.0147	-0.0140	-0.0134	-0.0116	-0.0094	-0.0077	-0.0077	-0.0077	-0.0077	-0.0077	-0.0077
% RR	71.36	73.76	72.46	71.42	70.63	68.47	66.45	65.06	64.14	63.33	62.42	61.74	61.11
FT All Share Index													
H.R.	0.74	0.76	0.76	0.74	0.73	0.71	0.69	0.68	0.67	0.67	0.67	0.67	0.67
Return	-0.0208	-0.2210	-0.2210	-0.0208	-0.0196	-0.0180	-0.0163	-0.0155	-0.0147	-0.0147	-0.0147	-0.0147	-0.0147
% RR	70.23	72.24	67.33	69.69	68.94	67.33	66.00	64.89	63.90	63.03	62.24	61.54	60.90
FTSE I.T. Index													
H.R.	0.59	0.61	0.59	0.57	0.57	0.52	0.49	0.47	0.47	0.47	0.47	0.47	0.47
Return	-0.0775	-0.0788	-0.0774	-0.0763	-0.0758	-0.0716	-0.0691	-0.0677	-0.0676	-0.0676	-0.0676	-0.0676	-0.0676
% RR	47.81	47.29	45.48	44.55	44.16	45.00	48.07	50.42	52.21	53.49	54.66	55.50	56.12

Table 4.4)
Hedging Effectiveness Using the EMG Approach: FTSE Mid 250 Contract

Hedged Portfolio:						**Risk Aversion Parameter (V)**							
	MV	**V=2**	**V=3**	**V=4**	**V=5**	**V=10**	**V=20**	**V=30**	**V=40**	**V=50**	**V=60**	**V=70**	**V=80**
FTSE 100 Index													
H.R.	1.01	1.02	1.03	1.06	1.07	1.09	1.01	0.99	0.95	0.94	0.88	0.86	0.86
Return	0.0990	0.1154	0.1158	0.1163	0.1166	0.1171	0.1152	0.1147	0.1138	0.1136	0.1122	0.1118	0.1118
% RR	59.57	59.30	59.26	59.20	59.18	59.61	61.48	63.25	64.58	65.53	66.41	67.06	67.55
FTSE Mid 250 Index													
H.R.	0.90	0.90	0.90	0.90	0.90	0.89	0.86	0.83	0.83	0.83	0.79	0.79	0.79
Return	-0.0133	-0.0132	-0.0131	-0.0131	-0.0131	-0.0133	-0.0141	-0.0147	-0.0147	-0.0148	-0.0156	-0.0156	-0.0157
% RR	73.04	73.49	72.66	72.09	71.69	70.98	71.28	71.96	72.56	72.99	73.48	73.85	74.14
FTSE 350 Index													
H.R.	0.99	0.98	0.99	1.00	1.00	1.00	0.97	0.94	0.92	0.91	0.90	0.88	0.88
Return	0.0731	0.0731	0.0732	0.0734	0.0735	0.0735	0.0728	0.0721	0.0717	0.0714	0.0712	0.0707	0.0707
% RR	66.75	66.32	66.09	65.98	65.95	66.64	68.67	70.29	71.56	72.42	73.14	73.67	74.04
FT All Share Index													
H.R.	0.95	0.95	0.96	0.96	0.96	0.97	0.95	0.93	0.90	0.90	0.90	0.90	0.90
Return	0.0624	0.0624	0.0628	0.0626	0.0626	0.0628	0.0624	0.0619	0.0612	0.0612	0.0612	0.0612	0.0612
% RR	69.66	67.83	68.71	67.72	67.78	68.70	70.83	72.44	73.63	74.50	75.13	75.18	75.91
FTSE I.T. Index													
H.R.	0.82	0.82	0.81	0.79	0.78	0.75	0.74	0.74	0.74	0.76	0.77	0.77	0.77
Return	-0.0101	-0.0101	-0.0104	-0.0107	-0.0110	-0.0117	-0.0120	-0.0120	-0.0120	-0.0116	-0.0112	-0.0112	-0.0112
% RR	62.25	61.93	61.53	61.23	61.01	61.05	62.30	63.29	63.98	64.36	64.61	64.75	64.78

Figure 4.4)

Plots of the EMG and MV Hedge Ratios For the FTSE 100 and Mid 250 Contracts



a) FTSE 100 Contract

b) Mid 250 Contract

]

However, the hedge ratios for very high levels of risk aversion are quite different from the MVHR. In figure 4.4, all the EMG plots begin with v =2, which is equivalent to the standard mean Gini coefficient, but differ considerably from the MVHR at high levels of risk aversion. This is because the highly risk averse investor determines their optimal hedge ratio in relation to only the worst return realisations, while the mean variance investor generates an hedge ratio which is appropriate for all return realisations, and therefore some discrepancy between the two approaches is inevitable. Even so, in absolute magnitude the differences are often less than 20%.

Secondly, the step function associated with the EMG hedge ratios which was identified by Hodgson and Okunev (1992) is also evident in figure 4.4. All the hedged portfolios in figure 4.4 are characterised by several distinct ratios. As Hodgson and Okunev (1992) point out, the practical implication of this feature is that it is not always necessary to precisely measure an investor's degree of risk aversion to determine which hedge ratio most appropriately meets their preferences. Rather the investor has only to choose between the several different risk categories. Therefore, unlike the minimum variance approach, the EMG approach offers a range of hedge ratios which suit the requirements of different categories of risk averse investors. Even so, a degree of caution is still required because there is still the potential for investors' with preferred adjacent values of v to have significantly different optimal futures positions.

Thirdly, changes in EMG hedge ratios for the two direct FTSE 100 and Mid 250 hedges are found to be a monotonic function of the risk aversion parameter, with both hedge ratios increasing continuously with risk aversion. However, for some of the cross hedges where the composition of the futures contract and spot portfolio are significantly different, reversals in the hedge ratio path are clearly evident. For instance, hedge ratios will initially follow a downward (or upward) path and then suddenly change direction. In the case of the FTSE 100 contract only the cross hedge with the Mid 250 index is characterised by a significant reversal, while for the Mid 250 contract all the cross hedges are characterised by significant reversals. It seems sensible to hypothesise that unhedgeable cross hedging risk may contribute to this phenomenon. This argument would seem reasonable considering that the FTSE 100 and Mid 250 contracts mirror the performance of specific sectors of the market, and are likely to be less responsive to shocks which occur in areas of the market which are not specific to their underlying index. In the case of the Mid 250 contract this problem is likely to be exacerbated by the problem of thin trading. In relation to the spot portfolios only the FTSE 100 index and the Mid 250 index have completely mutually exclusive market compositions, and these are the two cross hedges which are associated with the most significant reversals. However, as the composition of the spot index associated with cross hedge approaches that of the index underlying the futures contract, the reversals diminish in size. For instance, the reversal associated with the cross hedge between the Mid 250 contract and the FT All Share index is only a fraction of the reversal associated with the cross hedge between the Mid 250 contract and the FTSE 100 index.

Fourthly, while EMG hedge ratios for high levels of risk aversion differ widely from the MVHR, they also have a tendency to become less volatile. In fact Lien and Luo's (1993) observation that the size of changes in the hedge ratio decrease as v increases, such that the optimal hedge ratio remains constant at high levels of v, are strongly supported by the results in figure 4.4. However this finding of hedge ratio stabilisation at high levels of risk aversion is entirely consistent with the theoretical underpinnings of the EMG coefficient, in the sense that as risk aversion increases, the hedge ratio determined within the EMG framework is being calculated with respect to an increasingly smaller subset of observations. Therefore, the potential for the hedge ratio to change is severely constrained.

Fifthly, tables 4.3 and 4.4 show that changes in the optimal hedge ratio result in significant variations in the levels of expected returns and risk reduction associated with the hedged portfolio. Changes in the mean returns on the hedged portfolios associated with the MVHR strategy are compared to those associated with the EMG strategy, where v=80. In relation to the FTSE 100 index, the FTSE 250 index, the FTSE 350 index, FT All Share index and the FTIT index, hedging using the FTSE 100 contract results in changes in mean returns of 154%, -22%, 45%, 29.3% and 12% respectively, while the Mid 250 contract results in changes of 13%, -18%, -3%, -2% and -11% respectively. It is clear that for all hedged portfolios comprising the FTSE 100 contract mean returns improve as risk aversion increases, with the exception of the cross hedge consisting of the Mid 250 index. In the case of hedged portfolios comprising of the Mid 250 contract, mean returns are a decreasing function of risk aversion in all cases.

While the risk reduction potential of the minimum variance and EMG approaches are not strictly comparable, given that the reduction in the dispersion of returns is measured by changes in the standard deviation within the minimum variance approach, and by changes in the extended mean Gini coefficient within the EMG framework, nonetheless considering the differences may provide some useful insights into differences in hedging behaviour. It is clear from tables 4.3 and 4.4 that the degree of risk reduction achieved by both contracts in relation to all spot portfolios is substantial, for all levels of risk aversion. Even so, while the MVHR and the standard mean Gini hedge ratio (i.e. v=2) reduce very similar quantities of risk, as would be expected given the similarities in their portfolio concentration functions (see figure 4.3), there are significant differences in terms of the degree of risk reduction achieved from using the EMG approach at both low and high levels of risk aversion. Even more interesting, when comparing the percentage risk reduction achieved from using the EMG approach at both low and high levels of risk aversion, important differences exist regarding the effectiveness of the FTSE 100 and Mid 250 contracts with respect to the five spot portfolios. At low levels of risk aversion the pattern identified in chapter three is evident, whereby the FTSE 100 contract provides the most effective hedge for spot indexes comprising of high capitalisation stocks and the Mid 250 contract provides the most effective hedge for spot indexes comprising of medium or low capitalisation stocks. However, at high levels of risk aversion (v=80) the Mid 250 contract is a more effective hedge for all the spot portfolios. For example, in relation to the FTSE 100 index, Mid 250 index, FTSE 350 index, FT All Share index and FT Investment Trust Index, where v=80, the FTSE 100 contract achieves risk reduction levels of 66.4%, 39.4%, 61.1%, 60.9% and 56.1% respectively, while the Mid 250 contract achieves risk reduction of 67.6%, 74.1%, 74%, 75.9% and 64.8% respectively. This is a very important result since it indicates that even in the case where the portfolio to be hedged is the FTSE 100 index, strongly risk averse investors who are only concerned with reducing their exposure to the worst return realisations, would be better hedged using the Mid 250 contract than the FTSE 100 contract. This finding demonstrates that the new contract has a very important role to play as a UK hedging vehicle.

4.6) CONCLUSIONS

In conclusion, the hedging and cross hedging effectiveness of both the FTSE 100 contract and the Mid 250 contract have been examined within the extended mean Gini framework. Unlike the minimum variance approach, the extended mean Gini approach is consistent with the rules of stochastic dominance and offers greater flexibility in determining the optimal hedge ratio by allowing for differentiated risk aversion in the hedging model. While the application of Gini coefficients to financial theory has been a relatively recent development, they have provided useful tools for investors by ensuring that portfolio prospects are ranked according to the expected utility maximisation criterion.

Consistent with the findings from previous studies the results contained in this chapter show that in spite of significant differences in the risk-return profiles of the spot and futures series, all appear to be normally distributed. This finding is reinforced by the fact that for the majority of the hedged portfolios the mean variance approach and mean Gini approach produce almost identical results. However, once account is taken for the extended mean Gini approach, the hedge ratio at high levels of risk aversion are very different from those at low levels of risk aversion. Hence, the mean variance and mean Gini approaches generate hedge ratios that are inappropriate for the highly risk averse investor. Comparing the behaviour of direct and cross hedges, while direct hedges were found to be a monotonic function of risk aversion, the relationship between the behaviour of cross hedges and risk aversion was found to be characterised by reversals. The reversals are most significant where the market composition of the futures contract and the spot portfolio to be hedged are exclusive. Examples of such cases include cross hedges between the FTSE 100 contract and Mid 250 index, and the Mid 250 contract and the FTSE 100 index. The results indicate that cross hedges may be more sensitive to changes in risk aversion than direct hedges.

The degree of risk reduction achieved by both contracts is considerable at all levels of risk aversion. At low levels of risk aversion the pattern identified in chapter three is also evident, where the FTSE 100 contract provides the most effective hedge for stock indexes comprising of large capitalisation stocks and the Mid 250 contract provides the most effective hedge for stock indexes comprising of medium and low capitalisation stocks. However, at the highest levels of risk aversion, although the hedger does have to sacrifice greater mean returns than would be the case when using the FTSE 100 contract, the Mid 250 contract provides the most effective hedge for all the spot indexes considered. Hence, the results from this chapter support the view that the Mid 250 contract has an important role to perform as an additional hedging instrument.

The evidence presented in relation to the hedging effectiveness of the FTSE 100 and Mid 250 contracts in chapters three and four raises important questions regarding the pricing efficiency of both contract. The results show that the Mid 250 contract does not generally track its underlying spot market as effectively as the FTSE 100 contract and this might indicate that deviations from fair value are likely to be more prevalent for the Mid 250 contract than for the FTSE 100 contract. Therefore, the pricing efficiency of both the FTSE 100 and Mid 250 contracts is an important issue, especially when considering that greater arbitrage is likely to result in improved tracking and convergence between the spot and futures markets, and in doing so it raises the risk bearing capacity of these markets. The pricing efficiency of both these contracts and the potential for index arbitrage is examined in chapter five. This work is extended in chapter six with an investigation into the profitability of intramarket and intermarket spread trading.

CHAPTER FIVE

STOCK INDEX FUTURES PRICING: EVIDENCE RELATING TO THE FTSE 100 AND FTSE MID 250 STOCK INDEX FUTURES CONTRACTS

5.1) INTRODUCTION

In chapter two it was argued that an investigation into the pricing efficiency of index futures contracts is an integral part of any study investigating the economics of stock index futures trading. In this respect, the pricing efficiency of these contracts is strongly related to the work conducted into hedging effectiveness in chapters three and four. For example, increased arbitrage activity serves to improve the tracking between spot and futures markets, and in doing so improves hedging effectiveness. In this chapter pricing efficiency is considered in relation to both the FTSE 100 and Mid 250 contracts.

Concern has long been expressed about the wide price anomalies that have existed between stock index futures prices and their underlying spot market price, and the obvious implications for market efficiency. The pricing of index futures contracts is an empirical issue which is of interest to academics, market practitioners and regulators alike. Arbitrage occurs whenever a security sells for two different prices in two different markets. An arbitrage transaction involves the purchase of the security in the market where the lower price exists and the near simultaneous sale of the same security in the market with the higher price. Two consequences of the arbitrage transaction are the near riskless earnings of abnormal profit and the rapid elimination of any price discrepancies between the two markets. Hence the absence of any arbitrage opportunities is a necessary condition for market efficiency.

An important benefit of stock index arbitrage is that it ensures more accurate tracking between the stock and futures markets than might otherwise be the case. This in turn can lead to improved hedging effectiveness. Lien (1992) demonstrates how arbitrage behaviour and hedging behaviour within a portfolio framework mutually complement each other:

> "imposition of the no-arbitrage conditions improves the correlation between spot and futures prices, which increases hedging effectiveness. Thus, the no-arbitrage conditions and the risk minimising approach to hedging can be viewed as an integrated system of analysis." (1992, p. 587).

While the pricing of index futures contracts has been thoroughly researched for both US and Asian markets, this issue has been less well investigated in the UK (exceptions include Yadav and Pope (1990) and Strickland and Xu (1992)). This is surprising, because although the regulatory and institutional framework of UK markets have a tendency to complicate arbitrage activity, index arbitrage constitutes a significant portion of UK index futures open interest (De Santos (1995)). Furthermore, while index arbitrage has been discouraged in US markets, this is not the case for the UK:

> "the existence of wide pricing anomalies between the cash and derivative markets demonstrates the need for the London markets to

> encourage techniques, such as index arbitrage which help to provide convergence in these markets so that an efficient means of risk transfer can be achieved" (International Stock Exchange(1987), p. 44)

While research into the pricing efficiency of the FTSE 100 contract has been forthcoming, to date no work has been published on the pricing efficiency of the Mid 250 contract. The main purpose of this chapter is to investigate the pricing efficiency of the Mid 250 index futures contract, and additionally to ascertain whether the introduction of this contract has had any discernible impact on the pricing efficiency of the FTSE 100 contract. However, consistent with the established literature, other related empirical issues will also be examined.

The chapter is structured as follows. In section 5.2, theoretical issues such as the pricing of index futures contracts and the derivation of the no-arbitrage condition will be considered. Additionally, consideration will be given to the issue of transaction costs and the determinants of the size of the arbitrage window, within which profitable arbitrage is precluded. In section 5.3, the empirical investigation will be outlined. In section 5.4, data and methodological issues will be presented. In section 5.5, the empirical findings will be reported. Finally, in section 5.6 concluding remarks will be made.

5.2) THEORETICAL ISSUES

In a perfect capital market stock index futures contracts can be replicated through positions in the underlying stock market index and the riskless asset. The "fair price" of the index futures contract can be shown to be equal to the price of the underlying basket of stocks plus the cost of carrying the spot index between the current date (time t) and the contract expiration date (time T) of the index futures contract. Generally, for futures contracts, the "carrying costs" of the underlying asset are comprised of interest payments and storage costs minus the convenience yield from holding the spot asset. In the context of index futures, storage costs are zero and the convenience yield equates to the dividend payments on the underlying stocks which the holder of the index futures contract is forced to give up. Therefore:

> "the futures price equals the deferred value of the current stock price minus the deferred value of the dividends that will be paid over the contract period" (Cornell and French (1983a), p. 4).

The theoretical or fair price of a stock index futures contract is determined on the assumption that spot markets are frictionless, where there are no taxes or transaction costs, where all participants have equal access to the risk free rate of interest and trade at mid-prices, and can be expressed as:

$$FP_{t,T} = I_t \ e^{r(T-t)} - \sum_{s=1}^{T-t} D_{t+s} \ e^{r(T-t-s)} \qquad 5.1)$$

Where $FP_{t,T}$ is the theoretical or fair price of the index futures contract at time t with expiration date of T; I_t is the price of the underlying stock index at time t; r is the risk free rate of interest; D_{t+s} is the daily dividends (measured in terms of index units) payable on the underlying stock index at time t+s; T-t is the number of days remaining until contract expiration.

Where the actual futures price ($F_{t,T}$) deviates from the theoretical fair price ($FP_{t,T}$) the potential for stock index arbitrage exists and there is the possibility for the arbitrageur to generate risk free profits by simultaneously taking positions in both the spot and futures markets. The arbitrage opportunity is eliminated, and equality between the stock and futures market is restored by increasing the demand for the underpriced asset and increasing the supply of the overpriced asset. Where the futures contract is overpriced, the arbitrageur initiates the following arbitrage transactions. At time t, the arbitrageur sells one futures contract and simultaneously borrows an amount equivalent to one unit of the stock index I_t at the riskless rate of interest over the time t to maturity T to purchase the underlying basket of shares. For the index constituents going ex dividend over this period, all dividends (which are known with certainty and received at time period t + s, where $t + s \leq T$) are invested at the riskless rate of interest and generate a cash flow $\sum_{s=1}^{T-t} D_{t+s} \, e^{r(T-t-s)}$ by T. At maturity, the arbitrageur sells the stock index, and closes out his futures position, resulting in a cash flow of $I_T - I_t$ and $F_T - F_{t,T}$ respectively. Using the sum of the proceeds from these transactions, together with funds arising from dividend related investments, the arbitrageur repays the loan $I_t \, e^{r(T-t)}$ taken out at time t. This strategy generates arbitrage profits because the current value of the futures contract is greater than the deferred value of the stock index minus the cost of carrying the index over the period until maturity.

Alternatively, if the futures contract is underpriced, the arbitrageur initiates the following arbitrage strategy. At time t, the arbitrageur buys one futures contract and simultaneously sells the underlying basket of stocks short, lending the proceeds from the sale, an amount I_t, at the riskless rate of interest over the period to maturity. For the index constituents going ex dividend over this period the arbitrageur pays the broker from whom the stock has been borrowed all the dividends accruing on the respective dividend payment date, using further funds borrowed at the riskless rate of interest. This results in an outstanding debt at maturity of the amount $\sum_{s=1}^{T-t} D_{t+s}\, e^{r(T-t-s)}$. At maturity, the arbitrageur receives an amount $I_t\, e^{r(T-t)}$ as repayment for the loan made at time t, which he uses to repurchase the stock index, and closes out his futures position, resulting in two further cash flow of I_T - I_t and $F_T - F_{t,T}$ respectively. Finally, the arbitrageur completes the transaction by returning the stock to the broker from whom it was borrowed at time t, together with an amount $\sum_{s=1}^{T-t} D_{t+s}\, e^{r(T-t-s)}$ in repayment for the dividend related liability created at time t. This strategy generates arbitrage profits because the current value of the futures contract is less than the deferred value of the stock index minus the cost of carrying the index over the period until maturity.

In practice the futures price has the potential to deviate from the theoretical fair price without inducing any arbitrage activity because of transactions costs. Brenner, Subrahmanyan and Uno (1989a) identify six components to the round-trip transactions costs associated with an index arbitrage transaction. These are i) an equity market commission associated with trading the underlying basket of stocks; ii) a securities transfer tax paid when the stocks are sold (i.e. stamp duty); iii) a market impact cost from trading the stocks; iv) a futures market commission for trading futures contracts; v) a market impact cost from trading futures contracts; vi) the cost of borrowing the stocks when the stock in the spot index are sold short. Once transaction costs are taken into account, the relationship between the futures contract and the underlying stock index is characterised not by a fair price but rather a fair range of prices that lie within an *arbitrage window* (or band) around the fair price, within which arbitrage is not profitable. Hence, the futures price can move freely within these limits without inducing arbitrage trades. The upper and lower limits of the arbitrage window are represented by equations 5.2 and 5.3 respectively.

$$FP^{+}_{t,T} = I_t (1 + C^{+})\ e^{r(T-t)} - \sum_{s=1}^{T-t} D_{t+s}\ e^{r(T-t-s)} \qquad 5.2)$$

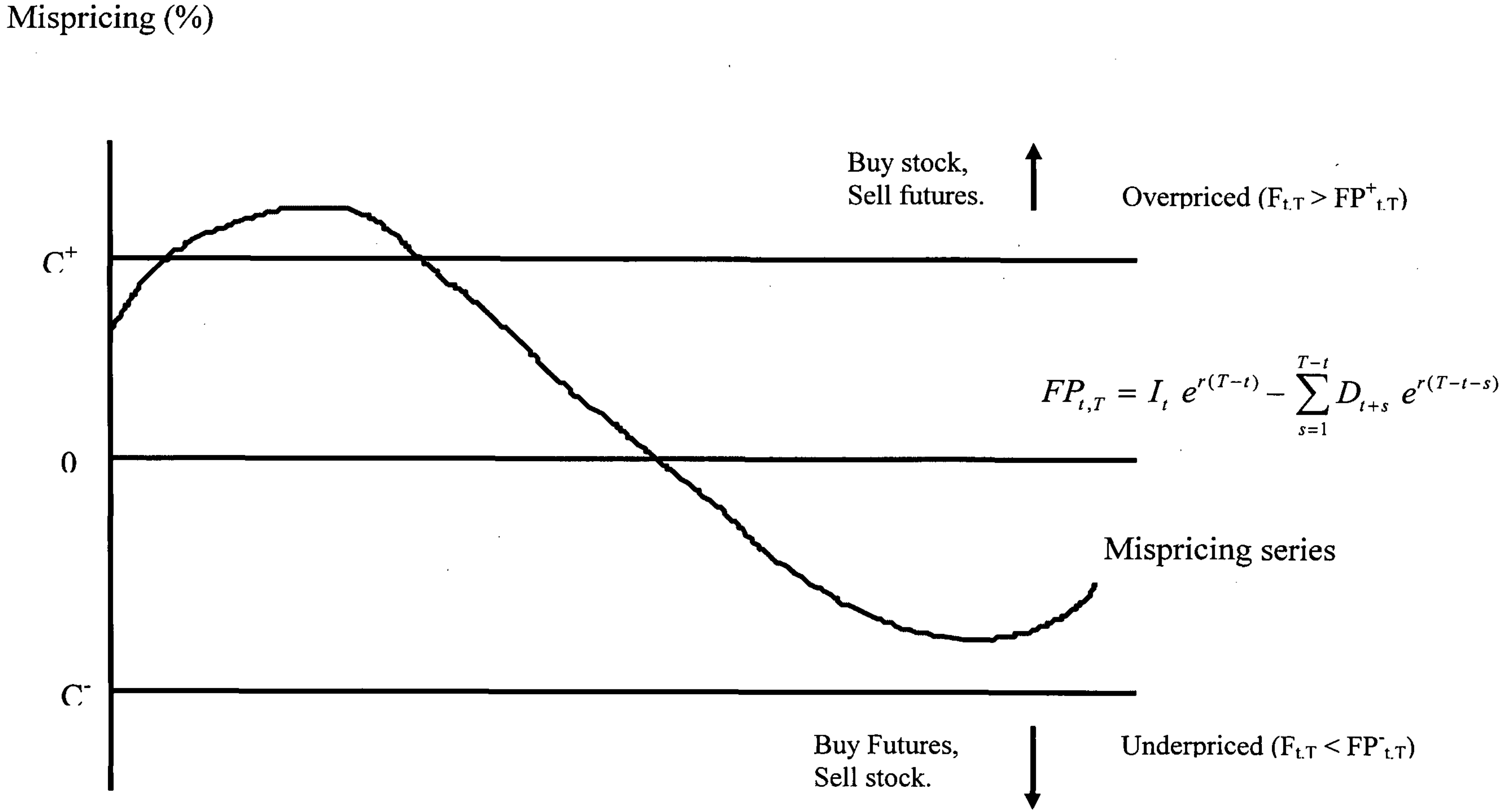
$$FP^{-}_{t,T} = I_t (1 + C^{-})\ e^{r(T-t)} - \sum_{s=1}^{T-t} D_{t+s}\ e^{r(T-t-s)} \qquad 5.3)$$

Where C^{+} refers to the upper transactions cost limit of the arbitrage window, and C^{-} refers to the lower transactions cost limit of the arbitrage window. Both C^{+} and C^{-} are expressed as a proportion of the spot index for consistency with the other determinants of the arbitrage window.

The no-arbitrage condition relevant to the pricing of index futures contracts is illustrated in figure 5.1. The upper transaction cost limit in figure 5.1 illustrates that only where the futures price exceeds the fair price (equation 5.1) by more than the amount implied by C^{+} will it be profitable to initiate an overpricing strategy, by buying stock and selling futures contracts. The lower transaction cost limit in figure 5.1 also illustrates that only where the fair price exceeds the futures price by more

Figure 5.1)

Arbitrage Window



than the amount implied by C^- will it be profitable to initiate an underpricing strategy by selling stock and buying futures contracts.

Index arbitrage operates slightly differently within each exchange, due to the different institutional and regulatory frameworks that underpin each financial centre. However, within each exchange several distinct categories of arbitrageur can be identified, each of whom is exposed to different degrees of arbitrage risk. This results in an arbitrage window of varying size. According to Mackinlay and Ramaswamy (1988) "the width of the band would be dictated by the most favourably situated arbitrageurs" (p. 138). The most favourably placed group of arbitrageurs are the member firms, who conduct index arbitrage in-house with their own market makers, trading index stocks most cost effectively. Less well favoured arbitrageurs such as institutional investors are exposed to a broader arbitrage window.

