The Impact of Transactions Costs in the UK Stock Market: Evidence and Implications

A Thesis submitted for the degree of Doctor of Philosophy

by

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May 2003

Abstract

There has been an increasing interest in the finance literature regarding the impact of transactions costs on US equity markets. The US empirical evidence indicates that transactions costs influence both trading volume (Atkins and Dyl (1997)) and asset returns (Amihud and Mendelson (1986)). Additionally, the theoretical finance literature also indicates that transactions costs affect equilibrium asset returns (Fisher (1994)).

In this thesis we assess the impact of transactions costs on the UK equity markets, from four aspects. Firstly, we provide empirical support to the hypothesis that transactions costs affect the "holding period" of an asset in the portfolio of an investor. Secondly, we provide robust results showing that transactions costs affect equilibrium asset returns. Thirdly, we explain the variability of transactions costs with the use of information asymmetry, proxied by the variance of analysts' forecasts, in the spirit of Kim and Verrecchia (1994, 2001). Finally, we find that stock price and trading volume reaction to changes in the FTSE 100 list can be explained by liquidity effects, as proxied by the bid-ask spread.

We provide overwhelming evidence, suggesting that transactions costs are important in UK equity markets.

Acknowledgements

I would like to thank my supervisor, Prof. C. Ioannidis for his help and assistance throughout my research. He has taught me both technical and analytical skills. I thank him immensely for without his help and support this thesis would have never been possible.

I thank Prof. L. Skerratt for helpful discussions concerning the issue of information asymmetry and the bid-ask spread. I am extremely grateful to I/B/E/S for access to their data of analysts' forecasts, Prof. K.Luintel and Dr J.Hunter for being more then able PhD convenors. In addition I would like to thank the Economics and Finance Department at Brunel University for their financial support, for establishing an extremely friendly working atmosphere and for providing me with excellent research facilities. I also thank my fellow research students for providing the team spirit required during trying times.

Finally I would like to thank my family for their continued support both emotionally and financially throughout my study.

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Introduction

Transactions costs are an important aspect of security trading, and may have several effects, on prices and investor portfolios, some of which are not intuitively obvious. Essentially, transactions costs in stock markets fall into two categories, direct trading costs and indirect trading costs. The direct trading costs include the market makers bid-ask spread, the brokerage fees, and any transaction taxes, such as stamp duty. The indirect costs include the costs of acquiring and processing information about share values, companies, market movements and any other information which may be relevant to the decision to trade.

In this thesis we aim to provide a comprehensive analysis of the impact of transactions costs, proxied by the bid-ask spread in the UK stock market, by looking at transactions costs from four different empirical aspects. Eventhough, transactions costs are a fundamental aspect of trading, the research into this area is relatively limited. The reason for this is that the availability of transaction data was very limited for a number of years. However, in more recent years transaction data has become more readily available and we can therefore provide more insight into the influence of transactions costs in stock markets.

The aim of the work is to look at transactions costs from various empirical perspectives. This will provide us with the evidence required to determine the importance of transactions costs in the UK stock market.

The thesis is organised as follows: Chapter 1 presents a review of the existing literature on transactions costs. In this literature review, we begin by looking at the different types of transactions costs and the importance of transactions costs with respect to the UK stock market. We then focus the review upon the bid-ask spread. The reason for this is that the other measures of transactions costs are either heterogeneous (brokerage fees), difficult to measure (opportunity costs), or are only relevant to large trades (price impacts). We go on and review the literature on the bid-ask spread, the relationship between the bid-ask spread, trading volume, information asymmetry and finally estimates of the bid-ask spread in different equity markets. The review of the literature gives the reader an insight of the current status of the transactions costs literature and gives a flavour of the research that the thesis entails.