Although transaction costs are the most important determinant of the size of the arbitrage window, there are also various other factors which interfere with the pricing mechanism underpinning the relationship between the stock index and futures contract, and have the potential to alter the width of the arbitrage window. Factors which lead to a widening of the arbitrage window are now discussed:

i) unanticipated changes in dividend payments are a potential source of arbitrage risk. While the fair value formula assumes that dividends are known with certainty, actual dividend flows do in fact fluctuate over the life of the contract, which can have the effect of increasing the width of the arbitrage window. However, by employing the contract which is closest to maturity any misspecification of dividend payments can be minimised:

ii) the forward pricing model (equation 5.1) strictly applies only to the pricing of forward contracts, and it is only applicable to futures contracts where the interest rate is non stochastic. The differences between forward and futures contracts are discussed by Cox, Ingersoll and Ross (1981). The implication of this result is that unanticipated interest rate earnings or charges which arise from tail risk are ignored, leading to differences between the forward and futures price (Klemkosky and Lee (1991)).

iii) a lack of arbitrage capital results in futures prices deviating from their fair value beyond the limits imposed by transactions costs for sustained periods of time without triggering an arbitrage response. Sofianos (1991) argues that when faced with capital constraints the arbitrageur has to selectively decide whether a profitable arbitrage opportunity is worth pursuing:

> "When capital constraints bind, the opportunity cost of an arbitrage trade is the subsequent profitable mispricing that cannot be exploited because of the lack of arbitrage capital" (p. 205).

Sofianos (1991) argues that in the presence of capital constraints arbitrage becomes "an art rather than a science" (p. 205).

iv) regulatory constraints which limit the arbitrageur's ability to sell stocks short have tended to extend the lower bound of the no arbitrage condition leading to an asymmetrical arbitrage window. The practice of short selling is outlawed on many exchanges, but where it is permitted its use is restricted by strict regulatory requirements (e.g. Uptick rule in the US).

v) differences in the taxable status of investors holding positions in the stock and futures market have been suggested as possible explanations for futures contracts trading at a discount. Cornell and French (1983a) show that the relationship between the price of an index futures contract and its underlying stock index is complicated by the tax timing option which has implications for the size of the arbitrage window. Cornell and French demonstrate that stock holders, unlike the holders of futures contracts are able to reduce their tax exposure by realising capital losses and deferring capital gains:

> "A trader who is long in the stock receives not only the cash flows from the equivalent futures portfolio, but also the opportunity to defer any capital gains taxes" (1983a, p. 9)

The relative attractiveness associated with holding stock for taxable purposes has a tendency to extend the lower limit of the arbitrage window.

vi) when initiating the stock side of the arbitrage transaction, trading the entire basket of stocks comprising the stock portfolio can be expensive and difficult to simultaneously execute, where the number of market constituents is large. To counter this problem traders have often undertaken a "near" arbitrage transaction where they trade a surrogate basket of stocks which consists of a subset of the stocks in the stock index. While attempts to replicate the stock index using a liquid basket of stocks minimises the market impact costs of the transaction, such a procedure also introduces tracking risk, which arises from an imperfect relationship between the stock index and the surrogate basket of stocks.

vii) Buhler and Kempf (1995) argue that since index arbitrage is a risky activity, an arbitrage response is not triggered as soon as the limits of the no-arbitrage are violated, but rather arbitrageurs require an additional premium to compensate for the risk they incur. This results in the arbitrage window being wider than that which transaction costs alone would imply.

Alternatively, the are also factors which lead to a narrowing of the arbitrage window and encourage an arbitrage response while prices remain within transaction cost limits. For instance:

i) Gould (1988) argues that specific circumstances may enable traders to initiate arbitrage trades at very low transaction costs. Where institutional investors have already decided to undertake a tactical asset allocation decision and alter their exposure to equities, these changes are often implemented through futures trading, rather than trading in the underlying stock.

ii) arbitrage trading is often a dynamic rather than a static process, where arbitrageurs may decide to close out their positions before maturity, or roll-over their positions until a later expiration date. As Merrick (1989) argues, the options to early unwind and roll-over positions explain why arbitrage activity can be active even while prices are still within transaction cost limits.

iii) other derivative assets such as put and call options on the market index, provide new arbitrage possibilities. Gould (1988) demonstrates that a long futures position can be synthesised by a long call and a short put position. Such financial engineering reduces transaction costs and results in a narrowing of the arbitrage window.

iv) Yadav and Pope (1990) point out that specific exemption clauses also exist for certain categories of arbitrageurs. For instance, in the UK only equity market makers are exempt from stamp duty levied at 0.5% on stock sales.

Consistent with Mackinlay and Ramaswamy (1988) and Yadav and Pope (1990), deviations from the theoretical fair value derived in equation 6.1 are examined by testing for the presence of any mispricing. The mispricing series (M_t) measures the difference between the actual futures price ($F_{t,T}$) and its theoretical fair price at time t.

$$M_t = \frac{F_t - (I_t e^{r(T-t)} - \sum_{s=1}^{n} D_{t+s} e^{r(T-t-s)})}{I_t} \qquad 5.4)$$

The mispricing series is normalised by dividing any futures mispricing by the value of the spot index (I_t) underlying the futures contract, because all the major determinants of the limits of the arbitrage window should be proportional to the index. The mispricing series represents the potential profit from stock index arbitrage.

As previously outlined, the simple buy and hold transaction involves initiating an arbitrage position and holding the position to contract maturity at which point they are reversed. A simple arbitrage strategy is feasible whenever the absolute size of any mispricing is sufficient to exceed the transaction cost limits (i.e. $|M_t| > C$) of the arbitrage window. Where the mispricing is positive the futures contract is deemed *overpriced*, and providing the extent of mispricing exceeds the upper transaction costs (i.e. $F_{t,T} > FP^{+}_{t,T}$) then there is the potential for profitable arbitrage, by undertaking a *short futures arbitrage* position. Alternatively, where the mispricing is negative the futures contract is deemed *underpriced*, and providing the extent of mispricing exceeds lower transaction costs limit (i.e. $F_{t,T} < FP^{-}_{t,T}$) of the arbitrage window then there is the potential for profitable arbitrage, by undertaking a *long* *futures arbitrage* position. By definition, since at maturity both the deferred interest accruing on the stock index and the cost of carrying the stock index are equal to zero, the price of the futures contract and the price of the index are identical, and the mispricing series (M_t) must converge to zero.

While the simple buy and hold strategy assumes that arbitrage positions are held until maturity, changes in the behaviour of the mispricing series over the life of the contract, together with the possibility of mispricing reversals have given arbitrageurs the option to unwind position early or roll over positions to the next contract. A mispricing reversal occurs where the initial mispricing is reversed and a mispricing occurs in the opposite direction. For instance, the futures contract switches from being overpriced (or underpriced) to being underpriced (or overpriced). Merrick (1989) considers the desirability of early and delayed unwinding index arbitrage strategies.

The option to unwind an arbitrage trade early enables the arbitrageur to liquidate his position at some point before maturity and capture spot-futures mispricings arising at opposite ends of the arbitrage window. Since arbitrage returns are accumulated at the point when the trade is both initiated and liquidated arbitrage profits exceed those associated with the basic buy and hold strategy, and result in arbitrage capital being used more effectively. Encouraging the use of the early unwinding option also reduces the concentration of arbitrage transactions at maturity, which are thought to strongly contribute to an increase in market volatility at expiration (Stoll and Whaley (1987)). Furthermore, arbitrageurs who have previously established an arbitrage position in response to an initial mispricing also have the opportunity to exploit any subsequent mispricing reversal at substantially lower transaction costs than an arbitrageur who is venturing into the market for the first time. As Merrick (1989) argues:

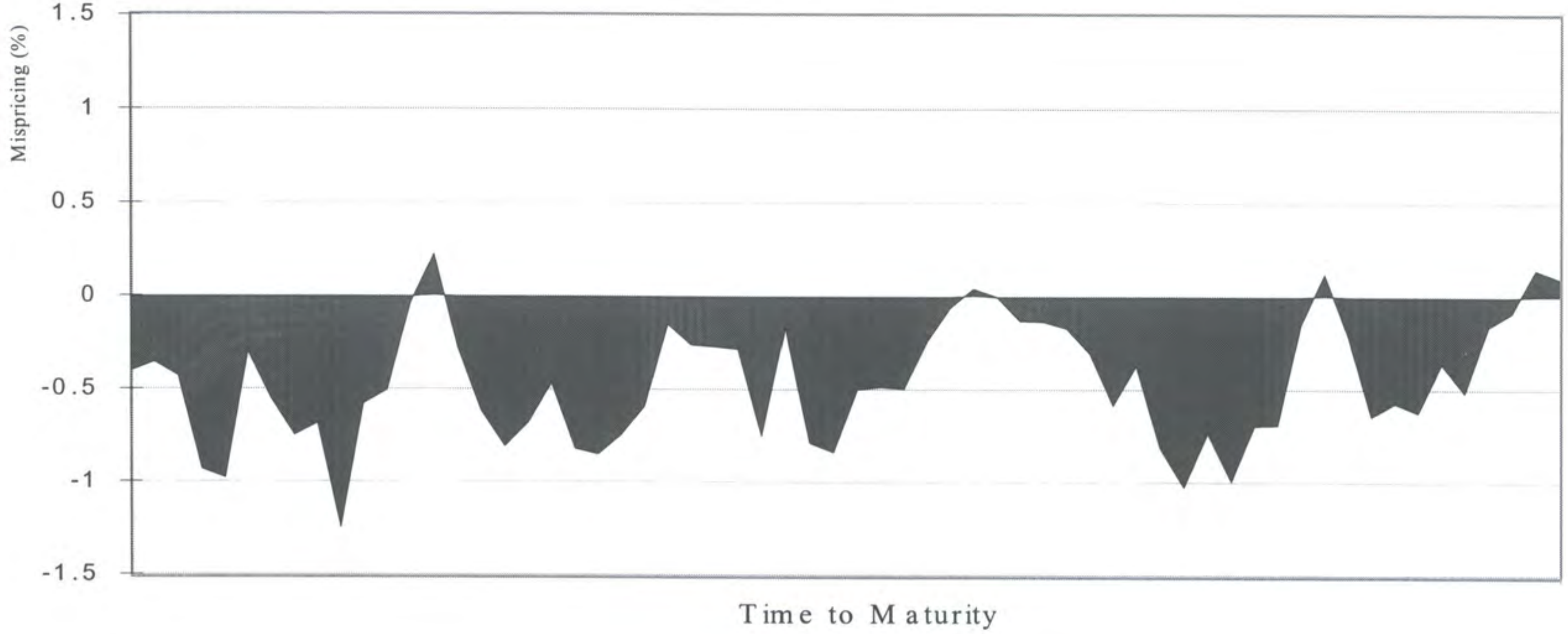
> "the transaction cost discounts implicit in early unwindings helps explain why arbitrage activity can be heavy even when market prices are within transaction cost bounds" (p. 109).

The opportunity for the arbitrageur to unwind early may result in any mispricing reversal being eliminated before the opposite limit of the arbitrage window is violated.

Mackinlay and Ramaswamy (1988) argue that this tendency for arbitrageurs to unwind positions early following a profitable mispricing reversal, introduces path dependence into the mispricing series. With path dependence the behaviour of the mispricing series in the future will be influenced by the behaviour of this series in the past. For instance, where mispricing has been sufficient to exceed the limits of the arbitrage window in the past and induce an arbitrage response, the early unwinding option should be sufficient to preclude any significant reverse mispricing in the opposite direction. In other words, once the upper (lower) limit of the arbitrage window has been broken, it is unlikely that the lower (upper) limit of the arbitrage window will be violated. Path dependence in the mispricing series is illustrated in figure 5.2. Figure 5.2 shows that the futures contract is initially strongly underpriced but over the life of the contract mispricing is reversed at times, and the contract

Figure 5.2)

Path Dependence in Mispricings



becomes overpriced. However, once the mispricing is reversed some of the arbitrage position taken while the contract was underpriced are unwound prematurely, inducing a second mispricing reversal and forcing mispricing back to being overpriced. The key point being that mispricing in the past will have an important bearing on the direction of mispricing in the future. Therefore, once the mispricing series has violated one of the limits of the arbitrage window, it is less likely to violate the other limit of the arbitrage window.

The delayed unwinding (or roll over) strategy involves replacing the original futures position with a position in the next nearest to maturity contract at the initial contract maturity date, while leaving the stock side of the original arbitrage transaction intact. Merrick (1989) demonstrates that the delayed unwinding option exists where the direction of the mispricing in the next nearest to maturity contract is the same as the initial mispricing. This option is profitable where the magnitude of mispricing in the next nearest to maturity contract is sufficiently greater than the initial mispricing to offset the additional transaction costs which arise in the futures markets. Merrick also discusses the possibility of combining the early unwinding and rollover options. Where the original mispricing has been reversed, but mispricing in the next nearest to maturity contract remains in the same direction as the original mispricing, combining an early unwinding and roll over strategy will be profitable providing the difference in mispricing is in excess of the additional transaction costs. The rolling over option is concerned with the relative prices between two futures contracts, and this relationship is examined in greater detail by considering the issue of intramarket spread trading in chapter six.

It is clear that the behaviour of the mispricing series as contract maturity approaches has important implications for the success of the early unwinding and roll over strategies. Mackinlay and Ramaswamy (1988) argue that the mispricing series is systematically related to the length of time remaining before the contract expiration date. It is reasonable to assume that because interest rate and dividend uncertainty decline as the contract approaches expiration, the mispricing series will do likewise. This is a directly testable hypothesis and will be considered as part of an empirical investigation into the pricing efficiency of the FTSE 100 and Mid 250 contracts in section 5.3.

5.3) EMPIRICAL INVESTIGATION

Stock index arbitrage in the UK is considerably more difficult to implement than in other markets owing to specific technical and structural differences which impede trading in equity and futures markets. In the UK index arbitrage has been positively encouraged owing to concern over the wide pricing differences which have been found to exist between spot and futures markets. The presence of greater arbitrage activity is likely to results in improved tracking and convergence between these markets, and so provides a more efficient means of risk transfer.

The major constraint on the level of arbitrage activity in the UK is transactions costs. Transactions costs include explicit commissions paid to take positions and market impact, which results in adverse price changes when buying or selling institutional size positions. The market impact effects are typically much larger. Table 1.3 (page 14) shows the breakdown of round trip transaction costs facing arbitrageurs who wish to execute index arbitrage strategies in relation to the FTSE 100 and Mid 250 contracts. Transaction costs consist of the size of the bid-offer spreads in stock and futures markets, stamp duty and stock and futures markets commissions. The differences in the size of the bid-offer spread in stock and futures markets are far larger for the Mid 250 than the FTSE 100, and are attributable to lower liquidity in both the Mid 250 stock and futures markets. In the UK, different categories of arbitrageurs can be identified, each characterised by a different level of transactions costs. The transaction costs of the most favourably placed arbitrageur determines the width of the arbitrage window and the degree to which the futures price can deviate from its theoretical value before triggering a profitable arbitrage opportunity. Equity market makers who are responsible for ensuring effective trading in each of the index constituents are exempt from stamp duty and equity commissions and are able to trade at the bid or offer price, and are therefore better placed to execute arbitrage transactions than institutional investors. Estimates of transactions costs in table 1.3 indicate that market makers typically operate with transactions costs of 0.75% and 1.41% for the FTSE 100 and Mid 250 markets respectively, while institutional investors typically operate with transactions costs of 1.59% and 2.31% respectively. However, these estimates are still likely to understate true transaction costs, especially for the Mid 250 market, owing to the difficulties in assessing the actual market impact cost of the transaction. As Lovell and Arnott (1989) argue:

> "Transaction costs take on the character of an iceberg. Commissions rise above the surface, visible to all. The submerged leviathan encompasses the market impact of trades and the imponderable cost of the trades that never happened" (p. 1)

Additionally, an examination of transaction costs alone overlooks the more serious technical and structural difficulties which inhibit index arbitrage in the UK. Specific technical problems which impede arbitrage trading in the UK are those of execution risk, tracking risk and convergence risk. While all of these problem are not unique to the UK, these difficulties often manifest themselves more acutely than on other exchanges. Execution risk arises because profitable mispricings last for only very short periods of time and without an automatic execution facility such as Super DOT, as in the US, the equity side of an arbitrage transaction has to be broken down into numerous orders for individual stocks. Assembling the equity side of the arbitrage transaction manually is both cumbersome and time consuming and severely constrains the arbitrageur's ability to respond to a mispricing opportunity, given that favourable price differentials are often rapidly reversed. The problem of execution risk is most serious for large broad based indexes such as the Mid 250 which are characterised by a large number of illiquid constituents and where rapid trading in these stocks as part of a basket is extremely difficult.

To alleviate the problem of execution risk index arbitrageurs frequently employ only a liquid subset of the total number of individual stocks. Sofianos (1993) found for the US, that on average arbitrageurs completed the equity side of the transaction using a surrogate basket comprising of just over half of the underlying index constituents. While the practice of using a subset of stocks minimises market impact effects and speeds up execution, it results in greater tracking risk given that the arbitrageur's equity and futures positions no longer move in "lockstep".

In the UK uncertainty surrounding both the final settlement price of the index futures contract (i.e. EDSP) and the corresponding index value at expiration gives rise to convergence risk. In the US arbitrageurs are able to close out positions at expiration by issuing market-on-open or market-on-close orders and so guarantee complete convergence between the price of their equity and futures positions at expiration. However, in the UK the futures settlement price at expiration is an average of the median values in the last minutes before expiration. In addition, the UK's equity market is a quote-driven market[1] whereby the index value at maturity is based on the weighted average of the mid-touch prices of the market constituents, a price at which arbitrageurs are unable to trade. Furthermore, due to the quote-driven nature of the market, the price of the FTSE 100 and Mid 250 indexes can change when market makers adjust their views, even though no trading has taken place. As a consequence of these distinct institutional features, arbitrageurs in the UK are unable to unwind their positions at expiration with complete certainty.

While for simplicity it is often assumed that both boundaries of the arbitrage window are of equal width, in actual fact the upper boundary is smaller in size than the lower boundary giving rise to an asymmetric arbitrage window. The asymmetry arises because of the restrictions which prohibit non-market makers from short selling stocks. For instance, when the futures contract is trading below its theoretical values arbitrageurs are required to go long in futures and short in stock. In order to go short in stock institutional investors who do not possess the stock in their portfolio are required to incur the costs of borrowing the stock, with the resulting widening of the lower arbitrage window. Finally, compared to markets in the US, UK markets are subject to more severe capital constraints given that the range of market participants is rather limited.

Owing to the unique institutional structure of the UK's equity and index futures markets, it seems reasonable to expect that equity market makers are likely to be the only effective arbitrageurs. Of the two UK index futures contracts it seems likely that mispricing may well be larger for the Mid 250 contract than the FTSE 100 contract, owing to the illiquid nature of the Mid 250 stocks, but after allowing for the larger transaction costs in this market it is not clear whether any mispricing will translate into profitable arbitrage opportunities. Whether index arbitrage in the UK is profitable is an empirical question which will subsequently be investigated.

The purpose of this chapter is to empirically investigate the pricing efficiency of and the potential for profitable index arbitrage in the context of UK index futures markets. Specifically, the following issues will be examined:

- this chapter provides the first empirical evaluation of the pricing efficiency of the Mid 250 index futures contract. Additionally, a comparison will be made with the pricing efficiency of the well established FTSE 100 contract. It is important that both contracts be efficiently priced to enable investors to gain effective exposure to the UK equity market.
- for the FTSE 100 contract only, mispricing is compared across different maturity contracts to test for any significant differences. It is not possible to consider this issue with respect to the Mid 250 contract, since trading volume is non-existent over much of the trading life of the next nearest to maturity contract. However, with respect to the FTSE 100 contract it is reasonable to expect that mispricing will be greater in the next nearest to maturity contract owing to the greater

arbitrage risk associated with a contract further from maturity.

- the ex post profitability of index arbitrage for the FTSE 100 and Mid 250 contracts is examined by testing for transaction costs violations associated with different categories of arbitrageurs.
- the behaviour of the mispricing series for both contracts is investigated to determine whether mispricing is systematically related to the length of time to contract expiration. Such a finding would have important implications for the profitability of the early and delayed unwinding strategies.
- the issue of persistence in mispricing is considered for both the FTSE 100 and Mid 250 contracts, with evidence of persistence indicating that current mispricing is strongly related to past mispricing.
- by employing ARMA modelling techniques, the autoregressive processes underlying the mispricing time series of the FTSE 100 and Mid 250 contracts are identified and estimated.

5.4) DATA AND METHODOLOGY

The stock index and index futures data relates to the daily closing and settlement prices respectively. While it has been the practice in recent studies to use intra-daily transactions data to test for index futures pricing inefficiencies, the very low levels of trading volume on the Mid 250 contract preclude the use of intra-daily data. Although the use of daily data will fail to detect any mispricing which occurs during the course of the day and can only be suggestive of actual arbitrage opportunities, nonetheless the findings should provide a meaningful comparison of the pricing efficiency of the two contracts, together with an indication of the width of the arbitrage window. The sample covers the ten contracts over the period March 1994 (following the introduction of the Mid 250 contract)[2] to September 1996, which consists of 634 observations. For both index futures contract the analysis concentrates on the contract nearest to maturity, which is the most heavily traded, and is rolled over to the next contract on the expiration day. However, when comparing mispricing between contracts of different maturity, attention is also given to the next nearest to maturity contract.

In computing the mispricing series, estimates are required for the daily interest rate and dividend payments associated with the underlying spot index. The UK treasury bill is chosen as an appropriate proxy for the interest rate. However, given that the maturity date associated with the treasury bill does not correspond with the maturity date on the respective futures contracts, the interest rate series is estimated through linear interpolation by combining a weighted average of both the one and three month rates.

Actual daily dividend payments[3] are used to calculate the theoretical futures price. In the UK, because companies make dividend payments more than once a year and as much as four times a year, there is less lumpiness in dividend flows compared to other European index futures contracts such as the DAX or MIB-30, where dividend payment are found to be characterised by a strong seasonal component (Bengali and Rattray (1996)). Figures 5.3 and 5.4 illustrate dividend payments for the FTSE 100 and Mid 250 indexes respectively. They confirm that UK companies pay dividends throughout the year, although dividend payments are larger than average during the months of March and August.

Figure 5.3)

Historic FTSE 100 Index Gross Dividend Pattern

February 1994 - December 1996

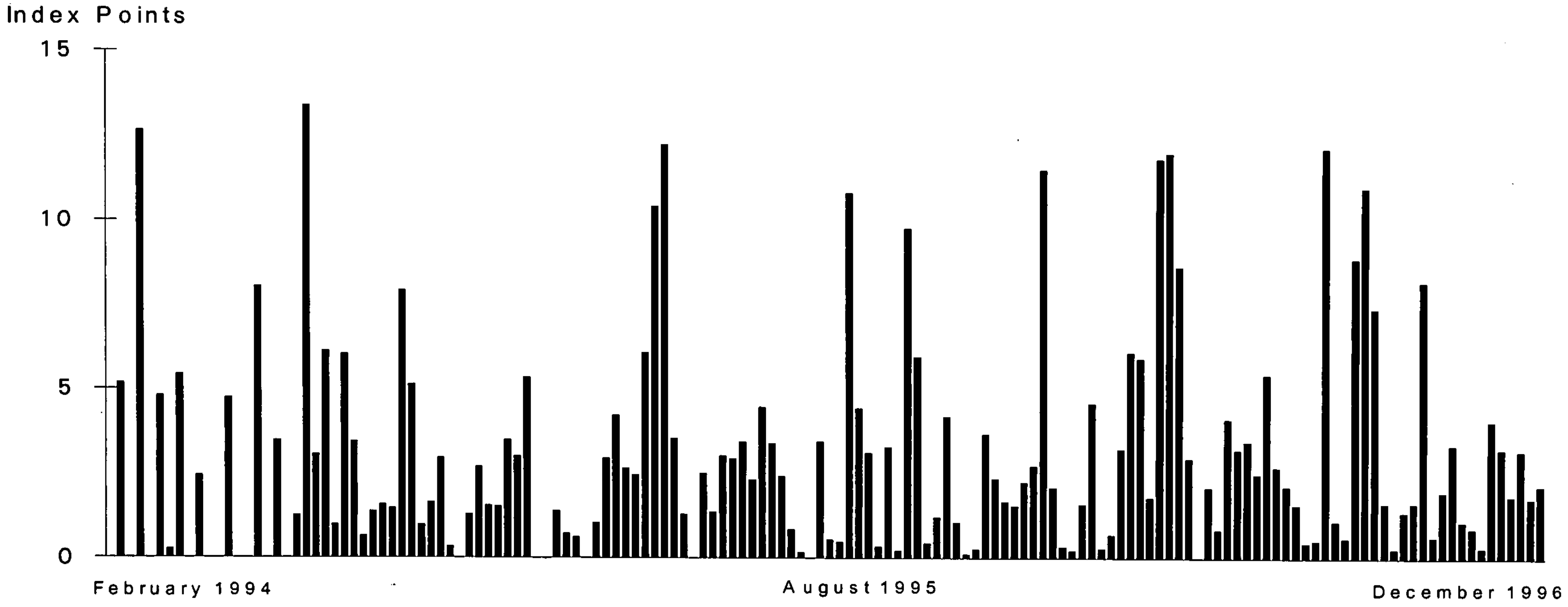
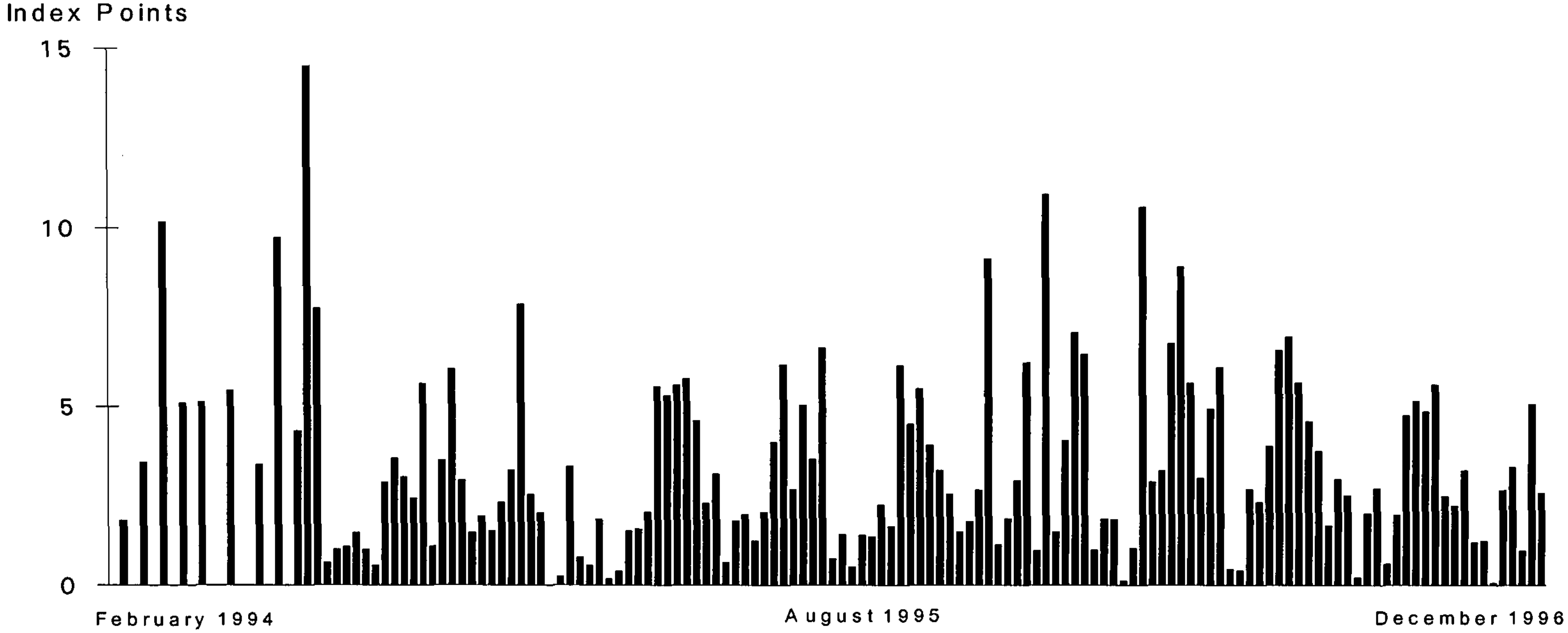


Figure 5.4)
Historic FTSE Mid 250 Index Gross Dividend Pattern
February 1994 - December 1996



5.5) EMPIRICAL RESULTS

Consistent with Yadav and Pope (1990) and Strickland and Xu (1992) mispricing was examined by employing equation 5.4 and testing for deviations from the theoretical fair price. Significant deviations are suggestive of arbitrage opportunities and the triggering of an index arbitrage response. If arbitrageurs are active in markets then their presence will serve to tie spot and futures markets together, and providing that both interest rates and dividends are non-stochastic, return variability will be the same in both markets, resulting in a variance ratio of unity. However, owing to differences in transaction costs between spot and futures markets, it is possible that information will be impounded more rapidly into the futures market than the spot market, and these changes are likely to manifest themselves in differences in return variability.

Table 5.1 reports the summary statistics relating to daily log returns for both the FTSE 100 and Mid 250 spot and futures markets. There are two interesting points to note. Firstly, over the whole sample period the standard deviation of returns in the futures market is greater than the standard deviation of returns in the spot market, with respect to both the FTSE 100 and Mid 250. The variance ratio statistic is 1.445 for the FTSE 100 and 1.347 for the Mid 250, with both statistics being significant at the 1% level. Therefore, the null hypothesis that the variance ratio statistic equals unity is rejected. This finding is consistent with Yadav and Pope (1990). Secondly, both on a contract by contract basis, and for the whole sample period, the standard deviation of returns associated with both the FTSE 100 spot and futures market are greater than those associated with the Mid 250 spot and futures market. For the

Table 5.1)
Relative Volatility:
Daily Returns on the FTSE 100 and Mid 250 Spot and Futures Markets*

		FTSE 100 Index		Mid 250 Index		
Contract		Spot	Futures	Spot	Futures	Obs.
June 94	Mean	-0.118	-0.119	-0.156	-0.161	61
	Max	1.654	2.042	0.853	1.051	
	Min:	-2.239	-2.568	-1.694	-1.926	
	Stdev:	0.797	1.035	0.474	0.589	
	VR	1.684	(0.046)	1.545	(0.095)	
Sept 94	Mean	0.042	0.041	0.050	0.040	64
	Max	1.922	2.384	1.025	1.281	
	Min:	-2.262	-2.449	-1.841	-1.717	
	Stdev:	0.825	1.024	0.555	0.612	
	VR	1.539	(0.089)	1.217	(0.438)	
Dec 94	Mean	-0.070	-0.076	-0.102	-0.110	65
	Max	1.773	1.921	1.019	1.997	
	Min:	-1.677	-2.167	-1.606	-1.819	
	Stdev:	0.892	1.075	0.538	0.730	
	VR	1.452	(0.139)	1.842	(0.016)	
March 95	Mean	0.064	0.051	-0.022	-0.040	62
	Max	1.534	1.616	0.747	1.168	
	Min:	-1.372	-1.615	-1.987	-1.473	
	Stdev:	0.694	0.848	0.462	0.549	
	VR	1.492	(0.121)	1.409	(0.183)	
June 95	Mean	0.140	0.137	0.137	0.131	61
	Max	1.422	1.669	0.773	0.952	
	Min:	-1.283	-1.634	-0.632	-0.653	
	Stdev:	0.549	0.648	0.297	0.348	
	VR	1.394	(0.201)	1.373	(0.222)	
Sept 95	Mean	0.088	0.074	0.120	0.110	64
	Max	2.178	2.143	1.577	1.204	
	Min:	-2.099	-2.330	-1.037	-1.642	
	Stdev:	0.642	0.762	0.380	0.453	
	VR	1.407	(0.178)	1.418	(0.168)	
Dec 95	Mean	0.045	0.038	0.002	-0.014	65
	Max	1.415	1.946	0.979	1.013	
	Min:	-1.440	-1.891	-1.270	-1.264	
	Stdev:	0.582	0.711	0.383	0.403	
	VR	1.492	(0.103)	1.105	(0.692)	
March 96	Mean	0.004	-0.014	0.107	0.093	62
	Max	1.299	1.308	0.713	0.722	
	Min:	-1.285	-1.795	-0.962	-1.525	
	Stdev:	0.617	0.699	0.342	0.387	
	VR	1.281	(0.336)	1.282	(0.335)	
June 96	Mean	0.019	0.024	0.076	0.068	66
	Max	0.955	1.138	0.942	1.036	
	Min:	-1.433	-1.472	-0.780	-1.030	
	Stdev:	0.542	0.611	0.321	0.352	
	VR	1.269	(0.339)	1.199	(0.467)	
Sept 96	Mean	0.100	0.109	-0.008	-0.014	64
	Max	1.244	1.899	0.585	0.590	
	Min:	-1.801	-1.666	-2.134	-1.980	
	Stdev:	0.586	0.640	0.479	0.475	
	VR	1.193	(0.485)	0.981	(0.940)	
Total	Mean	0.031	0.026	0.021	0.010	634
	Max	2.178	2.384	1.577	1.997	
	Min:	-2.262	-2.568	-2.134	-1.980	
	Stdev:	0.682	0.820	0.439	0.509	
	VR	1.445	(0.000)	1.347	(0.000)	

* The values in parentheses refer to the significance level of the F statistic calculated to test the equality of the variance in the spot and futures markets. Where the variance ratio statistic equates to the variance of the change in the log of futures price to the variance of the change in the log of the spot price.

whole sample, the standard deviation of returns are 0.682 and 0.439 respectively for the FTSE 100 and Mid 250 spot indexes and 0.820 and 0.509 respectively for the FTSE 100 and Mid 250 index futures contracts. The greater return variability associated with the FTSE 100 in both spot and futures markets is consistent with the fact that the transactions costs associated with these market are substantially lower than those for the Mid 250 market, suggesting that information is more rapidly impounded into the prices of the FTSE 100 spot and futures markets. This findings is consistent with more efficient pricing in the FTSE 100 contract than the Mid 250 contract.

The daily mispricing series for both the near FTSE 100 and Mid 250 futures contracts over the period March 1994 to September 1996 are illustrated in figures 5.5 and 5.6, and summarised in tables 5.2 and 5.3 respectively[4]. There are a number of important results to discuss. Firstly, while there are many deviations from fair value, both contracts appear to be quite efficiently priced, with mispricing for both contracts being generally constrained within the arbitrage limits of 0.5% and -1.0%. These results suggest that arbitrage opportunities are likely to be rare even for the most favourably placed arbitrageurs. Secondly, over the whole sample period neither contract trades at a chronic discount or premium. The FTSE 100 contract is overpriced on 290 (45.7%) occasions and underpriced on 344 (54.3%) occasions. The Mid 250 contract is overpriced on 305 (48.1%) occasions and underpriced on 329 (51.9%) occasions. However, in common with other newly introduced index futures contracts, the Mid 250 contract is priced at a rather severe discount to fair value in the period following its introduction. This finding would seem to support Figlewski's

Figure 5.5)

Mispricing Plot of the FTSE 100 Index Futures Contract: March 18th 1994 - September 20th 1996

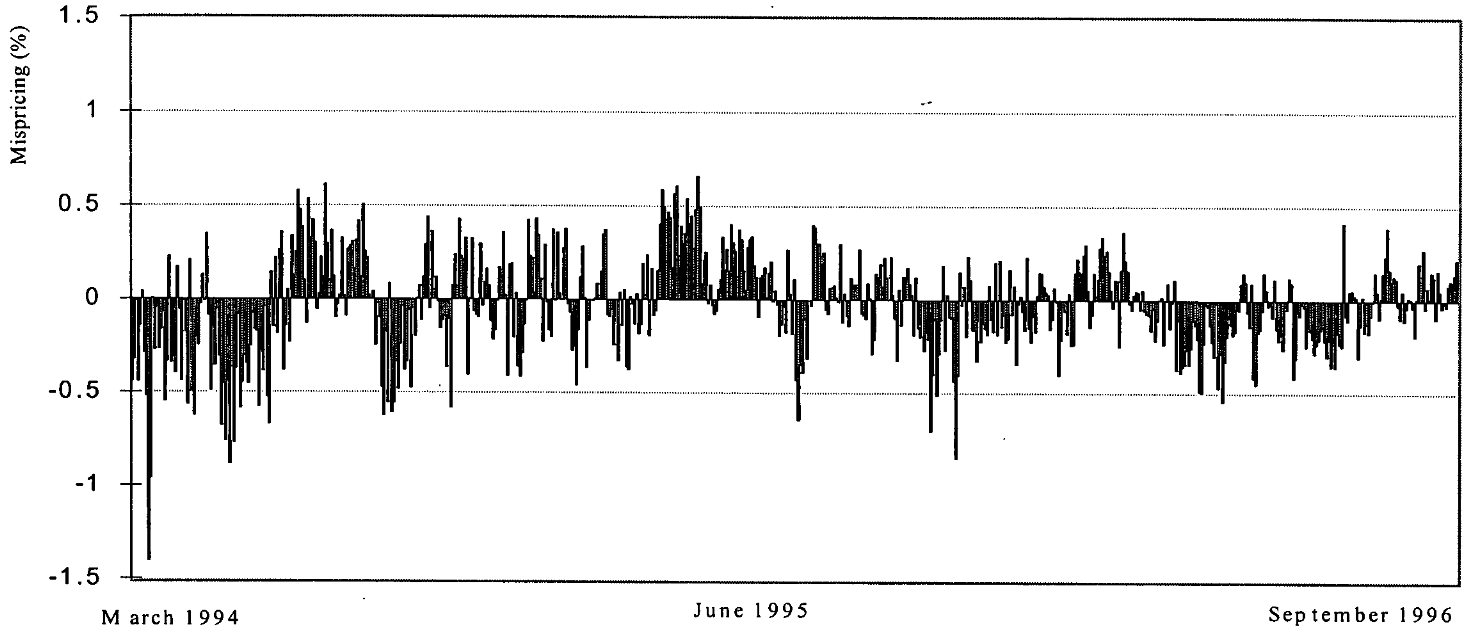


Figure 5.6)

Mispricing Plot of the FTSE Mid 250 Index Futures Contract: March 18th 1994 - September 20th 1996

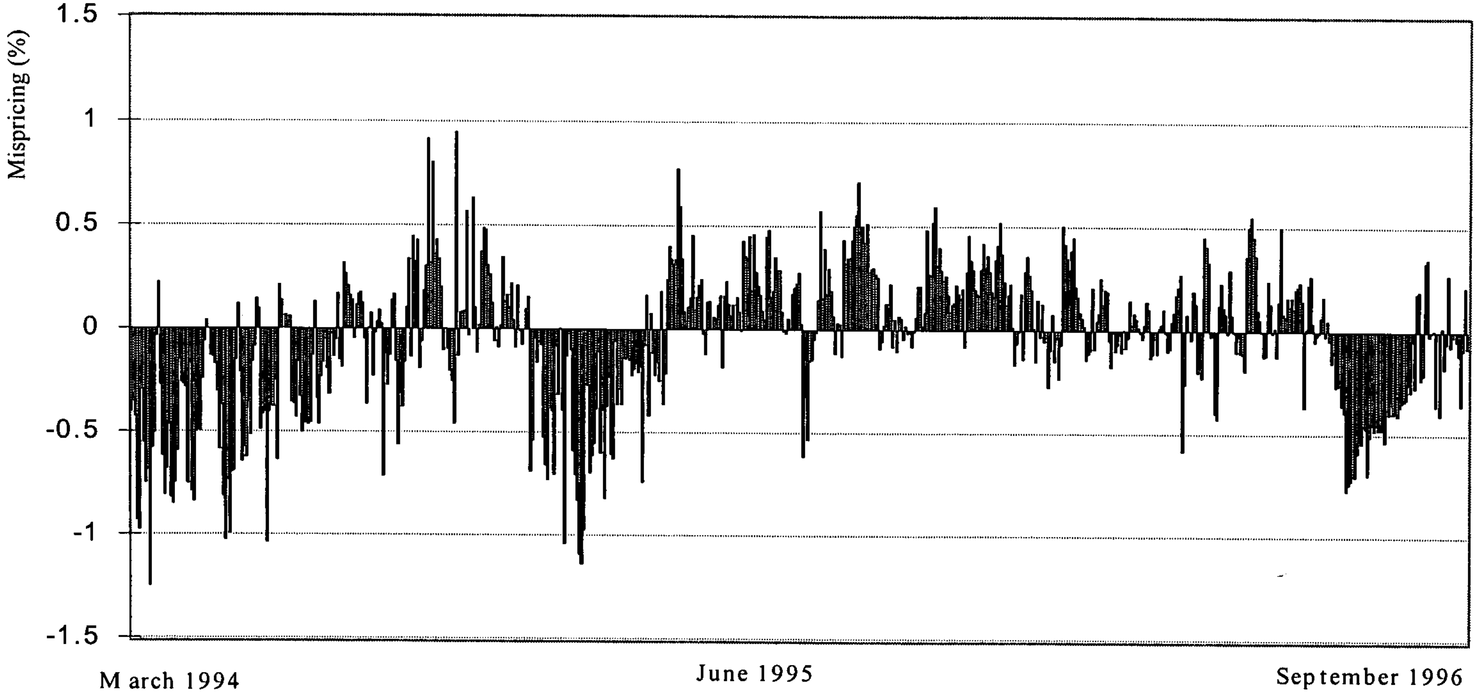


Table 5.2)

Premiums or Discounts: Summary Statistics for the Mispricing Series of the FTSE 100 Index Futures Contract (18th March 1994 - 20th September 1996)

Contract	Obs.	$M_t > 0$	$M_t < 0$	Mean	T Stat:	S.D.	Maximum	Minimum	Ave Abs	Ave Pos.	Ave Neg.	Reversal	> |0.25|
Jun 1994	61	7	54	-0.2956	-7.5461	0.3059	0.3500	-1.4033	0.3330	0.1630	-0.3550	14	2
Sep 1994	64	41	23	0.0626	1.6269	0.3079	0.6140	-0.6698	0.2552	0.2480	-0.2679	19	4
Dec 1994	65	28	37	-0.0489	-1.5258	0.2586	0.4396	-0.6072	0.2075	0.1840	-0.2252	20	6
Mar 1995	62	30	32	0.0139	0.4986	0.2191	0.4320	-0.4599	0.1696	0.1896	-0.1509	25	5
Jun 1995	61	51	10	0.2304	8.8769	0.2027	-0.1935	0.6602	0.2525	0.2888	-0.0673	9	0
Sep 1995	64	39	25	0.0105	0.4114	0.2045	0.4003	-0.6449	0.1589	0.1390	-0.1900	26	3
Dec 1995	65	20	45	-0.1082	-4.1777	0.2087	0.2335	-0.8484	0.1790	0.1151	-0.2074	26	0
Mar 1996	62	31	31	-0.0046	-0.1943	0.1862	0.3650	-0.4031	0.1475	0.1429	-0.1521	20	2
Jun 1996	66	9	57	-0.1510	-7.4624	0.1644	0.1482	-0.5437	0.1801	0.1070	-0.1917	10	0
Sep 1996	64	34	30	-0.0042	-0.2042	0.1660	0.4154	-0.3581	0.1302	0.1185	-0.1434	21	3
Total	634	290	344	-0.0302	-2.9215	0.2605	0.6602	-1.4033	0.2007	0.1863	-0.2128	190	25

Table 5.3)

Premiums or Discounts: Summary Statistics for the Mispricing Series of the FTSE Mid 250 Index Futures Contract (18th March 1994 - 20th September 1996)

Contract	Obs.	$M_t > 0$	$M_t < 0$	Mean	T Stat	S.D.	Maximum	Minimum	Ave Abs	Ave Pos.	Ave Neg.	Reversal	$> \lvert 0.7 \rvert$
Jun 1994	61	4	57	-0.4648	-11.2098	0.3239	0.2228	-1.2479	0.4822	0.1322	-0.5067	7	0
Sep 1994	64	22	42	-0.1556	-4.5865	0.2715	0.3179	-1.0381	0.2435	0.1278	-0.3041	17	0
Dec 1994	65	43	22	0.1265	3.4435	0.2963	0.9480	-0.5625	0.2395	0.2767	-0.1669	24	0
Mar 1995	62	3	59	-0.3760	-9.7620	0.3032	0.1659	-1.1407	0.3839	0.0826	-0.3993	6	0
Jun 1995	61	52	9	0.1824	7.2790	0.1957	0.7745	-0.3626	0.2132	0.2321	-0.1044	12	0
Sep 1995	64	46	18	0.1346	4.3194	0.2493	0.7125	-0.6156	0.2154	0.2435	-0.1437	16	0
Dec 1995	65	50	15	0.1735	7.1821	0.1947	0.5958	-0.2742	0.2225	0.2574	-0.1063	13	0
Mar 1996	62	37	25	0.0492	2.1632	0.1790	0.5048	-0.5830	0.1335	0.1531	-0.1046	17	0
Jun 1996	66	40	26	0.0770	2.9786	0.2101	0.5510	-0.4274	0.1709	0.2045	-0.1192	21	0
Sep 1996	64	8	56	-0.2772	-8.2063	0.2702	0.3486	-0.7736	0.3261	0.1954	-0.3447	12	0
Total	634	305	329	-0.0505	-3.7223	0.3413	0.9480	-1.2479	0.2619	0.2198	-0.3010	145	0

(1984b) argument that traders are reluctant to use an index futures contract while trading is still in its infancy. Thirdly, over the whole sample, the mean deviation for the FTSE 100 and Mid 250 contracts is significantly negative, with values of -0.0302 and -0.0505 respectively. Considering mean deviations on a contract by contract basis, the FTSE 100 is associated with four contracts that trade at a premium, and six contracts which trade at a discount, although only four contracts are significantly mispriced. While the Mid 250 is associated with six contracts which trade at a premium and four contracts which trade at a discount, of which all ten are significantly mispriced. These findings strongly suggest that the Mid 250 contract is the less efficiently priced than the FTSE 100 contract. Comparing the average absolute deviation for both futures provides further evidence of the greater pricing efficiency of the FTSE 100 contract. The average absolute deviation for the FTSE 100 contract is 0.2007 compared with a value of 0.2619 for the Mid 250 contract. Interestingly, for the FTSE 100 contract both the average absolute deviation and standard deviation of mispricing have declined in magnitude over the sample period. These changes indicate that the extent to which prices on the FTSE 100 contract deviate from their equilibrium values has declined since the introduction of the Mid 250 contract. It seems reasonable to suggest, that equipping equity market makers and institutional investors with a valuable instrument through which they can achieve more efficient management of lower capitalisation stocks has freed capital and resources which have been employed to achieve more effective tracking on the FTSE 100 contract. This would appear likely considering that one of the important functions of the Mid 250 contract in conjunction with the FTSE 100 contract is that of FT All Share Index replication.

Finally, both index futures contracts are characterised by frequent mispricing reversals. The mispricing series for the FTSE 100 contract is associated with 190 reversals (19 reversals per contract), while the mispricing series for the Mid 250 contract is associated with 145 reversal (14.5 reversals per contract). However, given the significance of mispricing reversals with respect to the early unwinding and rollover strategies, the extent to which the series oscillates is also important. Therefore, the final column in tables 5.2 and 5.3 report the number of reversals which occur where the respective mispricing series switch from being underpriced (overpriced) by an amount exceeding at least half of the cost of an arbitrage transaction, to being overpriced (underpriced) by an amount exceeding at least half of the cost the arbitrage transaction. This provides a more meaningful indicator of the potential for risky index arbitrage, which is undertaken when the mispricing series lies within transaction cost limits. For the FTSE 100, the mispricing series violates both the ± 0.25% limits on only 25 occasions. While the Mid 250 mispricing series fails to violate ± 0.7% limits on any occasion. These findings indicate mispricing is quite strongly path dependent in both markets, and suggests that the risky arbitrage strategy is unlikely to be particularly valuable.

We shall now consider whether there are any significant differences in mispricing between the near and deferred FTSE 100 contracts. The majority of the trading volume for the FTSE 100 contract is concentrated in the nearest to maturity contract and it only begins to build up in the next nearest to maturity contract in the month before maturity. Therefore, it seems reasonable to expect that index futures pricing will be more efficient in the nearest to maturity contract than the next nearest to maturity contract (henceforth the deferred contract). The daily mispricing series for the deferred FTSE 100 is represented in figure 5.7 and table 5.4. Comparing the results in table 5.4 to those of the near contract in table 5.2 several interesting points can be identified. Firstly, considering the direction of mispricing, over the entire sample period the next nearest to maturity is overpriced on 419 (66.1%) occasions and underpriced on 215 (33.9%) occasions, indicating that the next nearest to maturity contract trades at a premium to the nearest to maturity contract. In fact in every contract month, the number of positive observations is greater for the deferred contract than for the nearest to maturity contract. This finding suggests that research is required into the profitability of intramarket spread strategies using the near and deferred FTSE 100 contracts. Secondly, deviations from fair value are greater for the deferred contract than for the near contract over the sample period. The mean deviation over the entire sample is 0.0985, which is significant at the 1% level. On a contract by contract basis, eight contracts trade at a premium and two contracts trade at a discount, of which seven are significantly mispriced. Also the average absolute deviation of 0.2194 for the deferred contract is greater than that for the near contract. All of these findings suggest that the deferred contract is less efficiently priced than the near futures contract, and is consistent with less liquidity, and greater interest rate and dividend uncertainty for the contract further from maturity. Thirdly, over the entire sample period the frequency of mispricing reversals for the deferred contract are almost identical to the near contract, with 189 reversals. However, on a contract by contract basis the frequency of mispricing reversals varies widely between the near and deferred contract, indicating the possibility of profitable intramarket spread trading.

Figure 5.7)
Mispricing Plot of the FTSE 100 Deferred Index Futures Contract:
March 18th 1994 - September 20th 1996

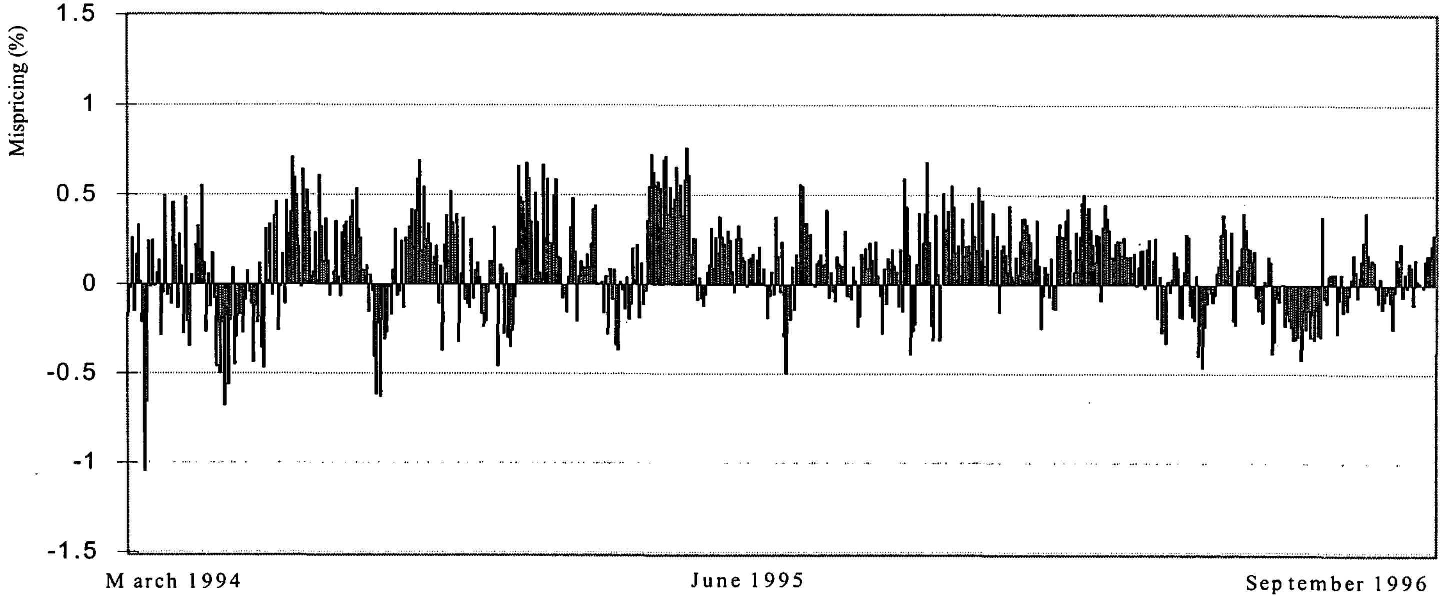


Table 5.4)

Premiums or Discounts: Summary Statistics for the Mispricing Series of the FTSE 100 Deferred Index Futures Contract (18th March 1994 - 20th September 1996)

Contract	Obs.	$M_t > 0$	$M_t < 0$	Mean	T Stat:	S.D.	Maximum	Minimum	Ave Abs	Ave Pos.	Ave Neg.	Reversal	> |0.25|
Sep 1994	61	24	37	-0.0563	-1.4539	0.3024	0.5527	-1.0475	0.2338	0.2256	-0.2391	30	6
Dec 1994	64	45	19	0.1386	3.6341	0.3051	0.7111	-0.6299	0.2715	0.2916	-0.2237	18	4
Mar 1995	65	40	25	0.0870	2.7102	0.2587	0.6954	-0.4571	0.2278	0.2557	-0.1831	23	6
Jun 1995	62	45	17	0.1458	4.3908	0.2615	0.6801	-0.3664	0.2273	0.2570	-2.5253	21	1
Sep 1995	61	52	9	0.2693	8.5791	0.2452	0.7641	-0.1880	0.2904	0.3283	-0.0716	10	0
Dec 1995	64	43	21	0.0765	3.1394	0.1951	0.5609	-0.4964	0.1686	0.1825	-0.1403	24	3
Mar 1996	65	57	8	0.1982	7.0298	0.2273	0.6832	-0.3895	0.2561	0.2590	-0.2354	10	5
Jun 1996	62	50	12	0.1554	6.4383	0.1901	0.5049	-0.3267	0.2132	0.2285	-1.7902	15	1
Sep 1996	66	30	36	-0.0269	-1.0322	0.2119	0.4005	-0.4663	0.1784	0.1666	-0.1882	17	3
Dec 1996	64	33	31	0.0038	0.1877	0.1617	0.4058	-0.3087	0.1313	0.1310	-0.1316	21	3
Total	634	419	215	0.0985	9.6425	0.2572	0.7641	-1.0475	0.2194	0.2405	-0.1782	189	32

The implementation of an effective arbitrage strategy in relation to both the FTSE 100 and Mid 250 contracts requires taking into account the costs of initiating the transaction for different categories of arbitrageurs. It is assumed that when the mispricing series violates a specific transaction cost threshold the arbitrageur takes the appropriate action in the spot and futures markets to exploit this perceived opportunity. However, the maximum and minimum mispricing levels reported in tables 5.2 and 5.3 for the nearest to maturity FTSE 100 and Mid 250 contracts respectively, suggest that arbitrage opportunities are likely to be rare and available only to favourably placed arbitrageurs. As was discussed earlier, the transactions costs associated with executing an arbitrage strategy involving the Mid 250 will be greatly in excess of those associated with executing a similar strategy involving the FTSE 100 (see table 1.3). However, to categorise mispricing with respect to different transaction cost limits, tables 5.5 and 5.6 report mispricing violations for transaction cost thresholds of 0.5%, 1.0% and 1.5% for the near FTSE 100 contract and Mid 250 contract respectively.