Chapter 2 looks at the relationship between the holding period of a common stock and transactions costs. Amihud and Mendelson (1986), Constantinides (1986) and Wilcox (1993) provide a theoretical basis for the proposition that assets with higher transactions costs are held by investors for longer holding periods as they are traded less frequently. Atkins and Dyl (1997) bring empirical support to this hypothesis by documenting a positive relationship between transactions costs and holding periods for common stocks in the NYSE and the NASDAQ. We provide some explicit theoretical rationale for the postulated relationship and following Atkins and Dyl (1997) we test the same hypothesis in the context of the FTSE All Share common stocks between 1990 and 2000. We extend the econometric model by the inclusion of the skewness of returns, to approximate any non-linearity present in the specification. We find that there is overwhelming evidence to suggest that there is a positive relationship between transactions costs and holding periods for common stocks in the UK stock market.

Chapter 3 looks at transactions costs with respect to asset pricing. Generally speaking the asset pricing literature tends to not incorporate transactions costs in their models. A possible reason for this could be that Constantinides (1986) argued that proportional transactions costs can only have a small impact on asset prices. However, the problem with his equilibrium model is the infrequent trading that implies for agents. Calibrating this model may understate the effect of transactions costs on asset prices given the much higher levels of trading that we observe empirically.

Following this, in Chapter 3 we test for the inclusion of the bid-ask spread in the consumption CAPM, in the UK stock market over the time period of 1980-2000. Two econometric models are used; first, Fisher's (1994) asset pricing model is estimated by GMM, and second, the VAR approach proposed by Campbell and Shiller (1988a) is extended to include the bid-ask spread. Overall the statistical tests are unable to reject the bid-ask spread as an independent explanatory variable in the C-CAPM. This leads to the conclusion that transactions costs should be included in asset pricing models.

Chapter 4 investigates the relationship between the bid-ask spread and information asymmetry. In estimating functions that determine the bid-ask spread in the US equity market, Atkins and Dyl (1997) and Glosten and Harris (1988) include measures of the volatility of returns in their set of explanatory variables to proxy the risk of adverse selection to which the market maker is exposed. They find that volatility is significant in explaining the spread.

We suggest that an augmented model of the spread should include additional variables and more specifically the reported disagreement amongst market analysts regarding the firms' earnings. Such variability will lead to increases in the bid-ask spread as it leaves market makers at an additional informational disadvantage with respect to informed traders (Kim and Verrecchia, 1994, 2001).

We find that both the volatility of returns and disagreement amongst analysts are significant (with the hypothesised signs) in explaining FTSE 100 company spreads, rendering strong empirical support to the hypotheses proposed by Kim and Verrecchia (1994, 2001). The influence of the variability of analysts' forecasts is significant over short horizons and thereafter tapers off. The volatility of returns exerts a significant and positive influence on the spread over all horizons. This modelling approach confirms that one of the major determinants of the bid-ask spread is information asymmetry.

In Chapter 5 we attempt to explain stock price and trading volume reaction in the status of the company as a participant in the FTSE 100, with the use of "liquidity effects", as proxied by the bid-as spread. The chapter examines the effect on the returns of firms that have been included to and deleted from the FTSE 100 over the time period of 1984-2001. Like the S&P 500 listing studies, we find that the price and trading volume of newly listed (deleted) firms increases (decreases). The evidence is consistent with the information cost/liquidity explanation. This is because investors hold stocks with more (less) available information, consequently implying that they have lower (higher) trading costs. This explains the increase (decrease) in the stock price and trading volume of newly listed (deleted) stocks to (from) the FTSE 100 list.

Chapter 1

Literature Review On Transactions Costs

1.1 Introduction

Transactions costs have immediate practical value for investors, portfolio managers, exchange officials, and regulators. These groups have considerable interest in the relationship between the structure of security markets and transactions costs.[1] Indeed the growth of alternative trading systems may be linked to efforts by large traders to reduce their transactions costs.

The increased interest in these issues has stimulated rapid growth in the literature on transactions costs, over the past ten years. The problem with transactions costs literature is that the data sets required to analyze many points of interest are difficult to obtain. In particular, publicly available databases do not indicate whether a trade was a buy or sell or whether a trade represented all or part of the desired order quantity. Furthermore, identifying the trades of institutional investors is difficult to impossible with publicly available data.