In relation to the transaction costs violations in both markets, the 0.5% transaction costs threshold is violated on 5.2% of occasions for FTSE 100 contract, and 14.2% of occasions for the Mid 250 contract, while the 1% transaction costs threshold is violated on just one occasion for the FTSE 100 contract and on 1% of occasions for the Mid 250 contract. In neither market is mispricing found to exceed 1.5%. By comparison, Yadav and Pope (1990) found that for the FTSE 100 contract the 0.5%, 1% and 1.5% transaction cost limits were violated on 56%, 22% and 8% of occasions respectively. Given that the transactions cost limit for the Mid 250 contract is

Table 5.5)

Transaction Costs Violations Associated with the Mispricing Series for the FTSE 100 Index Futures Contract (March 1994 - September 1996)

		TC: <-1.5		TC: <-1.0		TC: <-0.5		TC: >0.5		TC: >1.0		TC: >1.5	
Contract	Obs.	No.	Avg	No.	Avg	No.	Avg	No.	Avg	No.	Avg	No.	Avg
Jun 94	61	0	0	1	-1.40332	11	-0.754738	0	0	0	0	0	0
Sep 94	64	0	0	0	0	5	-0.589914	4	0.558965	0	0	0	0
Dec 94	65	0	0	0	0	3	-0.581303	0	0	0	0	0	0
Mar 95	62	0	0	0	0	0	0	0	0	0	0	0	0
Jun 94	61	0	0	0	0	0	0	5	0.592821	0	0	0	0
Sep 95	64	0	0	0	0	1	-0.64494	0	0	0	0	0	0
Dec 95	65	0	0	0	0	3	-0.68893	0	0	0	0	0	0
Mar 95	62	0	0	0	0	0	0	0	0	0	0	0	0
Jun 95	66	0	0	0	0	1	-0.54374	0	0	0	0	0	0
Sep 96	64	0	0	0	0	0	0	0	0	0	0	0	0
Total	634	0	0	1	-1.40332	24	-0.677128	9	0.577774	0	0	0	0

Table 5.6)

Transaction Costs Violations Associated with the Mispricing Series for the FTSE Mid 250 Index Futures Contract (March 1994 - September 1996)

		TC: <-1.5		TC: <-1.0		TC: <-0.5		TC: >0.5		TC: >1.0		TC: >1.5	
Contract	Obs.	No.	Avg	No.	Avg	No.	Avg	No.	Avg	No.	Avg	No.	Avg
Jun 94	61	0	0	2	-1.1369	29	-0.7453	0	0	0	0	0	0
Sep 94	64	0	0	1	-1.0381	4	-0.7234	0	0	0	0	0	0
Dec 94	65	0	0	0	0	1	-0.5625	5	0.7739	0	0	0	0
Mar 95	62	0	0	3	-1.0919	21	-0.7376	0	0	0	0	0	0
Jun 94	61	0	0	0	0	0	0	2	0.6834	0	0	0	0
Sep 95	64	0	0	0	0	2	-0.5747	7	0.5507	0	0	0	0
Dec 95	65	0	0	0	0	0	0	3	0.5459	0	0	0	0
Mar 95	62	0	0	0	0	1	-0.5830	1	0.5018	0	0	0	0
Jun 95	66	0	0	0	0	0	0	3	0.5171	0	0	0	0
Sep 96	64	0	0	0	0	11	-0.6419	0	0	0	0	0	0
Total	634	0	0	6	-1.0979	69	-0.7153	21	0.6089	0	0	0	0

estimated at 1.4%, it can be concluded that arbitrage opportunities are not found to exist for this contract. Additionally, at the 0.5% transactions cost threshold, for the FTSE 100 contract the majority of transactions cost violations are found to occur in the early part of the sample period and relate to the futures contract being underpriced. Such a mispricing would require a long arbitrage position involving selling stock and buying futures. However, owing to the restrictions associated with the short selling of stock in the UK, these opportunities would only be available to equity market makers or pension fund managers who are in possession of the full basket of stocks.

Time Series Properties

Previous studies have been interested in whether the mispricing series is systematically related to the length of time to the contract maturity date. Mackinlay and Ramaswamy (1988) argue that since arbitrage risk arising from interest rate, dividend and tracking uncertainty falls as maturity approaches, mispricing is likely to be a positive function of the length of time to maturity. The length of time to expiration hypothesis is tested for the FTSE 100 and Mid 250 contracts on a contract by contract basis for fifteen weeks prior to maturity. In relation to equation 5.5, the absolute magnitude of mispricing is regressed against the number of days to contract maturity.

$$|M_t| = \alpha + \beta(T-t) + \varepsilon_t \qquad 5.5)$$

Where $|Mt|$ denotes the absolute value of the mispricing series, T-t refers to the number of days remaining until the contract maturity date, and α, β are regression parameters and ε_t is a residual error term.

The results reported in table 5.7 largely support the hypothesis that mispricing is positively related to the length of time remaining to contract maturity. For the FTSE 100 contract, seven contracts are associated with a positive coefficient which are significant at the 5% level, and for the Mid 250 contract, eight contracts are associated with a positive coefficient which is significant at the 5% level. These results indicate that mispricing converges towards zero as maturity approaches, and are similar to those of Yadav and Pope (1990) in the post-Big Bang period. The time to expiration effect was further investigated by stratifying the sample into subsets on the basis of the number of days to maturity and calculating the mean absolute deviation per group for all contracts. In table 5.8 the results relating to the behaviour of the mean absolute deviation reinforces the results in table 5.7, showing that mispricing for both contracts declines as maturity approaches, although the decline was not monotonic.

An interesting feature of mispricing series observed in US and Asian markets was that of persistence, whereby once the series became mispriced in one direction, mispricing persisted in that direction for several days (see Brenner, Subrahmanyan and Uno (1989a)). An inspection of the mispricing plots in figures 5.5 and 5.6 indicates that persistence in mispricing may well be a phenomenon which is present in the FTSE 100 and Mid 250 contracts. The issue of persistence in mispricing can be investigated by simply measuring the average frequency of mispricing reversals, or by using parametric approaches such as testing for serial correlation in the mispricing

Table 5.7)
Is Mispricing Random?

$$|M_t| = \alpha + \beta(T-t) + \varepsilon_t$$

	FTSE 100 Contract				FTSE Mid 250 Contract		
Contract	β	t-stat	R^2	*	β	t-stat	R^2
				*			
June 1994	-0.00028	-0.150	0.00037	*	0.00305	1.447	0.03373
September 1994	0.00265	1.934	0.05602	*	0.00456	3.794	0.18603
December 1994	0.00091	0.933	0.01341	*	0.00333	2.523	0.09047
March 1995	0.00266	2.935	0.12375	*	0.00411	2.028	0.06413
June 1995	0.00667	6.158	0.38724	*	0.00156	1.387	0.03106
September 1995	0.00200	2.472	0.08840	*	0.00264	2.270	0.07560
December 1995	0.00278	3.036	0.12591	*	0.00374	4.824	0.26660
March 1996	0.00051	0.634	0.00634	*	0.00273	3.051	0.13238
June 1996	0.00165	2.041	0.06021	*	0.00199	2.211	0.07098
September 1996	0.00243	3.762	0.18347	*	0.00719	6.946	0.43366

Table 5.8)
Absolute Deviation Versus Time to Expiration

	Ave. Abs. Deviation (%)	
Days to Expiration	FTSE 100	FTSE Mid 250
Over 60	0.2635	0.3111
50 - 51	0.2773	0.3853
50 - 41	0.2274	0.3728
40 - 31	0.1863	0.3472
30 - 21	0.1480	0.2471
20 - 11	0.1870	0.2699
10 - 1	0.1676	0.2117

series. In relation to the FTSE 100 mispricing series, mispricing reversals are found to occur on average every 3.2 days, with a maximum run of 31 days and a minimum run of 1 day, and where 10% of all runs persist for over a week. By comparison, for the Mid 250 mispricing series, mispricing reversals are found to occur every 4.2 days, with a maximum run of 41 days and a minimum run of 1 day, and where 18% of all runs persist for over a week. Therefore, there is clear evidence that mispricing tends to be more persistent for the Mid 250 contract than the FTSE 100 contract. This finding of greater persistence is consistent with the fact that the Mid 250 contract is less effectively arbitraged than the FTSE 100 contract, and that when the Mid 250 futures price deviates from fair value the arbitraging forces pulling prices back towards equilibrium are not as strong as in the case of the FTSE 100 contract. According to Brenner et al (1989a) this is because when mispricing develops in a particular direction, transaction costs are likely to restrain arbitrage activity within no arbitrage limits.

The autocorrelation coefficients reported in table 5.9 confirm the view that mispricing is more persistent for the Mid 250 contract than for the FTSE 100 contract. For 8 of the 10 contracts, the first-order autocorrelation coefficient for the Mid 250 series are greater than those for the FTSE 100 series. Furthermore, when consideration is given to the entire sample, all 6 autocorrelation coefficients associated with lagged values of the mispricing series for the Mid 250 contract are larger than those for the FTSE 100 contract, providing clear evidence of greater persistence in the mispricing series of the new contract.

Table 5.9)

Autocorrelation and Partial Autocorrelation Coefficients Associated with the Mispricing Series for the FTSE 100 and Mid 250 Contracts.

A) Autocorrelation Coefficients (Lags)

Contract		FTSE 100 Contract							FTSE Mid 250 Contract					
	Obs.	1	2	3	4	5	6	*	1	2	3	4	5	6
Jun 1994	61	0.256	0.069	0.114	-0.078	0.073	-0.082	*	0.534	0.236	-0.014	-0.195	-0.145	-0.214
Sep 1994	64	0.449	0.389	0.351	0.185	0.253	0.055	*	0.470	0.337	0.340	0.209	0.280	0.054
Dec 1994	65	0.379	0.284	0.294	0.038	0.077	0.015	*	0.279	0.243	0.102	0.007	0.010	-0.222
Mar 1995	62	0.287	0.159	-0.008	0.156	-0.016	0.007	*	0.396	0.143	0.131	0.060	0.168	0.040
Jun 1995	61	0.656	0.477	0.437	0.402	0.307	0.261	*	0.478	0.117	0.058	0.042	0.051	-0.103
Sep 1995	64	0.445	0.358	0.189	0.036	-0.102	-0.245	*	0.703	0.616	0.409	0.298	0.199	0.095
Dec 1995	65	0.232	0.123	0.046	0.023	0.012	-0.192	*	0.639	0.476	0.371	0.309	0.301	0.263
Mar 1996	62	0.519	0.297	0.312	0.192	0.028	0.102	*	0.523	0.259	0.207	0.174	0.053	0.013
Jun 1996	66	0.460	0.152	-0.022	-0.087	0.028	0.059	*	0.466	0.004	-0.251	-0.267	-0.184	-0.077
Sep 1996	64	0.482	0.351	0.336	0.190	0.239	0.065	*	0.722	0.637	0.634	0.590	0.535	0.438
								*						
Total	634	0.548	0.452	0.423	0.333	0.350	0.272	*	0.727	0.617	0.561	0.505	0.508	0.443

B) Partial Autocorrelation Coefficients (Lags)

Contract		FTSE 100 Contract							FTSE Mid 250 Contract					
	Obs.	1	2	3	4	5	6	*	1	2	3	4	5	6
Jun 1994	61	0.256	0.004	0.102	0.142	0.137	-0.164	*	0.534	-0.069	-0.157	-0.156	0.087	-0.19
Sep 1994	64	0.449	0.235	0.148	-0.084	0.128	-0.170	*	0.47	0.148	0.178	-0.038	0.171	-0.239
Dec 1994	65	0.379	0.163	0.171	-0.177	0.039	-0.051	*	0.279	0.179	-0.004	-0.066	0.005	-0.238
Mar 1995	62	0.287	0.084	-0.081	0.183	-0.104	-0.005	*	0.396	-0.017	0.095	-0.027	0.175	-0.118
Jun 1995	61	0.656	0.081	0.169	0.079	-0.050	0.031	*	0.478	-0.144	0.083	-0.011	0.045	-0.195
Sep 1995	64	0.445	0.199	-0.035	-0.120	-0.144	-0.187	*	0.703	0.24	-0.186	-0.038	0.026	-0.088
Dec 1995	65	0.232	0.073	0.002	0.004	0.003	-0.210	*	0.639	0.115	0.049	0.05	0.097	0.011
Mar 1996	62	0.519	0.037	0.197	-0.065	-0.118	0.129	*	0.513	-0.007	0.104	0.04	-0.092	0.004
Jun 1996	66	0.460	-0.075	-0.081	-0.043	0.126	-0.001	*	0.466	-0.272	-0.174	-0.069	-0.077	-0.046
Sep 1996	64	0.482	0.154	0.158	-0.062	0.135	-0.175	*	0.722	0.246	0.241	0.082	0.015	-0.133
								*						
Total	634	0.548	0.218	0.165	0.016	0.121	-0.027	*	0.727	0.188	0.131	0.054	0.014	-0.046

Finally, ARMA modelling techniques are employed to identify and estimate the autoregressive processes underlying both the FTSE 100 and Mid 250 mispricing series. Plots of the autocorrelation functions for both of the mispricing series associated with the FTSE 100 and Mid 250 contracts rapidly converge to zero implying stationarity. Augmented Dickey-Fuller statistics are generated and found to be equal to -9.2902 and -7.889 respectively, providing formal evidence of stationarity. From the results presented in table 5.9, it is evident that for the entire time series an AR(3) process is applicable for both series. In relation to the partial autocorrelation coefficients in panel B, the first three coefficients are significant at the 5% level for both series, and an examination of the significance of partial autocorrelation coefficients on a contract by contract basis shows that an AR(3) process is the most frequently occurring in both series. A further argument in favour of this model is that over-fitting the process did not improve the explanatory significance of the model. This finding differs from that of Yadav and Pope (1990), who find that the mispricing series for the FTSE 100 contract is characterised by an AR(1) process. However, interestingly the value of the first-order partial auto correlation coefficient for the FTSE 100 mispricing series reported in table 5.9 panel b is identical to that reported by Yadav and Pope for the post Big Bang period. The estimated AR(3) processes for the FTSE 100 and Mid 250 series are presented in equations 5.6 and 5.7 respectively.

$$\underset{}{M_t^{100}} = \underset{(-0.939)}{-0.001} + \underset{(9.955)}{0.392\,M_{t-1}^{100}} + \underset{(3.587)}{0.150\,M_{t-2}^{100}} + \underset{(4.184)}{0.164\,M_{t-3}^{100}} + \varepsilon_t \qquad 5.6)$$

$R^2 = 0.353,\ S.E. = 0.210$

$$M_t^{250} = -0.001 + 0.565 M_{t-1}^{250} + 0.109 M_{t-2}^{250} + 0.133 M_{t-3}^{250} + \varepsilon_t \qquad 5.7)$$
$$\quad (-0.933) \quad (14.266) \quad (2.504) \quad (3.353)$$

$R^2 = 0.554, \; S.E. = 0.229$

Comparing the R^2 values for equations 5.6 and 5.7 suggests that lagged values of mispricing for the Mid 250 contract account for more of the variation in the current value, than lagged values of mispricing for the FTSE 100 contract. This is consistent with the earlier finding that mispricing for the Mid 250 contract tends to persist longer in a specific direction.

5.6) CONCLUSION

In conclusion, this study compares the pricing efficiency of the FTSE 100 and Mid 250 index futures contracts traded in the UK. Specifically the following conclusions can be drawn. Firstly, while there are many deviations from fair value, these are generally quite small in actual magnitude, suggesting that both contracts are efficiently priced. Although mispricings are larger and more frequent for the Mid 250 contract than for the FTSE 100 contract, this is consistent with the larger transactions costs and difficulties associated with trading the illiquid constituents of the Mid 250 index. Secondly, consistent with the introduction of other index futures contracts, the Mid 250 contract traded at a discount to fair value for much of the initial period which supports Figlewski's argument that traders are usually reluctant to trade a contract during its infancy. Thirdly, the onset of trading in the Mid 250 contract has been associated with an improvement in the pricing of the FTSE 100 contract. It appears reasonable to assume that equipping equity market makers and institutional investors with a vehicle through which they can achieve more efficient management of lower capitalisation portfolios, has freed capital and resources which can be employed to achieve more effective tracking of the FTSE 100 contract. Fourthly, mispricing in the deferred FTSE 100 contract was found to be of both a larger magnitude and more persistent than that in the near contract. This is an important result since it suggests that intramarket spread trading may be a profitable strategy. Furthermore, using the Mid 250 contract in conjunction with the FTSE 100 contract provides a unique opportunity to examine the potential for intermarket spread trading in the UK. Fifthly, the profitability of ex post arbitrage is found to be considerably less than has been implied by previous studies. In fact in the case of the Mid 250 contract the arbitrage window is never violated. However, given the reliance on daily data, the results reported are likely to underestimate real arbitrage opportunities. Sixthly, both the Mid 250 and FTSE 100 mispricing series are found to be systematically related to the length of time to expiration, with mispricing falling as the expiration date approaches. Seventhly, mispricing is found to be more persistent for the Mid 250 contract than the FTSE 100 contract, suggesting that in the case of the Mid 250 contract the larger transaction costs and difficulties in rapidly executing stocks discourages arbitrage activity and exert minimal pressure on the mispricing series to deviate from its current projectory. Finally, mispricing in both contracts is found to be underpinned by an AR(3) process.

While the Mid 250 contract was associated with limited trading volume it is found to be priced well within its transaction cost limits, supporting the hypothesis of market efficiency and its use as an effective hedging vehicle. While mispricing for the Mid 250 contract is greater than that on the related FTSE 100, the larger transaction costs and institutional difficulties preclude the profitable exploitation of any mispricing. In fact the evidence would suggest that in both markets the only effective arbitrageurs are equity market makers. Only when the trading volume on the Mid 250 increases sufficiently to justify the use of intra-daily data can more reliable ex ante tests of the profitability of Mid 250 index arbitrage be conducted.

The findings presented in this chapter strongly support the results reported in the earlier chapters relating to hedging effectiveness. While both contracts are generally found to trade within their no-arbitrage limits, of the two contracts the Mid 250 contract is the more mispriced. Although the larger transactions costs associated with using this contract account for this phenomena, this finding is also consistent with the finding that information is impounded into spot prices less rapidly following the onset of futures trading, and with information having a more persistent effect. Furthermore, given that index futures contracts are principally employed for short term trading purposes such as hedging, the extent to which futures contracts are mispriced has important implications for these strategies. For instance, while the cash settlement feature of index futures contracts guarantees that all hedges held to maturity are riskless, hedgers wishing to adopt a dynamic strategy and unwind positions before maturity rely on arbitrage activity to ensure that the futures price accurately tracks its fair value. The finding that the Mid 250 contract is less efficiently priced than the FTSE 100 contract corroborates the result in chapter three showing that the Mid 250 contract is not as effective as the FTSE 100 contract when used as a direct hedge.

The degree of mispricing is also an important issue when considering the cost of a hedging strategy, with the direction of the initial mispricing introducing a specific mispricing element into the returns of the hedged portfolio. For instance, where the futures contract is initially overpriced (underpriced) and the hedger initiates a short futures hedge, then (s)he will earn returns which are higher (lower) than those associated with a futures contract which is priced according to fair value. Given that deviations from fair value are larger and more sustained for the Mid 250 contract than for the FTSE 100 contract it is reasonable to suppose that the returns associated with mispricing have greater relevance for the trader using the Mid 250 contract than the FTSE 100 contract.

Finally, the evidence relating to the mispricing of the FTSE 100 and Mid 250 contracts suggests that spread trading opportunities may exist in relation to UK index futures contracts. In the case of the FTSE 100 contract, the deferred contract is priced at a chronic premium to the near contract with this indicating that an intramarket bull spread may be potentially profitable. Furthermore, using the Mid 250 contract in conjunction with the FTSE 100 contract provides an unique opportunity to examine the potential for intermarket spread trading. These issues will be investigated in chapter six.

Endnotes

[1] On the 20 October 1997 the UK stock market switched from a quote-diven system to an order-driven trading system of share trading. The decision was taken following widespread market consultation. Initially the order-book was introduced to cover only the FTSE 100 index and its reserve list, but has proved so successful that it will shortly be extended to all Mid 250 constituents. This change has resulted in tighter equity prices and is expected to simplify index arbitrage in the UK.

[2] Although the Mid 250 index futures contract was introduced on 25 February 1994 the data relating to the March 1994 contract was excluded owing to the limited number of observations.

[3] Many studies investigating index arbitrage in the US suffer from a serious dividend misspecification problem (e.g. Mackinlay and Ramaswamy (1988), Brennan and Schwartz (1990), Klemkosy and Lee (1991)). Since ex post dividend data for the S&P 500 index is not publicly available in the US, researchers have tended to use dividend data supplied by the Centre for Research into Security Prices (CRSP) which relates to the NYSE/AMEX indexes. Given that these indexes comprise of a large number of smaller capitalisation stocks, this series is unlikely to perfectly match the dividend series corresponding to the S&P 500 index.

[4] Mispricing plots for the FTSE 100 and Mid 250 contracts illustrated on a contract by contract basis are shown in appendices 3 and 4 respectively.

CHAPTER SIX

PRICING OF INTRAMARKET AND INTERMARKET SPREADS: EVIDENCE RELATING TO THE FTSE 100 AND FTSE MID 250 CONTRACTS

6.1) INTRODUCTION

In chapter two it was argued that spread trading provides an alternative mechanism to index arbitrage for investigating futures market efficiency, in the sense that the level of spread mispricing has important implications for the effectiveness of a spread trading strategy in much the same way that index futures mispricing has important implications for the effectiveness of a hedging strategy. The notion of spreading and its economic significance was introduced by Working (1949). He examined the inter-temporal price relationships which result from the cost of storage, and noted that futures traders may use spreads as a means of reducing their losses from price fluctuations. Spreads involve taking simultaneous short and long positions in different but economically related futures contracts, and they are initiated to profit from unusual pricing relationships that are believed to be temporary.

Although traditionally spread trading has been used to speculate on the cost of carry between different futures contracts (Working (1949)), spreading also serves the functions of arbitrage and hedging, together with providing an important source of market liquidity. It is surprising that while there has been considerable interest in the pricing of index futures contracts relative to their underlying spot indexes, only minimal interest has been given to the relative pricing of index futures contracts on either an intramarket or intermarket basis (Billingsley and Chance (1988), Brenner, Subrahmanyan and Uno (1989b), Yadav and Pope (1992b) and Board and Sutcliffe (1996)).

An analysis of spread trading provides an alternative mechanism to index arbitrage for testing for futures market efficiency, and spread trading significantly contributes to the economics of arbitrage. The limited interest in spread trading is rather difficult to comprehend because spread trading strategies can be more easily and cheaply implemented with significantly less risk than index arbitrage transactions. Given that spreads are associated with lower margin requirements and thus greater leverage than net long or short futures positions, together with lower transaction costs, the net costs of financing a spread position are very low, which results in tighter limits around the fair price of the spread. Therefore, deviations from fair price which are often too small to be exploited by index arbitrage can be profitably exploited by spread trading.

In addition, spread trading serves as an important risk transfer mechanism, which enables futures traders to allocate risk amongst themselves. Since the spread trader will be frequently offsetting and reinstating futures positions against their overall inventory position, spread trading provides a means of transferring risk from one trader to another. In the absence of spreading only the less risk averse traders with a balanced inventory position would be prepared to provide the price insurance services required by hedgers. Thus the ability to spread trade results in a lower cost of insurance and allows risk averse futures traders to provide market liquidity to hedgers in the cash market (Billingsley and Chance (1988)).

Furthermore, in trading as a group spreaders provide the illiquid distant contracts with its main source of liquidity. Therefore, without the presence of spreaders whose activities ensure that the price differentials between different contracts are held within close limits, hedges in the far contract could not be placed effectively. Thus spreaders are essential for providing "market thickness" and price stability, and it is debatable whether any futures market could effectively function without a "large pool" of active spread traders. As Meland (1981) argues:

> "It is difficult to adequately explain the importance of spread traders in this function. It is a role no one else can assume effectively, upon it depends the essence of futures markets as a risk transfer mechanism for the commercial world" (p. 409).

Although spreading provides an effective risk transfer mechanism, it is not a riskless strategy as is often assumed. While spreads are often characterised by less risk than naked long or short futures positions, in order to allocate risk effectively and provide market liquidity, the spreads must be correctly priced. Therefore, the degree of spread mispricing has important implications for the effectiveness of spreading, in the same way as spot-futures mispricing has important implications for hedging effectiveness (Merrick (1988b)).

Finally, an alternative rationale for spreading is as a risk reduction strategy within the context of hedging. For instance, the expected utility approach used for testing hedging effectiveness has been extended to spreading, with the holding of futures positions being examined within a mean variance framework (Schroch (1971), Peterson (1977) and Francis and Wolf (1991)). Schrock (1971) established that spread trading was an important risk management strategy, and demonstrated that holding a particular futures contract with a negative return was a rational activity where the specific leg significantly reduced the risk associated with the investor's overall market position. Furthermore, Peterson showed that because of the reduced margin requirements that arise from holding spreads, investors may be able to:

> "increase their total portfolio return for a given level of risk, or reduce risk in obtaining a given portfolio return, by substituting commodity futures straddles and interest bearing cash assets for outright long or short futures positions" (1977, p. 105).

Therefore, by initiating spreads the investor may be able to increase their overall total expected portfolio return without incurring any more risk, or alternatively reduce portfolio risk without reducing their expected portfolio return. In doing so spread trading strategies are important because they broaden the feasible set of investment opportunities beyond that achieved by simply undertaking offsetting spot and futures positions, thus enhancing the investor's risk-return profiles.

This chapter will be structured as follows. In section 6.2 the pricing of spreads is considered within a theoretical framework underpinned by the theoretical or fair price formula. Attention will be given to the pricing of intramarket and intermarket spreads, together with the necessary adjustments made for the inclusion of spread ratios. In section 6.3 the research issues to be investigated will be presented. In section 6.4 the data and methodology used will be outlined. In section 6.5 the results and findings will be reported. Finally, in section 6.6 concluding remarks will be made.

6.2) THEORETICAL ISSUES

Spreads are designed to exploit predicted changes in the relative prices between two futures contracts, referred to more generally as simply the spread basis. When pricing spreads, Jones (1981) notes that it is conventional for financial futures, for the spread price to be equal to the price of the nearby contract minus the price of the next nearest to maturity (henceforth deferred) contract. Therefore, an intramarket spread (S_t) between a near and a deferred contract, with the respective maturity dates of T_1 and T_2 can be expressed as:

$$S_t = F_{t,T_1} - F_{t,T_2} \qquad 6.1)$$

The pricing of spreads represent estimates of differences in the cost of carrying the various contracts to their respective maturity date, and therefore the price structure between expiration months is of interest to the spread trader. A *normal* market exists where the current price of a deferred contract is greater than that of a nearby contract, reflecting the greater costs of carrying the contract to maturity. By contrast the market is referred to as *inverted*, when the opposite occurs and the price of the different contracts is a decreasing function of the time to maturity.

Spreads of all types are undertaken to profit from distortions which arise in the normal or equilibrium relationship between two related futures contracts. In the context of index futures contracts, spread trading, like index arbitrage provides a mechanism for exploiting any relative mispricing, and thus provides an additional means of testing how efficiently index futures contracts are priced. As was demonstrated in chapter five, the equilibrium pricing relationship between the index futures contract and its associated basket of stocks can be determined by the theoretical or fair forward pricing model. For convenience, equation 5.1 is restated below as equation 6.2:

$$FP_{t,T} = I_t \; e^{r(T-t)} - \sum_{s=1}^{T-t} D_{t+s} \; e^{r(T-t-s)} \qquad 6.2)$$

Where $FP_{t,T}$ equates to the theoretical fair price of an index futures contract at time t with expiration date of T, I_t equates to the price of the underlying stock index at time t, r refers to the risk free rate of interest, D_{t+s} refers to the daily dividends payable (measured in terms of index units) on the underlying stock index at time t+s, T-t is equal to the number of days to contract expiration and T-t-s refers to the number of days between the date the dividend is paid on index stocks and the contract maturity date. The extent to which the futures price deviates from its fair value estimate (equation 6.2) determines the degree of mispricing, and it is the relative mispricing between the respective legs of the spread position which create spread trading opportunities.

Regarding the actual implementation of the spread trading strategy, Board and Sutcliffe (1996) demonstrate that spread trading requires fewer restrictive assumptions than is the case for index arbitrage. Specifically, while the problem of short selling stock creates asymmetric transaction cost limits in the context of index arbitrage, this difficulty is not relevant to the spread trader where short positions can be initiated with the same ease as long positions. Therefore it is likely that transaction cost limits will be symmetrical for spread trading. Additionally while marking to market creates tail risk in the context of index arbitrage, given that both legs of the spread are marked to market and that the positions are of equal but opposite value, the margin payments associated with the spread should generally cancel out leading to zero tail risk. Furthermore, dividend and interest rate uncertainty, tracking risk, execution risk and non-synchronous trading are all less of a problem for spread trading strategies than for index arbitrage strategies. However, one assumption underlying spread trading activity which is more restrictive than for index arbitrage trading is that of perfect divisibility. It is more difficult to achieve equality in the value of the two legs of the transaction for a spread than for index arbitrage because the large values associated with futures contracts makes them rather cumbersome. Even so, given that spread trading does not involve any stock side transaction, the transaction costs incurred by the spreader are only a fraction of the transaction costs incurred by the index arbitrageur, and therefore the spreader is capable of exploiting mispricing opportunities, where the arbitrageur is not. This results in tighter no-arbitrage limits existing around the fair value of the spread, than around the fair value of the index futures contract.

Intramarket Spread Pricing

The pricing of an intramarket spread involves taking both a long and a short position in the same futures contract but for different delivery dates[1]. Since no effort is made to buy or sell stocks or bonds the profits from these transactions are associated with less risk than is the case with index arbitrage. Assuming that the nearby futures contract matures at time T_1 and the deferred contract matures at T_2, the theoretical or fair price estimates of the nearby and deferred contracts can be expressed as equations 6.3 and 6.4 respectively:

$$FP_{t,T_1} = I_t \; e^{r(T_1-t)} - \sum_{s=1}^{T_1-t} D_{t+s} \; e^{r(T_1-t-s)} \qquad 6.3)$$

$$FP_{t,T_2} = I_t \; e^{r(T_2-t)} - \sum_{s=1}^{T_2-t} D_{t+s} \; e^{r(T_2-t-s)} \qquad 6.4)$$

The profitability of the intramarket spread can be examined by determining whether the actual price of the near and deferred contracts are correctly priced with respect to their fair price estimate. Should either (or both) of the legs of the spread be significantly mispriced then a viable spread trading strategy may be possible. The extent to which either of the legs of the spread may be mispriced can be determined by examining the degree to which the futures price deviates from its fair price. The mispricing series measures the difference between the actual futures price and its theoretical fair price at time t. Equations 6.5 and 6.6 represent the mispricing series for the near and deferred contracts respectively.

$$M_t^N = \frac{F_{t,T_1} - (I_t e^{r(T_1-t)} - \sum_{s=1}^{T_1-t} D_{t+s} e^{r(T_1-t-s)})}{I_t} \tag*{6.5)}$$

$$M_t^D = \frac{F_{t,T_2} - (I_t e^{r(T_2-t)} - \sum_{s=1}^{T_2-t} D_{t+s} e^{r(T_2-t-s)})}{I_t} \tag*{6.6)}$$

As stated in chapter five, the mispricing series is normalised by dividing any mispricing by the value of the spot index (I_t) underlying the futures contract, because all the major determinants of the limits of the arbitrage window should be proportional to the index, with mispricing being expressed in percentage terms.

By comparing the degree of mispricing associated with the near contract with respect to the degree of mispricing associated with the deferred contract, the relative spread mispricing associated with the intramarket spread can be expressed in terms of the spread mispricing differential (SM_t) which is measured as:

$$SM_t = M_t^N - M_t^D \tag*{6.7)}$$

In order to profit from a spread transaction the trader must determine whether the spread mispricing will increase or decrease over the life of the spread. Where SM_t is equal to zero, mispricing in each leg of the spread exactly offsets one another, in which case the spread is correctly priced and spread trading opportunities are not present. A spread transaction is profitable whenever the absolute size of the spread mispricing differential is in excess of the transaction costs of initiating the trade, and the future direction of the differential has been correctly determined. Where SM_t is negative the near futures contract is underpriced relative to the deferred futures contract and the trader should initiate a bull spread by buying the near contract and simultaneously selling the far contract. Alternatively, where SM_t is positive the near contract is overpriced relative to the deferred contract and the trader should initiate a bear spread by selling the nearby contract and simultaneously buying the deferred contract.

If it is assumed that both of the legs of the spread are closed out when the near contract reaches maturity at time T_1, the cash flows accruing from this transaction are $F_{t,T_1} - I_{T_1}$ and $F_{t,T_2} - F_{T_1,T_2}$. Thus the spread is profitable if the relative gain generated on one leg of the spread is large enough to offset the relative loss generated on the other leg of the spread.

Intermarket Spread Pricing

Intermarket spreads consist of positions in two different but economically related futures contracts either for the same or different maturity dates. Compared to intramarket spreads, trading intermarket spreads is inherently more risky because the relative price movements between the legs of an intermarket spread are likely to be less well correlated. Therefore, intermarket spreads are associated with both larger margin requirements and transactions costs. These facts have an important bearing on the relationship between the actual price of an intermarket spread and its fair price. This relationship will be further considered by employing the theoretical no-arbitrage conditions.

For an intermarket spread consisting of two different futures contracts with a common expiry date of time T, such as that between the near FTSE 100 contract ($F_{t,T}^{100}$) and the near FTSE Mid 250 contract ($F_{t,T}^{250}$) the theoretical or fair price estimates are expressed as equations 6.8 and 6.9 respectively:

$$FP_{t,T}^{100} = I_t^{100}\ e^{r(T-t)} - \sum_{s=1}^{T-t} D_{t+s}^{100}\ e^{r(T-t-s)} \tag{6.8}$$

$$FP_{t,T}^{250} = I_t^{250}\ e^{r(T-t)} - \sum_{s=1}^{T-t} D_{t+s}^{250}\ e^{r(T-t-s)} \tag{6.9}$$

Where the 100 and 250 superscripts refer to the FTSE 100 and Mid 250 respectively.

Once again the extent to which either of the legs of the spread are mispriced can only be determined by examining the degree to which the futures price deviates from its fair price. Therefore, equations 6.10 and 6.11 represent the mispricing series for both the FTSE 100 and Mid 250 contracts respectively.

$$M_t^{100} = \frac{F_{t,T}^{100} - (I_t^{100}\, e^{r(T-t)} - \sum_{s=1}^{n} D_{t+s}^{100}\, e^{r(T-t-s)})}{I_t^{100}} \tag{6.10}$$

$$M_t^{250} = \frac{F_{t,T}^{250} - (I_t^{250} e^{r(T-t)} - \sum_{s=1}^{n} D_{t+s}^{250} e^{r(T-t-s)})}{I_t^{250}} \qquad 6.11)$$

By comparing the degree of mispricing associated with each leg of the intermarket spread, the relative spread differential can be calculated and the profitability of the relationship evaluated. Thus spread mispricing for the intermarket spread comprises of positions in the FTSE 100 and Mid 250 contracts respectively, and is equal to equation 6.10 minus equation 6.11 and is expressed as the spread mispricing differential (SM_t).

$$SM_t = M_t^{100} - M_t^{250} \qquad 6.12)$$

In order to profit from a spread transaction the trader must determine whether the spread mispricing differential will increase or decrease over the life of the spread. Given that both legs of the intermarket spread have a common expiry date of T, when the spread differential is non-zero its actual value will contain predictive power with respect to changes in the relative mispricing between the two legs of the intermarket spread by time T, the contract maturity date. Although the relationship between the two legs of the spread may be characterised by variability over the life of the contract, at contract expiration mispricing on both contracts converges to zero, as does spread mispricing. Therefore, for positions which are held to maturity, the future direction of the spread mispricing series is known with certainty.

Intermarket spread trading should prove profitable whenever the absolute size of the spread differential exceeds the costs of initiating the transaction. Where SM_t is negative the spread is undervalued, and the trader needs to initiate a long spread transaction, buying the FTSE 100 contract and simultaneously selling the Mid 250 contract. In contrast, where SM_t is positive the spread is overpriced, the trader needs to initiate a short spread transaction, which involves selling the FTSE 100 contract and buying the Mid 250 contract. For spread positions held until maturity, the cash flows accruing from this spread transaction are $F_{t,T}^{100} - I_T^{100}$ and $F_{t,T}^{250} - I_T^{250}$. Providing the relative profits generated on the long leg of the transaction are sufficient to compensate for the relative losses generated on the short leg of the transaction the overall spread will be profitable. Although the FTSE 100 and Mid 250 contracts are technically good substitutes, the findings in chapter six prove that the Mid 250 contract is not as efficiently priced as the FTSE 100 contract owing to differences in transactions costs and trading volume. Therefore, it seems reasonable to assume that intermarket pricing inefficiencies will exist, and that they will manifest themselves in terms of spread trading opportunities. This issue will be empirically investigated.

Spread Ratio Adjustments

Unlike the pricing of an intramarket spread, the pricing of an intermarket spread is complicated by the fact that different futures contracts are associated with different contract multipliers and different index values. For instance, the contract multipliers associated with the FTSE 100 and Mid 250 contracts are £25 and £10 per index point respectively. Due to differences in both the value of the index and underlying contract multiplier, trading the same number of contracts in both legs of the intermarket spread can lead to a seriously unbalanced spread position. However, this problem can be remedied by making an adjustment for differences in the market value of the two contracts by computing a spread ratio, which ensures that both legs of the spread have an equal monetary value. The spread ratio relevant to the spread between the FTSE 100 and the Mid 250 contracts is equal to the ratio of their respective contract multipliers (CM) multiplied by the value in index points of the index futures contract. Thus the spread ratio relevant to the intermarket spread comprising of positions in the FTSE 100 contract and Mid 250 contract is calculated as:

$$Spread\ Ratio\ (R_t) = \frac{CM^{100}\ x\ F_t^{100}}{CM^{250}\ x\ F_t^{250}} \qquad 6.13)$$

For instance, if at time period t both the price of the FTSE 100 and Mid 250 contracts stand at 4000 points each, then the value of the contracts is £100,000 and £40,000 respectively. Thus to ensure that the spread is balanced the Mid 250 leg of the spread should consist of two and a half times as many contracts as the FTSE 100 leg of the spread. In the case where the two contract have different index values - e.g. the FTSE 100 contract is valued at 4500 index points and the Mid 250 is valued at 4000 index points - the Mid 250 leg of the spread consists of 2.8125 as many contracts as the FTSE 100 leg of the spread. Therefore, given that the spread ratio has the potential to vary considerably before the contract maturity date, spread ratio variability constitutes an important source of risk which is not relevant in the pricing of the intramarket spread. In order to circumvent this problem, the spreader is required to forecast the spread ratio at maturity, and only initiate positions once they are sure that the magnitude of the initial spread mispricing more than compensates for this additional source of risk.

6.3) EMPIRICAL INVESTIGATION

The purpose of this chapter is to empirically investigate the pricing efficiency and examine some of the time series properties of intramarket and intermarket spreads relating to the FTSE 100 and Mid 250 contracts. Specifically, the following issues will be investigated:

- the pricing efficiency of both intramarket and intermarket spreads is considered. The intramarket spread consists of positions in both the near and middle FTSE 100 contracts[2] and the intermarket spread consists of positions in both the near FTSE 100 and near Mid 250 contracts. The pricing efficiency of these spreads has important implications for the hedging effectiveness of the respective futures contracts.
- after allowing for adequate transaction costs the ex post profitability of trading intramarket and intermarket spreads is examined. Allowance is also given to the impact that spread ratio variability has on the profitability of trading intermarket spreads.
- the behaviour of the spread mispricing series for both spreads is examined to determine whether or not spread mispricing is systematically related to the length of time to the contract maturity date. It seems reasonable to assume that because trading volume increases on both the deferred FTSE 100 and near Mid 250

contracts as the maturity date approaches, mispricing on each specific leg will fall and spread mispricing will do likewise. Evidence of a maturity effect has important implications for the early unwinding strategy.

- the persistence hypothesis is investigated for both spreads to determine whether or not spread mispricing is path dependent. It seems reasonable to expect that since the near and deferred FTSE 100 contracts are likely to be more closely integrated and better arbitraged than the near FTSE 100 and Mid 250 contracts, the intramarket spread is more likely to be characterised by persistence than the intermarket spread.

6.4) DATA AND METHODOLOGY

Daily closing and settlement prices are used for the FTSE 100 and Mid 250 indexes and contracts respectively over the period 18 March 1994 (following the introduction of the Mid 250 contract)[3] to 19 September 1996 and consists of 634 observations. For the FTSE 100 contract, data on both the nearest to maturity and deferred contracts is employed. For the Mid 250 contract only the nearest to maturity contract is used. The contracts are rolled over on the expiration date, with the deferred contract becoming the near contract. In order to compute the mispricing series which underpins the spread pricing relationships the fair value model which was introduced in chapter five and shown earlier as equation 6.2 is used to determine the appropriate spread entry and exit triggers. The spread mispricing series for the intramarket spread is calculated on the basis of equation 6.7, and the spread mispricing series for the intermarket spread is calculated on the basis of equation 6.12. In calculating this mispricing series estimates are required for the daily interest rate and dividend payments associated with the market constituents which go ex dividend on that date. The UK treasury bill was chosen as an appropriate proxy for the interest rate. However, given that the maturity date associated with the treasury bill does not correspond with the maturity date on the respective futures contracts, the interest rate series is estimated through a process of linear interpolation by combining a weighted average of both the one and three month bills. The ex dividend adjustment for each constituent is calculated by multiplying the number of shares going ex dividend on that date by the dividend and aggregating over all constituents paying dividends. This figure is then divided by the total market capitalisation of the index to convert ex dividend adjustments into index points. All data was obtained from *Datastream*.

The round trip transaction costs associated with establishing spread trades are considerably lower than those associated with initiating an index arbitrage transaction because no stocks or bonds are bought or sold, and the trades are not subject to stamp duty. The transaction costs faced by traders wishing to execute spreads consist of the futures market commission, the futures market bid-offer spread and the market impact cost of the transaction. In the UK round-trip commissions can be negotiated to very low levels, with typical commissions of £25 and £10 per contract for the FTSE 100 and Mid 250 respectively, representing approximately 0.025% of the underlying value of the respective indexes. An examination of LIFFE time and sales data over this period suggests that bid-offer spreads on the futures transactions for the near and deferred FTSE 100 contracts and the near Mid 250 contract are often less than 0.1%, 0.2% and 0.3% respectively. Finally, it is assumed that because each leg of the spread transaction consists of only one or two contracts, the associated market impact of the trade would be minimal. Thus, the no arbitrage limits are set at 0.3% for the intramarket spread and 0.4% for the intermarket spread.

Spread transactions are assumed to be initiated on a daily basis whenever either of the no-arbitrage triggers outlined above are violated. Where the spread is found to be underpriced (SMt < 0), the spreader trading the intramarket spreads buys the near FTSE 100 contract and sells the deferred FTSE 100 contract, while the spreader trading the intermarket spread buys the near FTSE 100 contract and sells the near Mid 250 contract. Alternatively, where the spread was found to be overpriced (SMt > 0), the spreader trading the intramarket spread sells the near FTSE 100 contract and buys the deferred FTSE 100 contract, while the spreader trading the intermarket spread sells the near FTSE 100 contract and buys the near Mid 250 contract. These positions are then held until either the spread mispricing series is characterised by a mispricing reversal or the contract expiration date associated with the near leg of the contract is reached, at which point the trade is unwound. The trading rules adopted are deliberately simple because any profits which are generated by this straight forward trading rule which is based on a modicum of information serves as a more valid test of market inefficiency than profits generated by a sophisticated trading rule which is reliant on vast amounts of detailed information.

6.5) EMPIRICAL RESULTS

The daily intramarket and intermarket spread mispricing series represented by equations 6.7 and 6.12 are illustrated as figures 6.1 and 6.2 respectively. While the intramarket spread appears to be very efficiently priced, trading well within its no-arbitrage limits on the vast majority of occasions, the series is also chronically underpriced. These findings suggest that while both markets are very closely integrated, the deferred contract is priced at a relative premium to the near contract. This finding is consistent with Bhatt and Cakici (1990), who suggest that mispricing may represent a risk adjusted return to arbitrageurs. Overall, the mispricing plot indicates that intramarket spread mispricing opportunities will be rare even for the most favourably placed spread traders. In contrast, the intermarket spread often appears to suggest very inefficient pricing, frequently violating its no-arbitrage limits to a large degree. The mispricing plot indicates that this relationship is likely to trigger numerous spread mispricing opportunities, and the frequent mispricing reversals are likely to offer traders the opportunity to unwind their positions rapidly, thereby limiting the problem of spread ratio variability.

The intramarket and intermarket spread mispricing series are summarised in tables 6.1 and 6.2 respectively. There are a number of important points to discuss. Firstly, over the entire sample period the intramarket spread was underpriced on 540 (85.2%) occasions and overpriced on 94 (14.8%) occasions. While the intermarket spread was underpriced on 305 (48.1%) occasions and overpriced on 329 (51.9%) occasions. The fact that mispricing for the intramarket spread is strongly constrained in one direction, while mispricing on the intermarket spread displays a tendency to fluctuate rapidly, suggests that the intramarket spread relationship is much more actively arbitraged than the intermarket spread relationship, with the actions of spread traders holding intramarket spread mispricing within very tight limits. In addition, on a

Figure 6.1)
Spread Mispricing - Intra market Spread: FTSE 100 Contract
(March 1994 - September 1996)

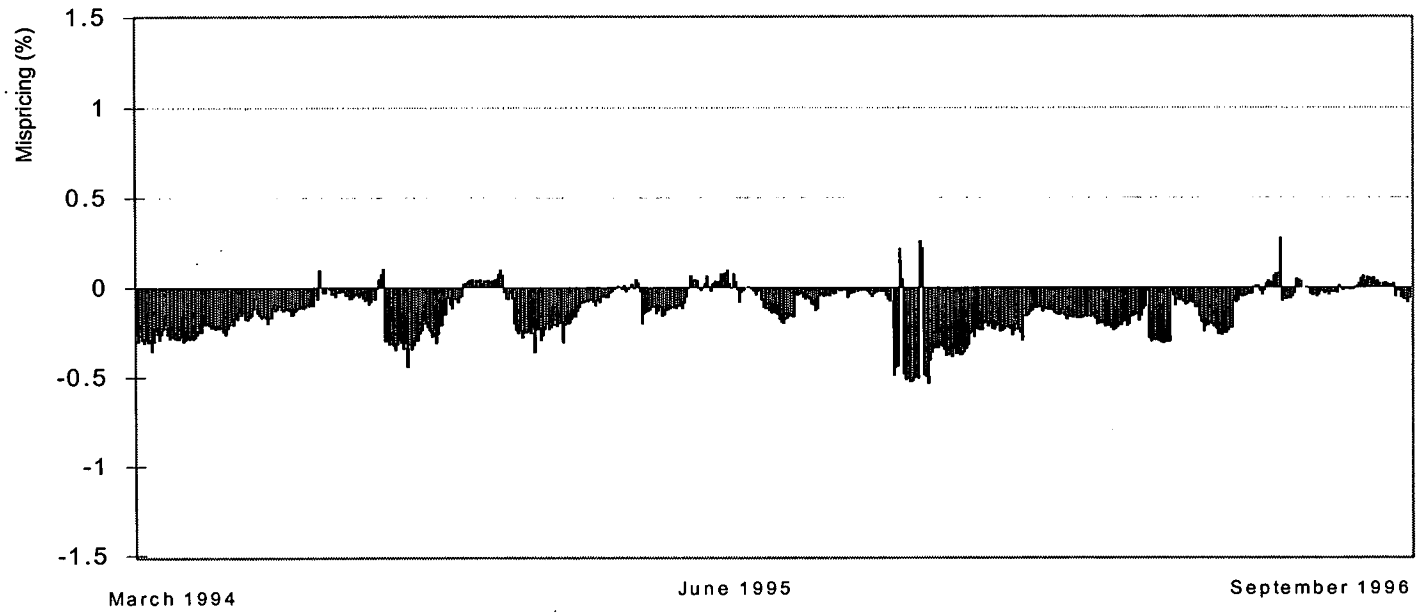


Figure 6.2)
Spread Mispricing - Inter market Spread: FTSE 100 / Mid 250 Contracts
(March 1994 - September 1996)

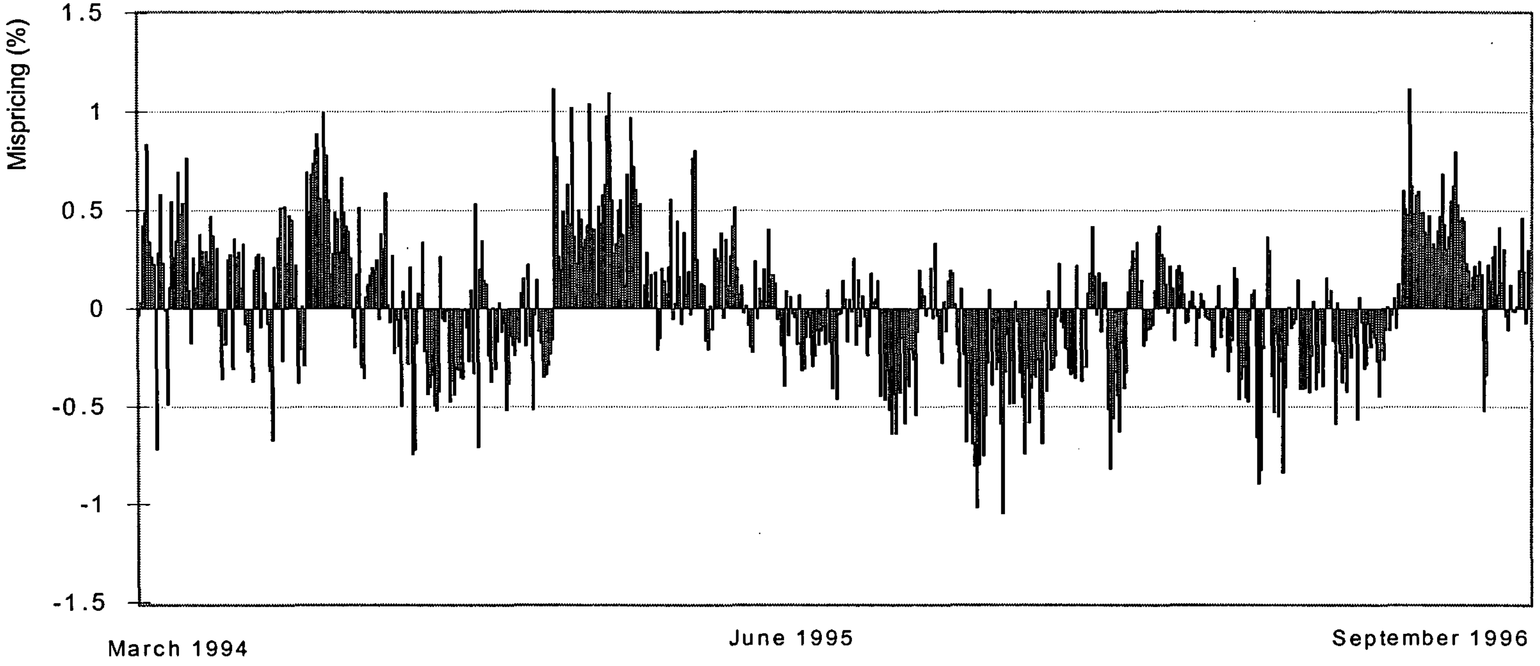


Table 6.1)
Summary Statistics - Intra Market Spread:
March 1994 to September 1996

Contract	Obs.	$SM_t > 0$	$SM_t < 0$	Mean	T Stat	S.D.	Maximum	Minimum	Ave Abs	Ave Pos	Ave Neg	Reversal	>|0.15|
Jun 1994	61	0	61	-0.2393	-33.0008	0.0566	-0.0605	-0.3559	0.2393	0.0000	-0.2393	0	0
Sep 1994	64	5	59	-0.0760	-9.4188	0.0645	0.1044	-0.2020	0.0862	0.0650	-0.0879	3	0
Dec 1994	65	20	45	-0.1359	-7.2042	0.1521	0.0985	-0.4435	0.1621	0.0426	-0.2152	2	0
Mar 1995	62	7	55	-0.1319	-9.8220	0.1058	0.0462	-0.3633	0.1358	0.0173	-0.1509	8	0
Jun 1995	61	21	40	-0.0389	-3.9898	0.0762	0.0975	-0.2014	0.0678	0.0419	-0.0814	10	0
Sep 1995	64	0	64	-0.0660	-9.4133	0.0561	-0.0013	-0.2019	0.0660	0.0000	-0.0660	0	0
Dec 1995	65	4	61	-0.3017	-14.7408	0.1650	0.2601	-0.5366	0.3248	0.1871	-0.3338	4	4
Mar 1996	62	0	62	-0.1600	-30.6113	0.0412	-0.0172	-0.2393	0.1600	0.0000	-0.1600	0	0
Jun 1996	66	11	55	-0.1240	-7.8328	0.1287	0.2766	-0.3097	0.1437	0.0589	-0.1606	3	1
Sep 1996	64	26	38	-0.0080	-1.6643	0.0386	0.0663	-0.0836	0.0330	0.0307	-0.0345	8	0
Total	634	94	540	-0.1282	-24.7317	0.1306	0.2766	-0.5366	0.1420	0.0465	-0.1587	38	5

Table 6.2)
Summary Statistics - Inter Market Spread:
March 1994 to September 1996

Contract	Obs.	$SM_t > 0$	$SM_t < 0$	Mean	T Stat	S.D.	Maximum	Minimum	Ave Abs	Ave Pos	Ave Neg	Reversal	>|0.2|
Jun 1994	61	44	17	0.1693	4.3592	0.3033	0.8369	-0.7197	0.2919	0.3197	-0.2201	16	10
Sep 1994	64	47	17	0.2183	4.8558	0.3596	0.9995	-0.6742	0.3481	0.3856	-0.2444	19	8
Dec 1994	65	16	49	-0.1755	-5.3294	0.2655	0.5347	-0.7461	0.2633	0.1785	-0.2911	20	8
Mar 1995	62	58	4	0.3898	9.9980	0.3070	1.1158	-0.2101	0.4058	0.4252	-0.1237	6	2
Jun 1995	61	32	29	0.0480	1.5470	0.2424	0.8042	-0.3955	0.1852	0.2223	-0.1443	20	5
Sep 1995	64	23	41	-0.1241	-4.0845	0.2431	0.3342	-0.6400	0.2122	0.1226	-0.2625	26	3
Dec 1995	65	13	52	-0.2816	-7.3158	0.3104	0.4185	-1.0493	0.3423	0.1518	-0.3900	15	5
Mar 1996	62	29	33	-0.0538	-1.6317	0.2595	0.4210	-0.8191	0.2059	0.1626	-0.2439	18	4
Jun 1996	66	13	53	-0.2280	-7.2429	0.2557	0.3653	-0.8963	0.2709	0.1088	-0.3106	17	2
Sep 1996	64	54	10	0.2854	8.3632	0.2730	1.1180	-0.5211	0.3273	0.3631	-0.1341	11	2
Total	634	329	305	0.0202	1.4201	0.3587	1.1180	-1.0493	0.2856	0.2965	-0.2740	168	49

contract by contract basis the standard deviation associated with intermarket spread mispricing series is often three to four times larger than that associated with the intramarket spread mispricing series, reinforcing the view that the intermarket spread is associated with less arbitrage activity. Secondly, with respect to the size and significance of the percentage mean spread deviations, 9 out of the 10 contracts are statistically significant at the 5% level for both the intramarket spread and 8 out of the 10 contracts are significantly significant at the 5% level for the intermarket spread. For the intramarket spread all 9 contracts are significantly negatively priced, while for the intermarket spread, 4 of the contracts are significantly positively priced and 4 of the contracts are significantly negatively priced. Furthermore, the percentage mean absolute deviation over all ten contracts is larger for the intermarket spread than the intramarket spread, and for the entire sample, it is over twice as large with values of 0.2856 and 0.1420 respectively. These results are consistent with the view that compared to the intramarket spread, the intermarket spread is less intensively arbitraged. Finally, the intermarket spread mispricing series dominates the intramarket spread mispricing series in terms of the number of mispricing reversals both on a contract by contract basis and over the entire sample period. The mispricing series for the intramarket spread is associated with 38 mispricing reversals (3.8 reversals a contract), while the intramarket spread is associated with 168 mispricing reversals (16.8 reversal a contract). The implication of this result is that spread trader will be able to liquidate intermarket trades with greater frequency and often at more favourable prices than the spreader trading intramarket spreads. However, in the final column of tables 6.1 and 6.2 mispricing reversals are limited to cases of where the mispricing series reverses by an amount of more (in both directions) than half the transactions cost of executing the spread, providing a more meaningful indicator of the potential for spread trading within transaction costs limits. These specific types of reversals are found to be almost ten times more common for the intermarket spread than the intramarket spread, suggesting that the practice of initiating risky spread trades is likely to be more successful for intermarket than intramarket spread transactions.