Recently however, detailed trading data from institutional traders has become available, which greatly expands researchers' understanding of the trading process and costs. The objective of this literature review is to summarize the findings of the recent literature on equity transactions costs.

[1] Christie et al (1994) find evidence that NASDAQ dealers engage in "implicit collusion" to keep spreads above competitive levels.

1.2 Measuring Transactions Costs

Evidence shows that execution costs can be large, often enough to substantially reduce or even eliminate the notional return on an investment strategy.[2] This means that it is important to measure, analyze and control transactions costs. The key is to distinguish between the major components of transactions costs. There are two major components of transactions costs, explicit and implicit transactions costs.

Explicit costs mainly comprise of commissions charged by brokers. However, they do also include fees, stamp duties and so on, for which there is an explicit accounting charge. Commissions vary, averaging 0.2% of trade value overall, and have been declining. They vary by price, market mechanism and broker type. For example, crossing networks (where natural buyers and sellers are matched at predetermined prices without intervention by a market maker) charge as little as 2% per share, whereas commissions on difficult trades executed by specialist brokers may be as high as 10-15% per share.[3] Trades are also liable to implicit costs, which are more difficult to measure. They consist of three major components, price impacts, opportunity costs and the bid-ask spread. We will now briefly look at each of them in turn.

1.2.1 Price Impacts

Institutions make large trades and demand increasing liquidity from markets. As a result, their trades often move prices in the direction of the trade, resulting in "market impact" or "price impact". The price impact of large trades varies with trade size and market capitalisation. Madhaven and Chang (1997) examine US data and find that the market

[2] For more details see Keim and Madhaven (1998).

[3] We provide evidence of commission charges from the New York Stock Exchange (NYSE).

impact of large (block) transactions for illiquid stocks in the smallest 20% of market capitalisation range from 3.04% for the smallest blocks to 6.21% for the largest blocks.

In contrast, Keim and Madhaven (1996) produce a study of block trades in very liquid Dow Jones Industrial stocks and over an average of 30 stocks they find relatively small price impacts, ranging from 0.15% to 0.18%. Finally, costs vary by time of day. Some studies document systematically higher costs at the close, a period when imbalances are often large and dealers are reluctant to carry inventories overnight.

1.2.2 Opportunity Costs

Opportunity costs are associated with missed trading opportunities. Trades are often motivated by information whose value decays over time. Opportunity cost is incurred when an order is only partially filled or is not executed at all, as well as when an order is executed with a delay, during which the price moves against the trader.

These costs are difficult to measure and depend on the discretion that a trader has to execute orders. One accepted method computes opportunity cost by measuring the difference in performance between a portfolio based on actual trades and a hypothetical portfolio whose returns are computed with the assumption that transactions were executed at prices observed at the time of the trading decision. The difference is called "performance shortfall".

1.2.3 Bid-Ask Spreads

One of the most important characteristics that investors look for in an organized financial market is liquidity. Liquidity is the ability to buy or sell significant quantities of a security quickly, anonymously, and with relatively little price impact. To maintain liquidity, many organized exchanges use market makers, which are individuals who stand ready to buy or sell whenever the public wishes to buy or sell. In return for providing liquidity, market makers are granted monopoly rights by the exchange to post different prices for purchases and sales. They buy at the bid price, P_b and sells at a higher ask price P_a. This ability to buy low and sell high is the market makers' primary source of compensation for providing liquidity. Their compensation is defined as $P_a - P_b$, which is intern defined as the bid-ask spread.

The bid-ask spread varies depending on the stocks' liquidity. Quoted spreads vary widely, from less then 0.3% for the most liquid (largest market capitalization) stocks to 4-6% for the least liquid (smallest market capitalization) stocks.[4]

There is however a problem with quoted spreads in that they often overstate true bid-ask spreads because trades are often executed inside the quoted spread, especially for exchange-listed stocks, by traders on the exchange floor. Also, bid and ask prices tend to rise after a buy order (or fall after a sell order). To eliminate the effect of these biases, researchers study actual transaction prices to measure effective bid-ask spreads that approximate the true spread more closely. Studies such as Lee (1993) confirm that effective spreads are, on average, lower then quoted spreads.