Consideration is now given to the profitability of trading intramarket and intermarket spreads employing the simple filter rules previously outlined. Each of the tables of results are organised on a contract by contract basis and each details the number of trades initiated, the type of trade, the profitability of trading both before and after transaction costs and the average duration of each trade. The results relating to intramarket spread transactions triggered by violations of the 0.3% limit of the arbitrage window are presented in table 6.3. In relation to this strategy a number of important points can be made. First, although intramarket spread trades are initiated on 63 (9.9%) occasions, over half of all trades are accounted for solely by the December 1995 contract, and 5 contracts are characterised by no spread trading at all. Second, all the initiated trades are bull trades which reflects the fact that the deferred contract is generally priced at a premium to the near contract. Third, on a pre-transaction cost basis the spread trader generates a profit of £15, 975, an average of £253.57 per trade. However, once allowances are made for transaction costs the spread trader incurs an overall loss of £211.71, an average of -£3.36 per trade. This finding supports the view that the no-arbitrage model employed to determine the

Table 6.3)

Transaction Cost Violations and Trading Profits for the Intra Market Spread at the 0.3% Transaction Cost Threshold

					Profits (£'s)				
		Number of	Type of Trade:		Pre Transaction Costs		Post Transaction Costs		Average
Contract	Observations	Trades	Bull	Bear	Total	Average	Total	Average	Duration
Jun 1994	61	7	7	0	1425.00	203.57	-191.48	-27.35	52.57
Sep 1994	64	0	0	0	0	0	0	0	0
Dec 1994	65	14	14	0	2475.00	176.79	-757.66	-54.12	30.29
Mar 1995	62	2	2	0	325.00	162.50	-130.00	-65.00	34.00
Jun 1995	61	0	0	0	0	0	0	0	0
Sep 1995	64	0	0	0	0	0	0	0	0
Dec 1995	65	34	34	0	9950.00	292.65	742.49	21.84	27.62
Mar 1996	62	0	0	0	0	0	0	0	0
Jun 1996	66	6	6	0	1800.00	300.00	124.95	20.83	51.17
Sep 1996	64	0	0	0	0	0	0	0	0
Total	634	63	63	0	15975.00	253.57	-211.71	-3.36	33.43

Table 6.4)

Transaction Cost Violations and Trading Profits for the Intra Market Spread at the 0.3% Transaction Cost Threshold with 0.35% Arbitrage Triggers

					Profits (£'s)				
		Number of	Type of Trade:		Pre Transaction Costs		Post Transaction Costs		Average
Contract	Observations	Trades	Bull	Bear	Total	Average	Total	Average	Duration
Jun 1994	61	1	1	0	212.50	212.50	-54.56	-54.56	53.00
Sep 1994	64	0	0	0	0	0	0	0	0
Dec 1994	65	1	1	0	175.00	175.00	-93.16	-93.16	28.00
Mar 1995	62	1	1	0	187.50	187.50	-80.87	-80.87	41.00
Jun 1995	61	0	0	0	0	0	0	0	0
Sep 1995	64	0	0	0	0	0	0	0	0
Dec 1995	65	25	25	0	9462.50	378.50	1585.69	63.43	23.68
Mar 1996	62	0	0	0	0	0	0	0	0
Jun 1996	66	0	0	0	0	0	0	0	0
Sep 1996	64	0	0	0	0	0	0	0	0
Total	634	28	28	0	10037.50	358.48	1357.10	48.50	25.50

entry and exit triggers is reasonably well specified. This overall loss is partly accounted for by the fact that many of the trades were initiated at mispricing levels which only marginally exceeded the transaction costs threshold, and together with the lack of mispricing reversals the spread trader was forced to hold these position till the maturity of the near contract, at which point the trades were unwound at unfavourable levels. The average duration for each trade of 33.43 days supports the view that traders had difficulty in unwinding their positions at profitable levels.

This problem of marginal arbitrage triggers is addressed by raising the mispricing level at which trades are initiated from 0.3% to 0.35% while retaining the transaction cost threshold of 0.3%. The effect of this adjustment is that the spread trader becomes more selective, and concentrates only on the more profitable spread mispricing opportunities. The effects of these changes are reported in table 6.4. First, the effect of raising the arbitrage trigger is that the number of trades initiated has fallen from 63 to 28 trades, with the average duration over which these positions are held narrowing from 33.43 to 24.5 days. Second, regarding the profitability of the strategy, on a pre-transaction cost basis total profits have fallen by over 30%, while average profits have risen by over 40%, to £10,037.50 and £358.48 respectively. While on a post transaction cost basis both total and average profits have risen, to £1,351.10 and £48.50 respectively. Therefore, while intramarket spread trading opportunities are rare, a finding which is consistent with both the near and deferred FTSE 100 contracts being closely integrated, profitable spread trading opportunities do nonetheless exist.

We now consider the profitability of intermarket spread trading, involving positions in the near FTSE 100 and Mid 250 contracts. The trading of intermarket spreads is both riskier and more complicated than is the case for intramarket spreads because of the problem of spread ratio variability, which arises from differences in the underlying values of the respective futures contracts. The behaviour of the intermarket spread ratio (equation 6.13) over the entire sample period is illustrated in figure 6.3, and statistics relating to its behaviour are reported on a contract by contract basis in table 6.5. The spread ratio fluctuates between the extremes of 2.326 and 2.043, with a mean value of 2.1979, indicating that spread ratio risk is present. Even so, on a contract by contract basis the spread ratio fluctuates within rather narrow limits, and over short periods the relationship is characterised by a degree of stability, as the low standard deviation statistics indicate. Therefore, it would seem reasonable to argue that the problem of spread ratio instability can be alleviated by unwinding intermarket spread trades at the earliest opportunity and thereby keeping the duration of the intermarket spread trades typically short.

The impact of spread ratio variability on the profitability of intermarket spreads between the FTSE 100 and Mid 250 contracts is examined for the two specific cases where the spread is balanced and unbalanced. In the case of the balanced spread it is assumed that fractions of the Mid 250 futures contract can be bought and sold to guarantee equivalency in the values of both legs. In all cases profits are calculated on the basis of the closing spread ratio. For instance, if the spread ratio is found to be equal to 2.145, it is assumed that a spread transaction can be implemented consisting

Figure 6.3)

Spread Ratio Associated with Inter Market Spread

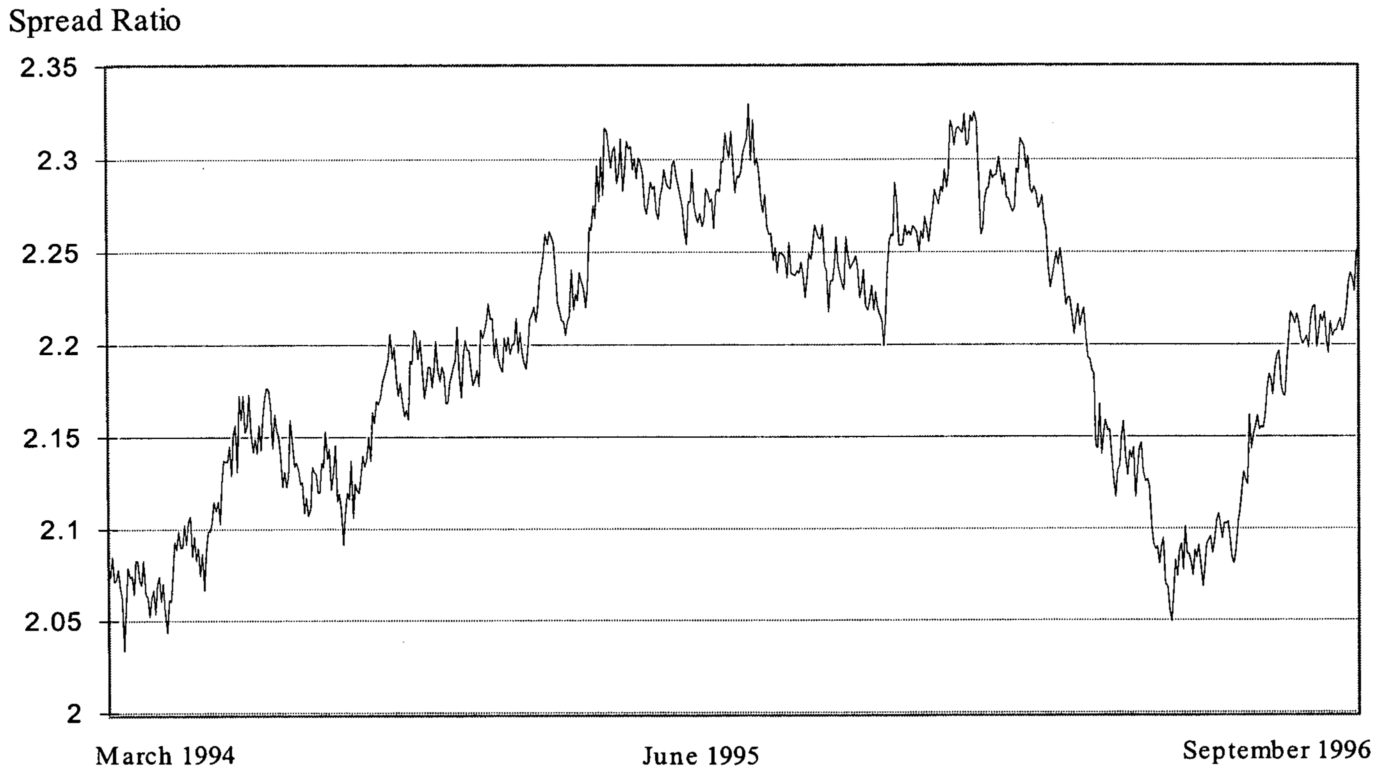


Table 6.5)

Spread Ratio Statistics

Contract	Obs.	Mean	S.D.	Max.	Min.
Jun 1994	61	2.0816	0.0210	2.1374	2.0339
Sep 1994	64	2.1388	0.0195	2.1768	2.0913
Dec 1994	65	2.1756	0.0234	2.2100	2.1061
Mar 1995	62	2.2240	0.0274	2.3013	2.1853
Jun 1995	61	2.2864	0.0142	2.3171	2.2541
Sep 1995	64	2.2641	0.0284	2.3299	2.2178
Dec 1995	65	2.2663	0.0340	2.3256	2.1991
Mar 1996	62	2.2541	0.0417	2.3113	2.1438
Jun 1996	66	2.1062	0.0283	2.1593	2.0492
Sep 1995	64	2.1851	0.0397	2.2508	2.0809
Total	634	2.1979	0.0741	2.3299	2.0339

of 1 FTSE 100 contract and 2.145 Mid 250 contracts. While this assumption is clearly unrealistic it serves as a useful benchmark for assessing the potential for spread trading. Secondly, for the more realistic case of the unbalanced spread only whole contracts are traded. The unbalanced intermarket spread trading strategy is determined on the basis of a spread ratio which is simply equal to the ratio of the contract multipliers underlying the two futures contracts. Given that the contract multiplier underlying the FTSE 100 contract is two and a half times as large as that underlying the Mid 250 contract it is assumed that 5 Mid 250 contracts are traded for every 2 FTSE 100 contracts.

The transaction costs violations and spread trading profits for the balanced and unbalanced inter market spreads are reported in tables 6.6 and 6.7 respectively. With respect to the balanced spread trading relationship there are a number of interesting points to be made. First, trades are triggered much more often than for the intramarket spread, with intermarket spread trades being triggered on 166 (26.2%) of occasions. Of these trades, 44% are long spread trades and 56% are short spread trades. Second, intermarket trades were unwound with much greater frequency than intramarket spread trades, and with an average duration of 11.76 days were held only approximately a third as long. Third, regarding the profitability of this strategy, over the entire sample the intermarket spread trading strategy generated a pre-transaction cost profit of £81,052, an average of £488 per trade, and a post-transaction cost profit of £25,016, an average of £151 per trade. Therefore, before any allowance is made

Table 6.6)

Transaction Cost Violations and Trading Profits for the Balanced Inter Market Spread at the 4.0% Transaction Cost Threshold: March 1994 to September 1996

					Profits (£'s)				
		Number of	Type of Trade		Pre Transaction Costs		Post Transaction Costs		Average
Contract	Observations	Trades	Long	Short	Total	Average	Total	Average	Duration
Jun 1994	61	12	2	10	16630.17	1385.85	12889.86	1074.16	4.08
Sep 1994	64	23	2	21	13584.29	590.62	6473.16	281.44	9.04
Dec 1994	65	13	12	1	1765.71	135.82	-2202.13	-169.39	3.92
Mar 1995	62	31	0	31	2979.5	96.11	-6454.54	-208.21	24.97
Jun 1995	61	5	0	5	4430.02	886	2826.21	565.24	4.8
Sep 1995	64	12	12	0	-4766.32	-397.19	-8906.65	-742.22	10
Dec 1995	65	20	19	1	20412.05	1020.6	13285.2	664.26	5.9
Mar 1996	62	8	7	1	9454.61	1181.83	6507.71	813.46	5.25
Jun 1996	66	18	18	0	18384.52	1021.36	11612.82	645.16	3.78
Sep 1996	64	24	1	23	-1822.65	-75.94	-11015.76	-458.99	20.75
Total	634	166	73	93	81051.9	488.26	25015.88	150.7	11.76

Table 6.7)

Transaction Cost Violations and Trading Profits for the Unbalanced Inter Market Spread at the 4.0% Transaction Cost Threshold: March 1994 to September 1996

					Profits (£'s)[a]				
		Number of	Type of Trade		Pre-Transaction Costs		Post-Transaction Costs		Average
Contract	Obs.	Trades	Long	Short	Total	Average	Total	Average	Duration
Jun 1994	61	12	2	10	16900	1408.33	8207.35	683.95	4.08
Sep 1994	64	23	2	21	57400	2495.65	41321.70	1796.59	9.04
Dec 1994	65	13	12	1	9925	763.46	1076.51	82.81	3.92
Mar 1995	62	31	0	31	-13750	-443.55	-34393	-1109.50	24.97
Jun 1995	61	5	0	5	6750	1350	3320.69	664.14	4.80
Sep 1995	64	12	12	0	4800	400	-4153.80	-346.15	7.42
Dec 1995	65	20	19	1	23650	1182.50	8258.89	412.94	5.65
Mar 1996	62	8	7	1	8975	1121.88	2639.29	329.91	5.25
Jun 1996	66	18	18	0	19100	1061.11	3727.88	207.10	3.67
Sep 1996	64	24	1	23	-25725	-1071.90	-45988	-1916.20	20.75
Total	634	166	73	93	108025	650.75	-15982.70	-96.28	11.76

[a] Profits are determined on the basis of a trading position of two FTSE 100 contracts to five Mid 250 contracts which is initiated in response to each transaction cost violation.

for the issue of spread ratio variability, the intermarket spread between the FTSE 100 and Mid 250 contracts appears a desirable trading strategy.

In table 6.7 the results are reported for the unbalanced intermarket spread trading strategy. Compared with results for the balanced intermarket spread, the most striking difference is that the profitability of the trading strategy based on the unbalanced intermarket spread has been reduced significantly. While on a pre-transaction cost basis the strategy generated a total profit of £108,025, an average of 650.75, once allowances are made for transaction costs this is transformed into a total loss of £15,983, an average of -£96.28 per trade. These losses can be largely accounted for by the problem of spread ratio variability and the difficulties which the spread trader experiences in liquidating trades early. For instance, it was the large losses incurred from trades involving the March 1995 and September 1996 contracts which the spreader held on average for over one month that so adversely affected the profitability of the strategy. These two contracts alone contributed to a loss of over £80, 000. Such large losses are incurred because both contracts are dominated by short trades in a market where the relative prices of the two contracts are moving against the spread trader, who has difficulty in unwinding his market positions.

Finally, since the spread pricing relationships outlined are founded on the same laws of arbitrage that underpin spot-futures pricing relationships (see chapter five), it seems reasonable to assume that some of the time series properties which characterise the spot-futures pricing relationship will also be present in the spread pricing relationship. First, studies investigating index arbitrage (Mackinlay and

Ramaswamy (1988), Yadav and Pope (1990)) have found that the spot-futures mispricing series are characterised by a maturity effect whereby mispricing converges towards zero as the contract maturity date approaches. This issue is investigated for both the intramarket and intermarket spread relationships by regressing the absolute value of spread mispricing against the number of days to contract maturity. The results in table 6.8 show that both the intramarket and intermarket spread mispricing series are a function of the length of time to maturity. For the intramarket spread 9 of the 10 contracts are characterised by a significant relationship, of which 8 are associated with a positive coefficient and 1 is associated with a negative coefficient. While for the intermarket spread 9 of the 10 contracts are also characterised by a significant relationship, of which all are associated with a positive coefficient. Presumably the fall in arbitrage risk associated with declining dividend and interest rate uncertainty, together with the increase in trading volume in the less liquid deferred contract as maturity approaches, have led to more effective tracking between the two markets and greater pricing efficiency. With respect to the length of time to maturity variable, the intramarket spread mispricing is associated with more explanatory power than the intermarket spread mispricing. The fact that the results in table 6.9 show intramarket spread mispricing to be a monotonic function of the days to maturity corroborates this view.

The spot-futures mispricing relationship is also found to be characterised by significant persistence, whereby once significant positive or negative mispricing develops, mispricing remains positive or negative for many days (see Brenner,

Table 6.8)

Is Spread Mispricing Random?

$$|SM_t| = \alpha + \beta(T-t) + \varepsilon_t$$

	Intra Market Spread Mispricing				Inter Market Spread Mispricing		
Near Contract	β	T-stat	R^2	*	β	T-stat	R^2
June 1994	0.0026	10.894	0.6679	*	0.0034	2.642	0.1058
September 1994	0.0020	8.800	0.5554	*	0.0042	2.806	0.1127
December 1994	0.0056	13.454	0.7418	*	0.0028	2.476	0.0887
March 1995	0.0052	20.371	0.8737	*	0.0075	4.193	0.2266
June 1995	0.0019	6.878	0.4409	*	0.0023	2.041	0.0659
September 1995	0.0022	8.739	0.5519	*	-0.0003	-0.278	0.0012
December 1995	0.0040	7.214	0.4524	*	0.0071	5.297	0.3081
March 1996	-0.0009	-3.122	0.1398	*	0.0039	3.625	0.1796
June 1996	0.0027	4.496	0.2401	*	0.0032	2.436	0.0848
September 1996	-0.0001	-0.181	0.0005	*	0.0043	3.099	0.1341

Table 6.9)

Absolute Deviations Versus Time to Maturity

	Ave. Abs. Deviation (%)	
Days to Expiration	Intra market	Inter market
Over 60	0.2339	0.3059
60 - 51	0.2113	0.3698
50 - 41	0.1713	0.3227
40-- 31	0.1575	0.3676
30 - 21	0.1099	0.2482
20 - 11	0.0891	0.1861
10 - 1	0.0859	0.1930

Subrahmanyam and Uno (1989a)). An inspection of the mispricing plots in figures 6.1 and 6.2 indicate that persistence in mispricing is a phenomenon which is very strongly evident in the mispricing series of the intramarket spread, and is to a lesser extent evident for the intermarket spread. The issue of persistence in mispricing can be considered by simply measuring the average frequency of mispricing reversals, or by using parametric approaches such as testing for serial correlation in the mispricing series. In relation to the entire intramarket spread mispricing series, mispricing reversals occur on average every 16.5 days, with a maximum run of 164 days and a minimum run of 1 day, and where 23% of all runs persist for over three weeks. By comparison, for the intermarket spread mispricing series, mispricing reversals occur on average every 3.8 days, with a maximum run of 47 days and a minimum run of 1 day, and where 2.5% of all runs persist for over three weeks. This provides clear evidence that mispricing tends to be more persistent for the intramarket spread than the intermarket spread and is consistent with the fact that the intermarket spread is less effectively arbitraged than the intramarket spread. Hence, when the price of the intermarket spread deviates from its fair price, the arbitraging forces pulling prices back towards equilibrium are not as strong as in the case of the intramarket spread.

The autocorrelation coefficients reported in table 6.10 confirm the view that mispricing is more persistent for the intramarket spread than for the intermarket spread. For all 10 contracts, the first-order autocorrelation coefficient for the mispricing series associated with the intramarket series are greater than those for the mispricing series associated with the intermarket spread. Furthermore, when consideration is given to the entire sample, all 6 autocorrelation coefficients associated with lagged values of the mispricing series for the intramarket spread are larger than those for the FTSE 100 contract, providing clear evidence of greater persistence in the mispricing series of the intramarket spread.

Finally, ARMA modelling techniques are employed to identify and estimate the autoregressive processes underlying both the intramarket and intermarket spread mispricing series. Plots of the autocorrelation functions for both of the mispricing series associated with the intramarket and intermarket spreads rapidly converge to zero implying stationarity. Furthermore, Augmented Dickey-Fuller statistics are generated and found to be equal to -6.798 and -8.2086 respectively, providing formal evidence of stationarity. From the autocorrelation and partial autocorrelation coefficients reported in panels A and B of table 6.10, it was decided that for the entire time series an AR(1) process is most applicable for the intramarket spread mispricing series, and an AR(2) process is most applicable for the intermarket spread mispricing series. In relation to the partial autocorrelation coefficients in panel B, only the first coefficient is significant at the 5% level for intramarket spread mispricing, and only the first 2 coefficients are significant at the 5% level for intermarket spread mispricing. A further argument in favour of both these models is that overfitting the processes does not improve the explanatory significance of either model. The estimated AR(1) process for the intramarket spread mispricing series, and the estimated AR(2) process for the intermarket spread mispricing series are presented in equations 6.14 and 6.15 receptively.

Table 6.10)

Autocorrelation and Partial Autocorrelation Coefficients For the Intra and Inter Market Spreads

A) Autocorrelation Coefficients (Lags)

Contract		Intra Market Spread							Inter Market Spread					
	Obs.	1	2	3	4	5	6	*	1	2	3	4	5	6
Jun 1994	61	0.809	0.686	0.625	0.595	0.536	0.451	*	0.306	0.041	0.023	-0.106	0.016	-0.055
Sep 1994	64	0.808	0.691	0.550	0.467	0.419	0.354	*	0.438	0.375	0.331	0.158	0.266	-0.035
Dec 1994	65	0.950	0.921	0.881	0.842	0.802	0.748	*	0.175	0.096	-0.062	-0.201	-0.075	-0.09
Mar 1995	62	0.917	0.883	0.853	0.804	0.754	0.721	*	0.434	0.269	0.234	0.268	0.122	0.149
Jun 1995	61	0.860	0.752	0.711	0.663	0.599	0.553	*	0.526	0.373	0.242	0.191	0.068	0.02
Sep 1995	64	0.884	0.798	0.726	0.726	0.567	0.496	*	0.447	0.505	0.292	0.277	0.278	0.172
Dec 1995	65	0.448	-0.096	-0.164	-0.103	-0.012	0.007	*	0.533	0.428	0.329	0.258	0.315	0.128
Mar 1996	62	0.715	0.623	0.523	0.441	0.464	0.422	*	0.682	0.401	0.312	0.228	0.128	0.041
Jun 1996	66	0.831	0.742	0.660	0.563	0.484	0.398	*	0.324	-0.067	-0.279	-0.342	-0.165	-0.017
Sep 1996	64	0.814	0.669	0.537	0.386	0.237	0.143	*	0.635	0.46	0.417	0.273	0.249	0.138
								*						
Total	634	0.851	0.727	0.681	0.676	0.667	0.630	*	0.654	0.552	0.497	0.432	0.444	0.387

B) Partial Autocorrelation Coefficients (Lags)

Contract		Intra Market Spread							Inter Market Spread					
	Obs.	1	2	3	4	5	6	*	1	2	3	4	5	6
Jun 1994	61	0.809	0.091	0.139	0.115	-0.030	-0.030	*	0.306	-0.058	0.03	-0.133	0.102	-0.108
Sep 1994	64	0.808	0.108	-0.103	0.065	0.093	-0.060	*	0.438	0.226	0.137	-0.095	0.173	-0.296
Dec 1994	65	0.950	0.188	-0.089	-0.050	-0.015	-0.181	*	0.175	0.067	-0.093	-0.191	0.001	-0.048
Mar 1995	62	0.917	0.263	0.105	-0.100	-0.100	0.051	*	0.434	0.099	0.107	0.147	-0.083	0.084
Jun 1995	61	0.860	0.047	0.207	0.006	-0.032	-0.032	*	0.526	0.133	0.002	0.043	-0.093	-0.025
Sep 1995	64	0.884	0.077	0.030	-0.110	0.035	0.035	*	0.447	0.382	-0.027	0.013	0.142	-0.058
Dec 1995	65	0.448	-0.372	0.090	-0.114	0.067	-0.073	*	0.533	0.201	0.058	0.022	0.173	-0.181
Mar 1996	62	0.715	0.230	0.034	0.003	0.201	0.018	*	0.682	-0.119	0.167	-0.061	-0.031	-0.059
Jun 1996	66	0.831	0.164	0.027	-0.078	-0.014	-0.059	*	0.324	-0.192	-0.221	-0.222	-0.05	-0.074
Sep 1996	64	0.814	0.018	-0.035	-0.137	-0.112	0.044	*	0.635	0.097	0.155	-0.107	0.101	-0.144
								*						
Total	634	0.851	0.012	0.216	0.168	0.091	-0.004	*	0.654	0.218	0.131	0.043	0.144	-0.004

$$SM_t = -0.019 + 0.851 SM_{t-1} + \varepsilon_t \qquad 6.14)$$
$$\qquad (-4.922) \quad (40.813)$$

$$R^2 = 0.725, \ S.E. = 0.069$$

$$SM_t = -0.006 + 0.5118 SM_{t-1} + 0.218 SM_{t-2} + \varepsilon_t \qquad 6.15)$$
$$\qquad (-0.578) \quad (13.136) \quad (5.592)$$

$$R^2 = 0.455, \ S.E. = 0.266$$

6.6) CONCLUSION

In conclusion, spreading is an essential futures trading strategy which seeks to profit from temporary distortions in the relative pricing relationship between two related futures contracts. Spread trading provides an alternative mechanism for testing for the market efficiency of stock index futures contracts. This mechanism is essential for tying the prices of different contracts together, and by increasing the correlation between the different markets serves to add liquidity and risk bearing capacity, while simultaneously increasing the hedging effectiveness of the markets.

In this chapter the profitability of intramarket and intermarket spreads comprising of UK stock index futures contracts has been examined. Important points can be noted. First, while the intramarket spread is found to be very efficiently priced, trading well within its no arbitrage limits, the intermarket spread is less efficiently priced, frequently violating its no-arbitrage limits. Second, the intramarket spread is priced at a chronic discount to fair value, while the direction of mispricing is evenly divided between overpricing and underpricing for the intermarket spread. Third, the average absolute deviation for the intramarket spread is only half the size of the intermarket spread. Fourth, with respect to the profitability of intramarket spread trading, spread trading opportunities are rare with profits often being eliminated once allowance is made for transaction costs. This problem was alleviated by selecting only the more profitable mispricing opportunities. Fifth, intermarket spreads were found to be both riskier and more complicated than intramarket spreads, because of the problem of spread ratio variability. However, the spread ratio is found to be quite stable over very short periods of time, hence this difficulty could be mitigated by unwinding the intermarket spread trades as soon as it was profitable to do so. Sixth, compared to intramarket spread trades, intermarket spread trades are initiated more often and unwound with greater frequency. Seventh, while there appeared the potential for profitable intermarket spread trading, this strategy generated losses once account had been taken for spread ratio variability. Finally, in relation to the time series properties of the mispricing series, both spreads are found to be characterised by a time to maturity effect, and there is strong evidence of persistence in mispricing, especially for the intramarket spread.

Comparing the findings in chapter five which relate to the pricing of the individual FTSE 100 and Mid 250 contracts with the findings in this chapter which relate to the pricing of the intramarket and intermarket spreads comprising of the FTSE 100 and Mid 250 contracts, a number of important points can be made in relation to their observed pricing characteristics. It is evident from the results that the mispricing series which comprise the Mid 250 contract are less efficiently priced and more volatile than the mispricing series which comprise of only the FTSE 100 contract. This finding suggests that these relationships are not as effectively arbitraged as those comprising only the FTSE 100 contract. Even so, owing to thin trading and the larger transaction costs associated with the new contract, the evidence of greater mispricing does not always translate into greater opportunities for profitable arbitrage. In fact in the case of the Mid 250 contract no arbitrage transactions are triggered. However, in the case of the intermarket spread, many arbitrage transactions are triggered and where the duration is typically short the strategy is generally profitable. Therefore, the onset of trading in the Mid 250 contract has provided arbitrageurs with a range of exciting new trading opportunities.

Endnotes

[1] Intramarket spreads are also referred to as calendar spreads, intracommodity spreads, horizontal spreads or time spreads.

[2] Given that trading volume in the deferred Mid 250 contract is almost non-existent on many days it was not feasible to examine intramarket spread relationships for the Mid 250 contract.

[3] Although the FTSE Mid 250 contract was introduced on the 25th February 1994, the data relating to the March 1994 contract was excluded owing to the limited number of observations.

CHAPTER SEVEN

CONCLUDING REMARKS

Previously it was argued that while stock index futures trading has been an area where leading US academics have been very active, the research conducted into the behaviour of UK index futures contracts was rather limited. The main purpose of this thesis is to address this issue by empirically investigating the role and function of the FTSE 100 and Mid 250 contracts. Although work into the usefulness of the established FTSE 100 contract has been forthcoming, no detailed examination had been conducted for the recently introduced Mid 250 contract. Academic research into the role and function of these contracts has been motivated by the following considerations. Firstly, index futures markets were established as a mechanism for facilitating the transfer of price risk, by extending the range of portfolio opportunities which are available to investors and portfolio managers. Thus the main justification for index futures is that of hedging. Secondly, in order to perform their risk reduction role effectively index futures need to be correctly priced with respect to the underlying spot markets. Where they are found to be mispriced relative to their fair value estimates, hedging effectiveness will be impaired and arbitrage opportunities may present themselves.

While the issues investigated are not exhaustive in coverage, they address what are perceived to be the most important aspects of index futures trading and the empirical findings are of particular interest to market participants, regulators and academics in the UK. The introduction of the Mid 250 contract provided market practitioners with the opportunity to take advantage of their knowledge and their views on the prospects of the two different areas of the market. The UK index futures market also provides an example of how an additional instrument could be introduced to support and complement an existing contract.

Owing to the short life of stock index futures trading in the UK, research into the effectiveness of these contracts has been limited in scope, and the literature remains in its infancy. The aim of this thesis is to explore some of the gaps in the literature, by providing a detailed empirical investigation of the role and function of stock index futures contracts in the UK. The thesis concentrates on important aspects relating to the introduction of the Mid 250 contract, and what additional benefits it has made to stock index futures trading in the UK. Specifically, it focuses on two related issues which are central to evaluating the value of index futures trading in a UK context. Hence, the specific research objectives of the thesis are to investigate the hedging effectiveness of the FTSE 100 and Mid 250 contract, and the pricing efficiency of the FTSE 100 and Mid 250 contracts.

After outlining the justification for the thesis in chapter one, and reviewing the relevant literature in chapter two, chapter three investigated the hedging effectiveness of the FTSE 100 and Mid 250 contracts to determine whether the Mid 250 contract provided any additional benefits. While the Mid 250 contract was introduced to enable investors to acquire market wide exposure to medium size capitalisation stocks, it was possible that the hedging effectiveness of this new contract may be seriously impaired by the low levels of trading volume. Hedging effectiveness was examined in both an ex post and an ex ante context in relation to a diverse range of spot portfolios. The FTSE 100 contract is found to provide a more effective hedge for spot portfolios dominated by large capitalisation stocks, while the Mid 250 contract is found to provide a more effective hedge for portfolios dominated by lower capitalisation stocks. In addition when consideration was given to professionally managed portfolios, hedging effectiveness was greater for the new contract in all cases.

For ex ante hedge ratios estimated by means of a dynamic moving window, it is found that where the underlying spot portfolios are broad based market indexes, the levels of risk reduction are of a similar magnitude to those achieved using the ex post strategy. For these portfolios inter-temporal hedge ratio instability did not appear to strongly adversely affect hedging performance. However, where the spot portfolios to be hedged consisted of professionally managed portfolios, ex ante hedging effectiveness is found to be poor, and the presence of significant hedge ratio instability resulted in levels of risk reduction lower than those achieved when using the ex post strategy. In these circumstances the degree of hedge ratio instability dictated the proportion of ex post risk reduction which could be attained on an ex ante basis. Even so, it was found that the size of the estimating period is an important determinant of hedge ratio instability, and that the degree of hedge ratio instability could be alleviated by enlarging the window size used for estimating hedge ratios. When larger window sizes are employed ex ante hedge ratios are found to stabilise, converging towards the ex post benchmark, and maximising risk reduction. It is evident that previous studies which have evaluated the hedging effectiveness of index futures contracts by employing an ex post strategy with spot portfolios that mirror the composition of the underlying contract have seriously exaggerated the risk reduction potential of these instruments. Hedging effectiveness can only be truly examined by using an ex ante strategy in conjunction with a spot portfolios that do not replicate market portfolios.

In chapter four the work conducted into hedging effectiveness is extended by investigating the performance of hedge ratios estimated within an extended mean Gini (EMG) framework. The EMG approach provides a robust alternative to the mean variance approach by explicitly accommodating a risk aversion parameter into hedging decisions, and producing hedge ratios that are consistent with the rules of stochastic dominance. The results indicate that for both the FTSE 100 and Mid 250 contracts, EMG hedge ratio series are characterised by a step function which is strongly related to the hedger's degree of risk aversion. The implication of this result is that each spot-futures relationship is associated with several optimal hedge ratios. Comparing the behaviour of direct and cross-hedges, while direct hedges are found to be a monotonic function of risk aversion, the relationship between the behaviour of cross-hedges and risk aversion is found to be characterised by reversals. This suggests that cross-hedges are likely to be more sensitive to changes in risk aversion than direct hedges.

In chapter five the pricing efficiency of the FTSE 100 and Mid 250 contracts is examined. This is an important issue because while index arbitrage strategies have been discouraged in the US, they have been encouraged in the UK. Given that index futures are frequently used to initiate short term hedging strategies, the effectiveness of these strategies in reducing risk depends crucially on whether the contracts are efficiently priced relative to their underlying fair value. The results from this chapter indicate that while there are many deviations from fair value both contracts appear to be efficiently priced, with mispricing being generally constrained within transactions cost limits. Although mispricings are larger and more frequent for the Mid 250 contract than for the FTSE 100 contract, this is consistent with the larger transactions cost and difficulties associated with trading the illiquid constituents of the Mid 250 index. The results also suggests that the onset of trading in the Mid 250 index contract has been associated with an improvement in the pricing of the FTSE 100 contract. It appears that by equipping equity market makers and institutional investors with a vehicle through which they can achieve more efficient management of lower capitalisation portfolios, this has freed capital and resources which have been employed to achieve more effective tracking between the FTSE 100 spot and futures markets.

Finally, in chapter six the issue of intramarket and intermarket spread trading based on the FTSE 100 and Mid 250 contracts is investigated, as an alternative approach for testing for futures market efficiency. This is an important issue because spread trading contributes to the discussion on the economics of arbitrage, with spread mispricing having implications for the effectiveness of spread trading in the same way that index futures mispricing has important implications for hedging effectiveness. While the intramarket spread is found to be very efficiently priced, trading well within its no-arbitrage limits, the intermarket spread is less efficiently priced frequently violating its no-arbitrage limits. In relation to the profitability of intramarket spread trading, spread trading opportunities are rare with profits often being eliminated once allowance is made for transaction costs. However, the profitability of the intramarket trading strategy could be enhanced by selecting only the more profitable mispricing opportunities. Intermarket spreads are found to be both riskier and more complicated than intramarket spreads, owing to the problem of spread ratio variability.

In conclusion, the Mid 250 contract was introduced to complement the well established FTSE 100 contract and provide investors with an important mechanism for tracking the performance of medium capitalisation stocks in the UK. The evidence presented in this thesis demonstrates that although the new contract has the potential to greatly extend the range of investment services available to users of the UK equity market, its practical usefulness to date has been impaired by the thinness of the market, high transaction costs arising from wide bid-offer spreads, and technical and structural difficulties which impede trading in the illiquid constituents of the Mid 250 index. Nonetheless, the findings in this thesis show that there are important areas where the Mid 250 contract has a significant contribution to make, and offers real benefits to users of the market which would not be attainable from using the FTSE 100 contract alone. The results show that the Mid 250 contract is a very effective hedging for stock indexes comprising of smaller capitalisation stocks, and that additional benefits of the new contract are also evident in relation to managed spot portfolios in the form of investment trust vehicles. Furthermore, in the context of the EMG framework, the results show that for a strongly risk averse investor who is prepared to sacrifice mean return in order to reduce risk, the Mid 250 contracts provides a more effective hedge than the FTSE 100 contract for all spot indexes, even the spot portfolio underlying the FTSE 100 contract. Hence, the Mid 250 contract has an important role to perform as an additional hedging instrument.

In relation to the pricing efficiency of the Mid 250 contract, while the new contract is found to be more mispriced that the FTSE 100 contract, on no occasion does mispricing violate either of the no-arbitrage limits, supporting the view that the Mid 250 contract is relatively efficiently priced. However, the degree of mispricing has important implications for the cost of a hedging strategy, with the direction of the initial mispricing introducing a specific mispricing element into the returns on the hedged portfolio. Given that deviations from fair value are larger and more sustained for the Mid 250 contract than for the FTSE 100 contract the returns associated with the mispricing component have much greater relevance for traders using the Mid 250 contract than those using FTSE 100 contract. Furthermore, the introduction of the Mid 250 contract offers a unique opportunity to investigate the potential for intermarket spread trading. In the case of the intermarket spread comprising of positions in the FTSE 100 contract and Mid 250 contract many arbitrage transactions are triggered and where the duration is typically short the strategy is generally profitable. Hence, the onset of trading in the Mid 250 contract has provided users of the UK equity market with a range of exciting new trading opportunities.

Appendix 1
Optimal Portfolio Weighting For the 'Synthetic' FTSE 350 Index Futures Contract: Daily Data.

Portfolio Weighting (FTSE100 :FTSE250)*

	2 : -1		1.75 : -0.75		1.50 : -0.50		1.25 : -0.25		FTSE100		0.75 : 0.25		0.50 : 0.50		0.25 : 0.75		FTSE250		-0.25 : 1.25		-0.50 : 1.50		-0.75 : 1.75		-1 : 2	
Spot	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2
FTSE100	0.479	0.832	0.538	0.856	0.610	0.882	0.698	0.907	0.803	0.926	**0.924**	**0.930**	1.042	0.901	1.112	0.794	1.050	0.597	0.811	0.342	0.475	0.131	0.179	0.023	-0.018	0.000
FTSE250	0.195	0.335	0.227	0.369	0.267	0.412	0.321	0.466	0.391	0.533	0.481	0.613	0.590	0.700	0.702	0.769	**0.766**	**0.772**	0.726	0.667	0.587	0.487	0.421	0.312	0.283	0.185
FTSE350	0.415	0.784	0.467	0.813	0.532	0.844	0.612	0.878	0.710	0.909	**0.823**	**0.928**	0.940	0.916	1.018	0.837	0.985	0.660	0.791	0.409	0.499	0.182	0.233	0.049	0.049	0.003
FTALLSH	0.389	0.769	0.439	0.799	0.500	0.832	0.576	0.867	0.669	0.900	**0.777**	**0.923**	0.889	0.916	0.967	0.843	0.940	0.671	0.761	0.422	0.487	0.193	0.235	0.056	0.060	0.005
FTIT	0.240	0.377	0.276	0.405	0.321	0.438	0.378	0.478	0.451	0.524	0.542	0.575	0.647	0.621	**0.743**	**0.639**	0.779	0.590	0.701	0.460	0.531	0.295	0.349	0.158	0.207	0.073
Malvern	0.334	0.246	0.383	0.265	0.446	0.288	0.527	0.315	0.630	0.347	0.759	0.383	0.909	0.416	**1.048**	**0.431**	1.104	0.402	1.000	0.317	0.763	0.206	0.507	0.113	0.306	0.054
Mercury Keystone	0.178	0.158	0.207	0.174	0.244	0.195	0.527	0.315	0.356	0.251	0.438	0.289	0.538	0.330	0.640	0.363	**0.698**	**0.364**	0.662	0.314	0.535	0.230	0.384	0.147	0.258	0.087
Flem. Claverhouse	0.148	0.126	0.172	0.140	0.156	0.156	0.245	0.177	0.298	0.204	0.368	0.235	0.453	0.270	0.540	0.300	**0.592**	**0.303**	0.564	0.263	0.458	0.194	0.331	0.126	0.224	0.076
Edinburgh	0.311	0.355	0.356	0.378	0.413	0.407	0.484	0.440	0.575	0.479	0.688	0.520	0.816	0.554	**0.930**	**0.560**	0.964	0.506	0.856	0.384	0.636	0.236	0.406	0.120	0.229	0.050
Govett	0.224	0.194	0.259	0.211	0.303	0.232	0.360	0.257	0.435	0.288	0.529	0.324	0.641	0.360	**0.749**	**0.383**	0.803	0.370	0.743	0.305	0.584	0.211	0.404	0.125	0.259	0.067
Schroder	0.174	0.083	0.202	0.092	0.238	0.102	0.284	0.114	0.345	0.130	0.423	0.148	0.517	0.168	0.612	0.183	**0.664**	**0.183**	0.625	0.154	0.501	0.111	0.356	0.069	0.236	0.040
British Empire	0.185	0.157	0.212	0.170	0.248	0.185	0.293	0.203	0.351	0.225	0.424	0.249	0.509	0.272	**0.589**	**0.284**	0.623	0.267	0.567	0.213	0.437	0.141	0.293	0.079	0.180	0.039
Fleming Enterprise	0.110	0.069	0.131	0.080	0.158	0.093	0.195	0.111	0.245	0.135	0.311	0.165	0.396	0.203	0.491	0.242	**0.561**	**0.267**	0.560	0.256	0.481	0.211	0.370	0.155	0.270	0.108
M&G Recovery	0.072	0.033	0.085	0.037	0.102	0.043	0.124	0.050	0.153	0.059	0.192	0.070	0.241	0.084	0.293	0.096	**0.329**	**0.102**	0.322	0.094	0.270	0.074	0.203	0.052	0.144	0.034
IS Trust	0.025	0.004	0.034	0.006	0.047	0.008	0.065	0.013	0.090	0.019	0.128	0.029	0.180	0.043	0.245	0.062	**0.309**	**0.083**	0.339	0.096	0.320	0.096	0.270	0.085	0.216	0.071
Lowland	0.093	0.055	0.111	0.063	0.134	0.074	0.165	0.088	0.206	0.107	0.262	0.130	0.333	0.160	0.412	0.190	**0.470**	**0.208**	0.468	0.199	0.401	0.163	0.308	0.119	0.224	0.083
Merchant	0.256	0.215	0.296	0.235	0.348	0.260	0.415	0.290	0.503	0.328	0.615	0.372	0.749	0.419	**0.882**	**0.452**	0.952	0.444	0.891	0.373	0.709	0.264	0.498	0.162	0.326	0.091
Murray	0.223	0.212	0.257	0.231	0.301	0.254	0.358	0.282	0.432	0.316	0.526	0.355	0.637	0.395	**0.746**	**0.421**	0.799	0.407	0.740	0.336	0.582	0.232	0.402	0.138	0.258	0.074
Value	0.095	0.066	0.110	0.073	0.130	0.081	0.156	0.092	0.190	0.105	0.234	0.526	0.287	0.138	0.340	0.151	**0.371**	**0.151**	0.352	0.740	0.284	0.095	0.204	0.061	0.137	0.036
Morgan	0.202	0.123	0.232	0.134	0.271	0.146	0.321	0.161	0.386	0.179	0.467	0.200	0.563	0.220	**0.655**	**0.231**	0.696	0.219	0.638	0.177	0.495	0.119	0.336	0.069	0.210	0.035
Henderson	0.099	0.054	0.116	0.059	0.137	0.066	0.164	0.075	0.201	0.086	0.248	0.100	0.305	0.115	0.363	0.127	**0.398**	**0.128**	0.379	0.112	0.308	0.083	0.223	0.054	0.151	0.032
Govet High Income	0.177	0.070	0.207	0.079	0.247	0.089	0.299	0.103	0.368	0.120	0.458	0.141	0.570	0.166	0.688	0.188	**0.765**	**0.195**	0.740	0.176	0.614	0.135	0.454	0.092	0.317	0.058
TR High Income	0.108	0.057	0.127	0.065	0.153	0.075	0.187	0.088	0.232	0.105	0.292	0.126	0.367	0.151	0.449	0.176	**0.507**	**0.188**	0.498	0.175	0.421	0.140	0.318	0.099	0.228	0.066
Shires	0.154	0.098	0.179	0.108	0.211	0.120	0.252	0.134	0.306	0.152	0.375	0.174	0.458	0.197	**0.541**	**0.214**	0.587	0.212	0.552	0.180	0.443	0.129	0.314	0.081	0.208	0.046
Abtrus	0.100	0.032	0.118	0.037	0.143	0.043	0.176	0.051	0.220	0.062	0.280	0.076	0.356	0.093	0.440	0.110	**0.502**	**0.121**	0.500	0.115	0.428	0.095	0.329	0.069	0.239	0.048
Gartmore	0.034	0.011	0.042	0.014	0.053	0.018	0.069	0.023	0.090	0.030	0.119	0.041	0.159	0.054	0.206	0.071	0.247	0.086	**0.259**	**0.091**	0.234	0.083	0.189	0.068	0.146	0.053
Natwest	0.093	0.035	0.110	0.040	0.132	0.046	0.162	0.054	0.201	0.065	0.254	0.078	0.320	0.094	0.392	0.110	**0.443**	**0.119**	0.437	0.111	0.370	0.089	0.280	0.064	0.201	0.043
Moorgate	0.105	0.043	0.123	0.048	0.148	0.056	0.180	0.065	0.224	0.077	0.281	0.093	0.353	0.111	0.431	0.128	**0.485**	**0.137**	0.476	0.127	0.401	0.100	0.302	0.071	0.215	0.047
Throgmorton	0.230	0.149	0.264	0.160	0.308	0.174	0.363	0.190	0.434	0.209	0.522	0.230	0.625	0.250	**0.720**	**0.258**	0.757	0.240	0.685	0.189	0.522	0.122	0.346	0.067	0.208	0.032
Aberforth	0.103	0.060	0.121	0.068	0.144	0.077	0.175	0.090	0.106	0.106	0.271	0.126	0.339	0.149	0.411	0.171	**0.460**	**0.179**	0.448	0.164	0.374	0.128	0.279	0.089	0.197	0.058
Electra	0.151	0.131	0.174	0.141	0.202	0.153	0.238	0.167	0.284	0.184	0.342	0.202	0.409	0.223	**0.471**	**0.226**	0.495	0.210	0.447	0.165	0.340	0.106	0.225	0.058	0.135	0.027
IS Enterprise	0.075	0.027	0.090	0.031	0.109	0.036	0.134	0.043	0.169	0.053	0.215	0.065	0.275	0.081	0.341	0.098	**0.391**	**0.107**	0.392	0.103	0.337	0.085	0.260	0.063	0.191	0.044
Murray	0.036	0.012	0.044	0.015	0.054	0.018	0.068	0.134	0.087	0.029	0.113	0.037	0.147	0.047	0.187	0.059	0.219	0.069	**0.225**	**0.070**	0.199	0.061	0.158	0.047	0.119	0.035
F&C Enterprise	0.093	0.050	0.109	0.057	0.131	0.064	0.159	0.075	0.196	0.088	0.245	0.104	0.305	0.123	0.370	0.140	**0.413**	**0.147**	0.402	0.134	0.336	0.104	0.250	0.072	0.176	0.047
Dunedin	0.026	0.006	0.031	0.007	0.038	0.008	0.047	0.010	0.059	0.012	0.076	0.015	0.097	0.019	0.121	0.023	**0.140**	**0.026**	0.141	0.026	0.122	0.021	0.095	0.016	0.070	0.012
TR Property	0.128	0.128	0.151	0.044	0.181	0.051	0.220	0.059	0.272	0.070	0.341	0.083	0.427	0.099	0.520	0.114	**0.583**	**0.120**	0.570	0.110	0.478	0.087	0.358	0.061	0.253	0.040
Wigmore Property	0.020	0.001	0.031	0.002	0.046	0.003	0.068	0.005	0.101	0.009	0.149	0.015	0.218	0.024	0.307	0.037	0.398	0.053	0.447	0.064	**0.431**	**0.067**	0.371	0.061	0.302	0.053

* The optimal weighting associated with the construction of the 'synthetic' FTSE 350 index futures contract is shown in bold.

Appendix 2

Optimal Portfolio Weighting For the 'Synthetic' FTSE 350 Index Futures Contract: Weekly Data.

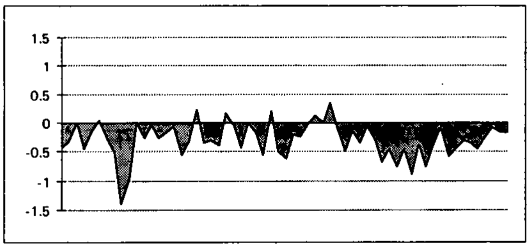
Portfolio Weighting (FTSE100 :FTSE250)