Demsetz (1968) provides the first formal definition of the bid-ask spread. He says that transaction costs may be defined as the cost of exchanging ownership titles. In the specific case of the FTSE, it is the cost of exchanging titles to money and to shares of stock. It is possible to increase or decrease this cost by a more or less inclusive definition of which activities are to be counted as transaction activities. From one viewpoint the cost of

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[4] See Loeb (1983), Keim (1989) and Hong and Stoll (1996) for further details.

producing assets is necessary to the exchange of assets, whereas, from another viewpoint, only titles to assets need be produced for exchange to take place, the production of the assets themselves can be postponed indefinitely. One could also include in transaction cost the cost of being informed about the general nature of the market, the cost of making phone calls to one's broker or of reading the financial pages. Transaction cost is defined narrowly as the cost of using the FTSE to accomplish a quick exchange of stock for money. Broader interpretations lead to extremely difficult empirical and conceptual problems.

Given that titles to assets exist, given that decisions to exchange these titles have been made, and given that brokers or sales representatives have been informed of these decisions, what are the costs to buyers and sellers of using the FTSE to contract with each other. These remaining costs comprise transaction cost as the term that is used in this literature review. On the FTSE, two elements comprise almost all of transaction costs, brokerage fees and bid-ask spreads. Transfer taxes could be included, but it is expedient to concentrate our attention on the two major components.

The inclusion of the bid-ask spread in transaction costs can be understood best by considering the neglected problem of "immediacy" in supply and demand analysis. Predictable immediacy is a rarity in human actions, and to approximate it requires that costs be borne by persons who specialize in standing ready and waiting to trade with the incoming orders of those who demand immediate servicing of their orders.

The bid-ask spread is the markup that is paid for predictable immediacy of exchange in organized markets; in other markets, it is the inventory markup of retailer or wholesaler.

A person who plays an important role in these submarkets in the FTSE is the specialist. The specialist earns his income in two ways: by managing orders and by assuming risk. The former role is to manage orders left with him by traders who desire to move to other positions on the floor of the exchange. In this role, the specialist acts as a broker; he matches buy and sell orders. If he matches an order left to his care with an order that is subsequently presented to him by another floor trader, the specialist shares in the commission charged to the customer by the floor trader. This is the specialist's first source of income and in earning this income he serves as an information repository.

In his second role, the specialist may step in to match the order left with him by trading for his own account. If he does so, he acts as a trader and receives no part of the commission charged to the customer. Thus, if the first trader presents an order to sell (or buy) and the specialist buys (or sells) for his own account to match the trader's order, he does not earn any share of commissions on the exchange. However, such an operation can generate income for the specialist from other sources. He can engage in an opposite trading action at a preferential price differential later. If he buys for his own account, he can hope to resell later at a higher price than he paid; if he sells for his own account, he can expect to repurchase later at a lower price than he paid.

The specialist earns income through buying and selling for his own account by standing ready to step in during periods when bid-ask quotations, submitted by outsiders are too far apart to keep trade active without wide jumps in price. The specialist can increase the rapidity of exchange with narrower price movements during such periods by offering a narrower bid-ask spread than outsiders are currently submitting.

This role of the specialist involves judgment, investment, and risk-taking; it is a role that is difficult to computerize completely, although computer programs conceivably could aid the specialist in playing this role. The investment involved is common to that made by other inventory specialists such as retailers and wholesalers of commodities. It is the willingness to invest in inventory and to stand ready to exchange in order to offer quicker exchange at given cost to ultimate buyers and sellers. What makes the specialist important in this process is that he is obligated to fellow members of the exchange to make a market for the securities in which he specializes. If there exists no quotation from outsiders that is "reasonably" narrow, he must offer one of his own to facilitate trading. The specialist hopes, of course, to realize a profit on inventory turnover. Specialists in all types of markets perform essentially these same functions. All would like to acquire inventory at low prices and resell at high prices and to do so very rapidly, but competitive forces, to be discussed later, are at work in varying degrees in these markets and the stronger are these forces the closer will these markups be to the cost of waiting and carrying inventory.