	2 : -1		1.75: -0.75		1.50 : -0.50		1.25 : -0.25		FTSE100		0.75 : 0.25		0.50 : 0.50		0.25 : 0.75		FTSE250		-0.25 : 1.25		-0.50 : 1.50		-0.75 : 1.75		-1.0 : 2.0	
Spot	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2	HR	R^2
FTSE100	0.587	0.847	0.650	0.882	0.722	0.917	0.801	0.947	0.882	0.967	**0.959**	**0.971**	1.014	0.936	1.029	0.860	0.985	0.738	0.878	0.582	0.725	0.417	0.555	0.272	0.397	0.160
FTSE250	0.324	0.373	0.376	0.427	0.439	0.490	0.514	0.565	0.601	0.651	0.698	0.743	0.794	0.831	0.874	0.900	**0.918**	**0.928**	0.909	0.903	0.847	0.827	0.751	0.720	0.641	0.603
FTSE350	0.528	0.780	0.589	0.823	0.658	0.868	0.736	0.911	0.819	0.949	**0.900**	**0.971**	0.965	0.964	0.994	0.914	0.970	0.814	0.885	0.672	0.752	0.511	0.599	0.359	0.452	0.235
FTALLSH	0.499	0.761	0.558	0.804	0.625	0.851	0.700	0.898	0.781	0.939	**0.861**	**0.966**	0.926	0.966	0.958	0.923	0.938	0.831	0.860	0.692	0.736	0.534	0.591	0.381	0.451	0.255
FTIT	0.351	0.463	0.399	0.508	0.455	0.558	0.521	0.614	0.595	0.672	0.672	0.728	0.744	0.771	**0.795**	**0.786**	0.809	0.761	0.774	0.692	0.696	0.589	0.593	0.474	0.485	0.365
Malvern	0.466	0.360	0.524	0.386	0.592	0.415	0.669	0.445	0.753	0.478	0.838	0.498	0.912	0.509	**0.956**	**0.500**	0.952	0.464	0.889	0.402	0.778	0.324	0.642	0.244	0.506	0.175
Mercury Keystone	0.336	0.257	0.384	0.285	0.442	0.318	0.509	0.355	0.586	0.395	0.668	0.435	0.746	0.468	**0.805**	**0.487**	0.827	0.482	0.801	0.448	0.730	0.392	0.630	0.324	0.524	0.257
Flem. Claverhouse	0.251	0.164	0.293	0.189	0.343	0.219	0.403	0.254	0.474	0.295	0.552	0.339	0.631	0.383	0.698	0.418	**0.736**	**0.435**	0.732	0.427	0.686	0.395	0.611	0.347	0.524	0.293
Edinburgh	0.472	0.502	0.531	0.539	0.599	0.579	0.677	0.621	0.762	0.662	0.849	0.695	**0.924**	**0.711**	0.969	0.699	0.964	0.648	0.901	0.561	0.788	0.453	0.651	0.342	0.513	0.244
Govett	0.286	0.196	0.334	0.226	0.391	0.262	0.461	0.305	0.541	0.354	0.631	0.408	0.722	0.461	0.799	0.504	**0.843**	**0.525**	0.839	0.516	0.787	0.478	0.701	0.421	0.602	0.356
Schroder	0.296	0.147	0.337	0.161	0.385	0.177	0.441	0.195	0.504	0.215	0.571	0.233	0.633	0.247	**0.677**	**0.253**	0.690	0.246	0.662	0.224	0.596	0.192	0.509	0.155	0.418	0.120
British Empire	0.268	0.186	0.305	0.204	0.349	0.225	0.400	0.249	0.458	0.273	0.518	0.297	0.575	0.316	**0.615**	**0.323**	0.627	0.314	0.602	0.287	0.543	0.246	0.464	0.199	0.381	0.154
Fleming Enterprise	0.212	0.102	0.256	0.123	0.309	0.152	0.376	0.189	0.456	0.234	0.548	0.287	0.647	0.345	0.738	0.401	0.803	0.444	**0.824**	**0.464**	0.796	0.456	0.731	0.426	0.647	0.384
M&G Recovery	0.144	0.059	0.166	0.066	0.191	0.074	0.221	0.084	0.256	0.094	0.294	0.105	0.330	0.114	0.358	0.120	**0.371**	**0.121**	0.362	0.114	0.332	0.101	0.289	0.085	0.243	0.069
IS Trust	0.097	0.023	0.120	0.034	0.149	0.039	0.186	0.050	0.231	0.065	0.284	0.083	0.342	0.105	0.397	0.126	0.440	0.145	0.459	0.157	**0.451**	**0.159**	0.421	0.154	0.378	0.142
Lowland	0.171	0.066	0.208	0.084	0.254	0.106	0.312	0.134	0.382	0.169	0.464	0.211	0.553	0.258	0.636	0.305	0.698	0.345	**0.722**	**0.365**	0.703	0.364	0.650	0.345	0.579	0.315
Merchant	0.403	0.250	0.462	0.279	0.533	0.312	0.616	0.350	0.710	0.392	0.812	0.434	0.910	0.471	**0.985**	**0.493**	1.016	0.491	0.988	0.461	0.904	0.406	0.785	0.339	0.655	0.272
Murray	0.405	0.363	0.458	0.394	0.520	0.429	0.592	0.467	0.671	0.505	0.754	0.540	0.829	0.564	**0.879**	**0.566**	0.886	0.538	0.840	0.480	0.747	0.400	0.629	0.314	0.507	0.235
Value	0.264	0.214	0.301	0.236	0.345	0.262	0.397	0.291	0.455	0.322	0.518	0.352	0.576	0.377	**0.620**	**0.390**	0.635	0.383	0.612	0.353	0.555	0.306	0.477	0.250	0.394	0.197
Morgan	0.236	0.119	0.275	0.137	0.322	0.158	0.378	0.183	0.444	0.213	0.517	0.244	0.591	0.275	0.653	0.300	**0.688**	**0.312**	0.684	0.306	0.640	0.282	0.570	0.248	0.488	0.209
Henderson	0.230	0.140	0.262	0.154	0.300	0.170	0.344	0.188	0.394	0.207	0.447	0.226	0.496	0.241	**0.532**	**0.248**	0.544	0.242	0.523	0.222	0.473	0.191	0.405	0.156	0.334	0.121
Govet High Income	0.327	0.139	0.375	0.154	0.431	0.172	0.497	0.192	0.572	0.214	0.653	0.236	0.730	0.255	**0.788**	**0.265**	0.811	0.263	0.786	0.245	0.717	0.215	0.620	0.178	0.516	0.142
TR High Income	0.213	0.116	0.247	0.133	0.288	0.153	0.176	0.176	0.394	0.202	0.457	0.231	0.521	0.258	0.573	0.279	**0.601**	**0.288**	0.595	0.279	0.554	0.256	0.491	0.222	0.419	0.186
Shires	0.260	0.100	0.302	0.114	0.352	0.131	0.413	0.151	0.483	0.174	0.560	0.198	0.637	0.222	0.701	0.240	**0.735**	**0.247**	0.728	0.240	0.678	0.220	0.601	0.191	0.512	0.160
Abtrus	0.218	0.083	0.254	0.095	0.296	0.109	0.347	0.126	0.407	0.146	0.472	0.167	0.538	0.187	0.593	0.203	**0.623**	**0.209**	0.618	0.204	0.577	0.187	0.512	0.163	0.437	0.137
Gartmore	0.067	0.017	0.086	0.024	0.111	0.034	0.143	0.048	0.184	0.066	0.232	0.089	0.286	0.118	0.341	0.149	0.385	0.178	0.409	0.200	**0.409**	**0.210**	0.388	0.209	0.353	0.199
Natwest	0.283	0.141	0.326	0.159	0.379	0.181	0.441	0.210	0.513	0.234	0.591	0.263	0.668	0.291	0.730	0.310	**0.760**	**0.315**	0.747	0.301	0.691	0.272	0.607	0.232	0.513	0.191
Moorgate	0.223	0.101	0.262	0.119	0.309	0.140	0.367	0.165	0.434	0.194	0.510	0.227	0.588	0.265	0.656	0.290	**0.698**	**0.307**	0.700	0.306	0.662	0.289	0.595	0.258	0.223	0.223
Throgmorton	0.324	0.154	0.371	0.171	0.426	0.191	0.491	0.213	0.564	0.236	0.643	0.262	0.718	0.280	**0.775**	**0.291**	0.795	0.287	0.770	0.267	0.701	0.233	0.605	0.192	0.502	0.152
Aberforth	0.260	0.168	0.302	0.191	0.351	0.218	0.410	0.250	0.479	0.288	0.554	0.325	0.629	0.361	0.690	0.389	**0.722**	**0.398**	0.712	0.385	0.662	0.350	0.585	0.303	0.497	0.252
Electra	0.247	0.186	0.278	0.200	0.314	0.215	0.355	0.230	0.399	0.245	0.445	0.258	**0.484**	**0.264**	0.508	0.260	0.506	0.241	0.473	0.209	0.414	0.169	0.342	0.127	0.270	0.091
IS Enterprise	0.203	0.107	0.232	0.119	0.266	0.132	0.307	0.147	0.353	0.163	0.401	0.180	0.448	0.193	**0.483**	**0.206**	0.496	0.203	0.479	0.183	0.436	0.160	0.376	0.138	0.312	0.104
Murray	0.119	0.068	0.137	0.077	0.160	0.088	0.187	0.101	0.218	0.116	0.252	0.132	0.286	0.147	0.314	0.158	**0.329**	**0.161**	0.324	0.156	0.301	0.142	0.266	0.123	0.226	0.102
F&C Enterprise	0.122	0.114	0.146	0.062	0.175	0.075	0.211	0.092	0.255	0.112	0.304	0.135	0.357	0.161	0.404	0.184	**0.437**	**0.202**	0.446	0.208	0.428	0.202	0.391	0.187	0.344	0.166
Dunedin	0.014	0.001	0.023	0.002	0.037	0.004	0.051	0.007	0.071	0.011	0.097	0.017	0.127	0.026	0.158	0.036	0.187	0.047	0.206	0.057	0.212	0.063	**0.207**	**0.067**	0.193	0.067
TR Property	0.379	0.143	0.433	0.158	0.497	0.175	0.572	0.195	0.657	0.216	0.747	0.237	0.832	0.254	**0.896**	**0.263**	0.919	0.259	0.887	0.239	0.806	0.208	0.694	0.171	0.575	0.135
Wigmore Property	0.169	0.032	0.203	0.040	0.245	0.049	0.298	0.061	0.361	0.075	0.433	0.092	0.511	0.110	0.582	0.136	0.633	0.141	**0.649**	**0.147**	0.627	0.145	0.575	0.135	0.508	0.121

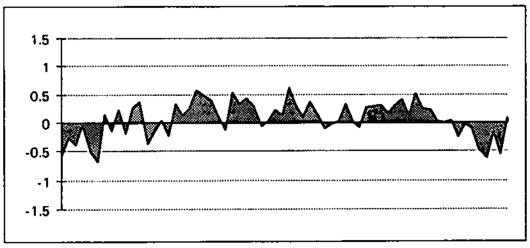
* The optimal weighting associated with the construction of the 'synthetic' FTSE 350 index futures contract is shown in bold.

Appendix 3
Mispricing Series - FTSE 100 Contract (Near)

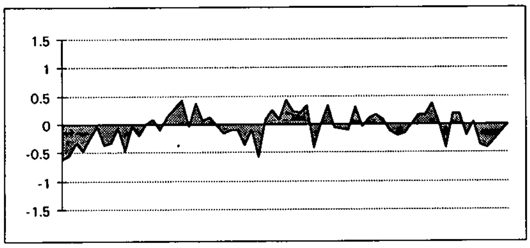
1) June 1994



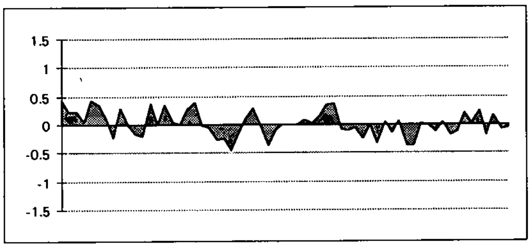
2) September 1994



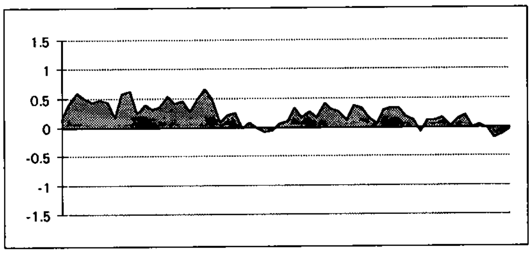
3) December 1994



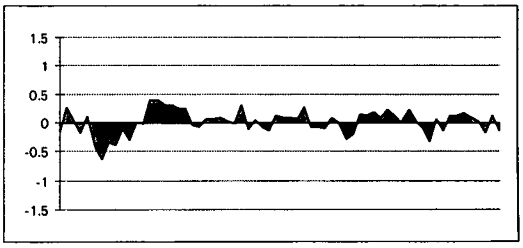
4) March 1995



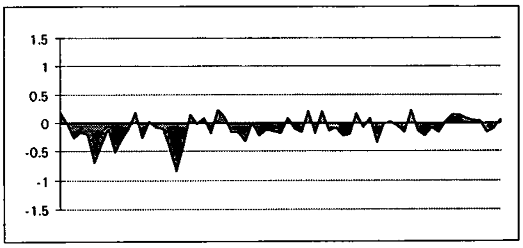
5) June 1995



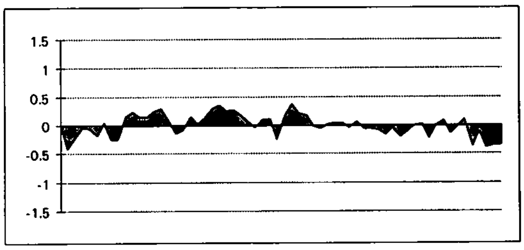
6) September 1995



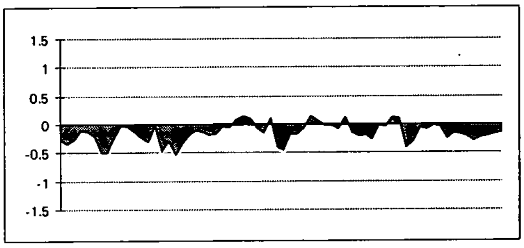
7) December 1995



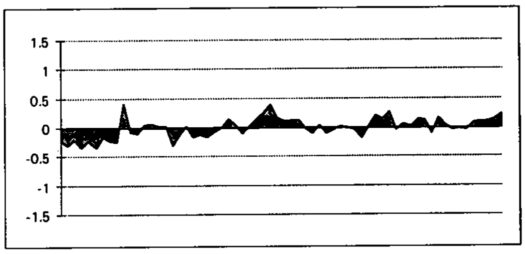
8) March 1996



9) June 1996

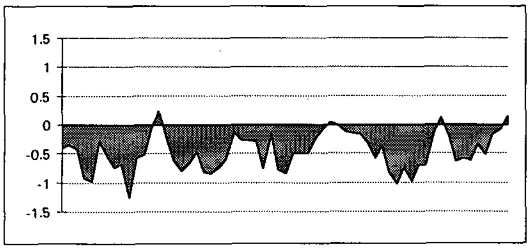


10) September 1996

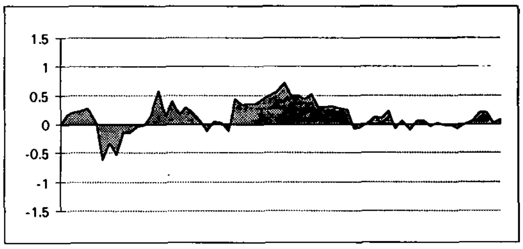


Appendix 4
Mispricing Series - FTSE Mid 250 Contract (Near)

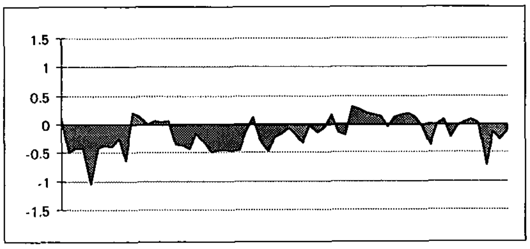
1) June 1994



6) September 1995



2) September 1994



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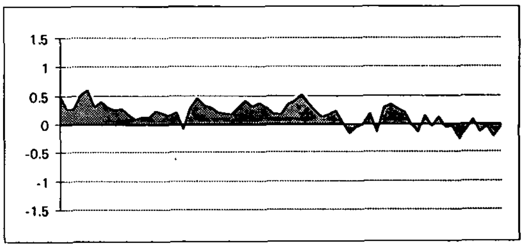
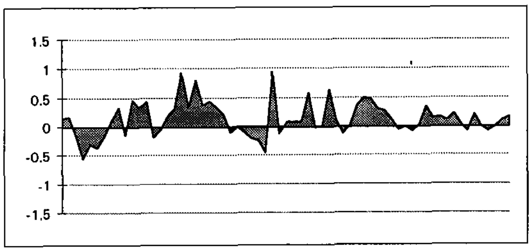
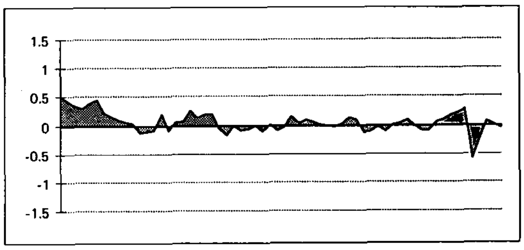


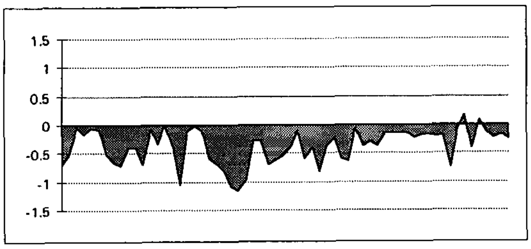
3) December 1994



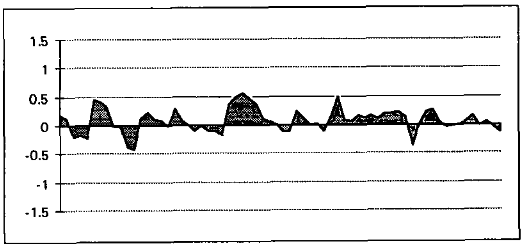
8) March 1996



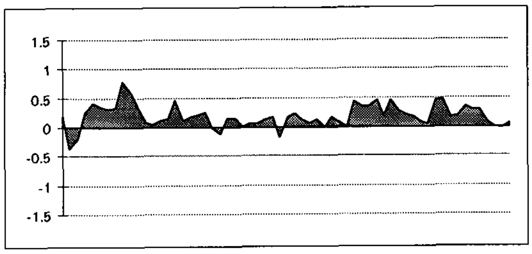
4) March 1995



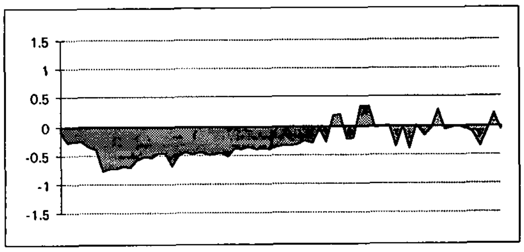
9) June 1996



5) June 1995

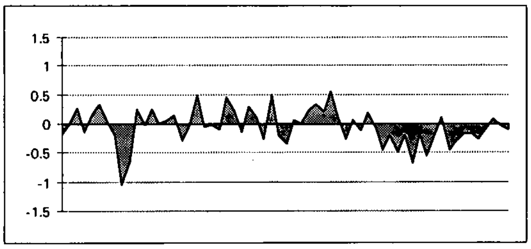


10) September 1996

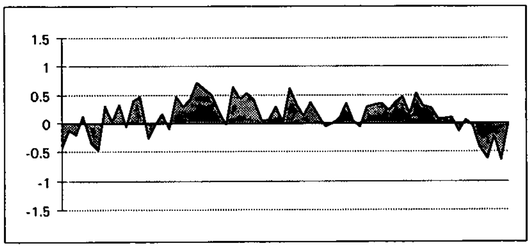


Appendix 5
Mispricing Series - FTSE 100 Contract (Deferred)

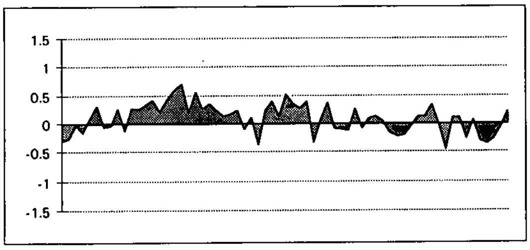
1) September 1994



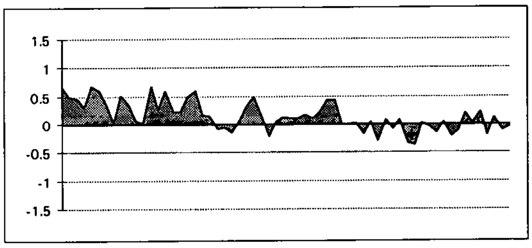
2) December 1994



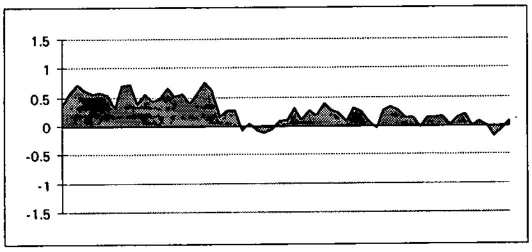
3) March 1995



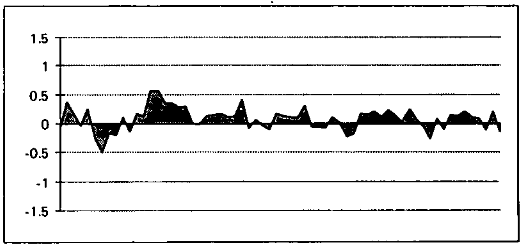
4) June 1995



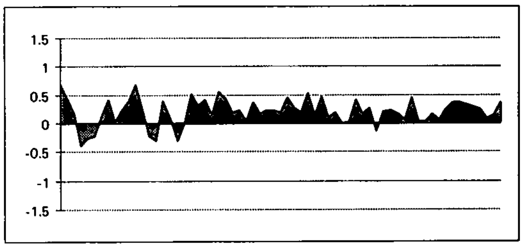
5) September 1995



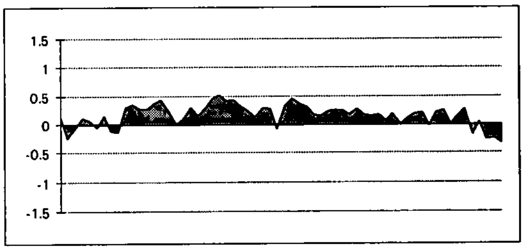
6) December 1995



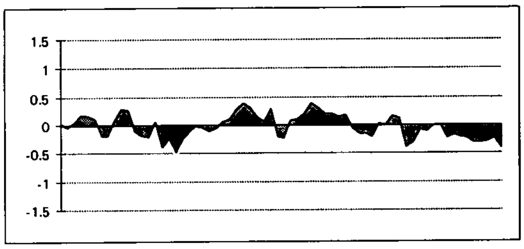
7) March 1996



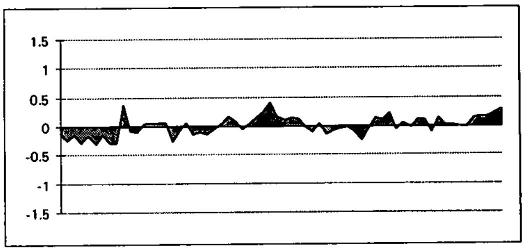
8) June 1996



9) September 1996

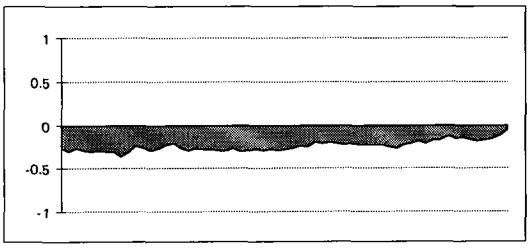


10) December 1996

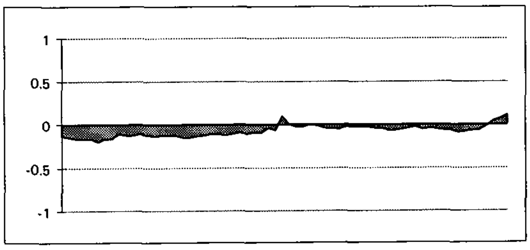


Appendix 6
Spread Mispricing - Intra Market Spread

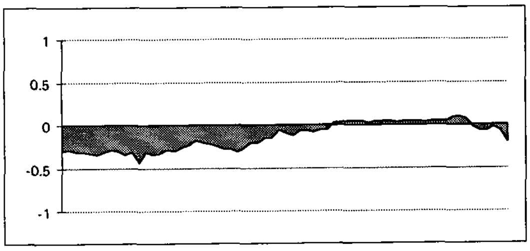
1) June / September 1994



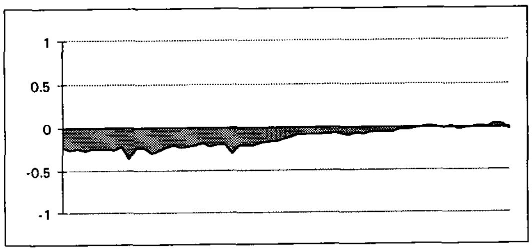
2) September / December 1994



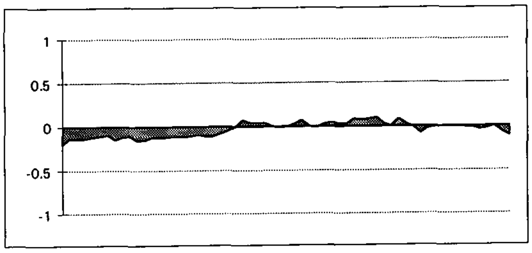
3) December 1994 / March 1995



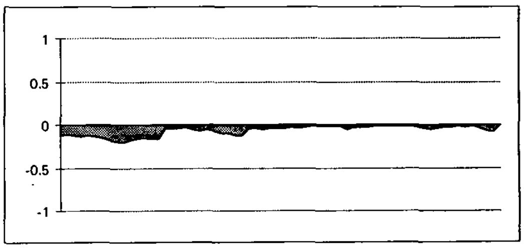
4) March / June 1995



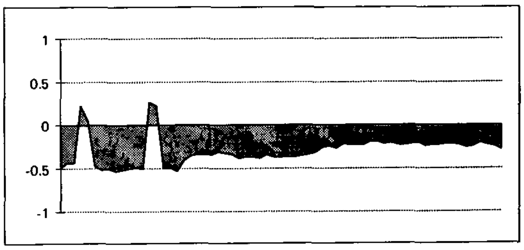
5) June / September 1995



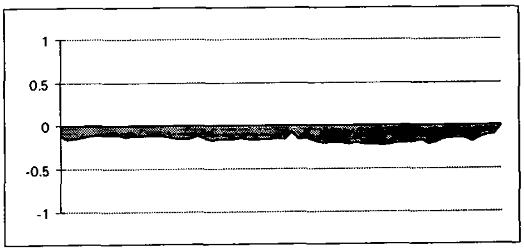
6) September / December 1995



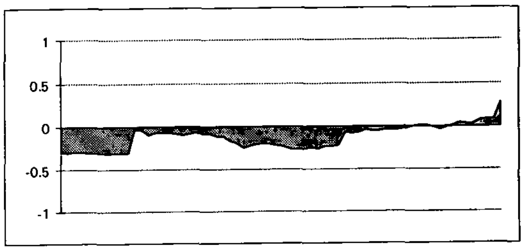
7) December 1995 / March 1996



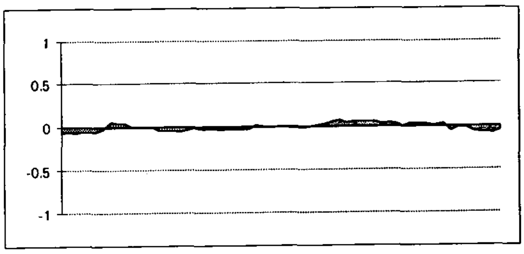
8) March / June 1996



9) June / September 1996

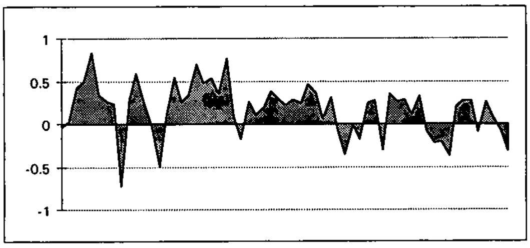


10) September / December 1996

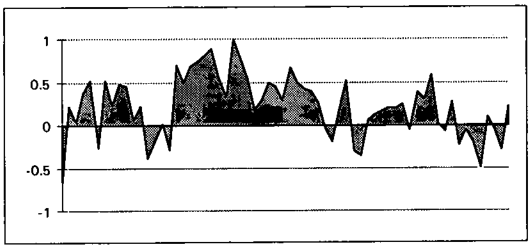


Appendix 7
Spread Mispricing - Inter Market Spread

1) June 1994



2) September 1994



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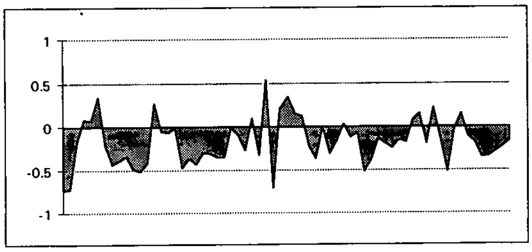
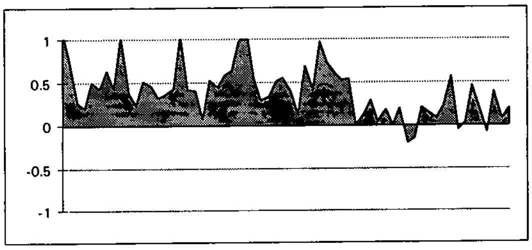
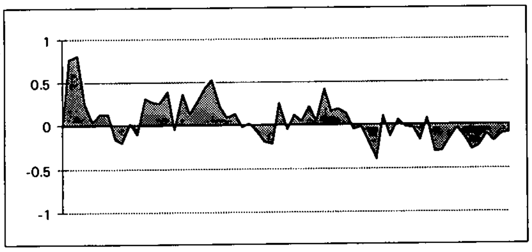


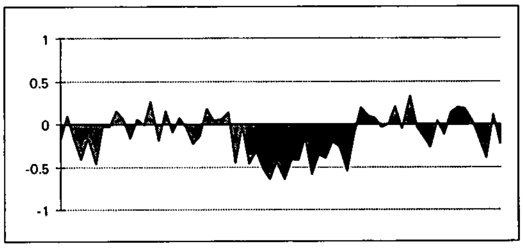
4) March 1995



5) June 1995



6) September 1995



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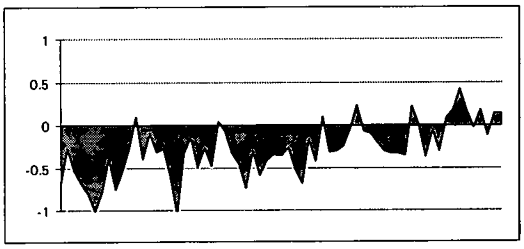

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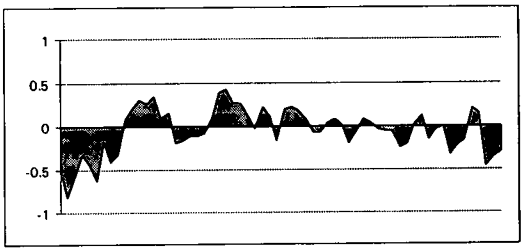

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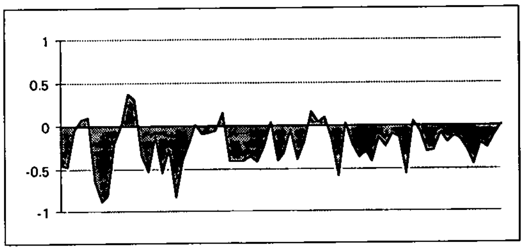

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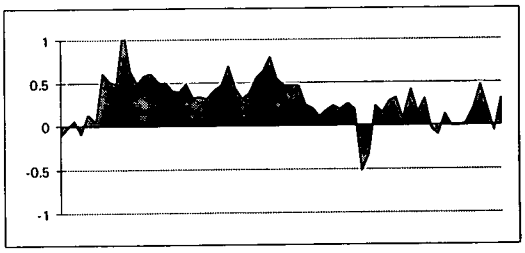

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