It is apparent from the discussion that under competitive conditions the bid-ask spread, or markup will measure the cost of making transactions without delay. A person who has just purchased a security and who desires immediately to resell it will, on the average, be forced to suffer a markdown equal to the spread found in the market place. This markdown (plus brokerage commissions) measures the cost of an immediate round-trip exchange. Under less competitive conditions, this spread may somewhat exaggerate the underlying cost to those who stand ready and waiting of quick round-trip transactions, but, for any given degree of competition (since brokerage commissions do not vary with the time taken to complete a transaction), differences in spread will indicate differences in the cost of quick exchange. The typical spread for one security may be twice the percentage of price that it is for another; this can be taken to indicate that the cost of quick exchange per dollar invested in the first security is greater than it is for the second, and, perhaps, approximately twice as great. The spread, of course, can be thought of as measuring twice the cost of a one-way transaction; the last transaction price may be $40 and the currently quoted spread may ask $40.5 and bid $39.5, so that a market order pays a half point penalty relative to the last transaction price.

If the cost of quick exchange is higher for one asset than it is for another, we may assume that the cost of exchanging with any given time delay will be higher also, although not necessarily proportionately higher. The forces at work in determining the cost of quick exchange, we shall see, are not such that they can be expected to work in opposite directions if we increase the time interval during which an exchange is concluded. Hence, the analysis, which follows can be, expected to determine the identity of variables and to measure the direction of their effect on the cost of making transactions in highly organized markets whatever the time allowed to conclude an exchange. The magnitude of the effects measured, however, can be associated with quick exchange only.

The bid-ask spread and the commission brokerage are determined by different procedures and institutional arrangements. Generally, commission brokerage depends only on the price of a share and is independent of whether or not the executed order is a market or limit order. The relationship of commissions to prices is established collectively by members of the FTSE. The spread is determined by persons acting individually, by specialists, by floor-traders or by outsiders submitting market or limit orders. The spread component of transaction cost will vary according to several aspects of the market for a security. The structural requirements for competition are more clearly in evidence in determining the spread than they are in determining brokerage commissions.

1.3 The Importance of Transactions Costs in Equity Markets

The diminutive size of typical spreads also belies their potential importance in determining the time-series properties of asset returns. For example, Phillips and Smith (1980) show that most of the abnormal returns associated with particular options trading strategies are eliminated when the costs associated with the bid-ask spread are included. Blume and Stambaugh (1983) argue that the bid-ask spread creates a significant upward bias in mean returns calculated with transaction prices. More recently, Keim (1989) shows that a significant portion of the January effect (the fact that smaller capitalisation stocks seem to outperform larger capitalisation stocks over the few days surrounding the turn of the year), may be attributable to closing prices recorded at the bid price at the end of December and closing prices recorded at the ask price at the beginning of January.

Even if the bid-ask spread remains unchanged during this period, the movement from bid to ask is enough to yield large portfolio returns, especially for lower-priced stocks for which the percentage bid-ask spread is larger. Since low-priced stocks also tend to be low-capitalisation stocks, Keim's (1989) results do offer a partial explanation for the January effect. Empirically, Atkins and Dyl (1990) discover that stocks that exhibit a large price decline (losers) subsequently earn significant abnormal returns. They also find evidence that stocks that exhibit a large price increase (winners) subsequently earn negative abnormal returns. However when they incorporate the bid ask spread in their analysis, they conclude that traders could not profit from the price reversals that they observe. This implies that the Efficient Market Hypothesis remains intact once transactions costs have been accounted for.

Demsetz (1968) presents statistical evidence, which suggests that the bid-ask spread and the price of a security are positively related. This implies that when transaction costs increase the price of a security increases and vice versa. This is logical and intuitive. This gives strong empirical evidence that transactions costs are important with respect to security valuation.

Constanitindes (1986) took the Demestz (1968) analysis a step further by developing a two-asset intertemporal model to assess the importance of transactions costs. Initially in the model there were no transactions costs and the investor resulted in an isoelastic utility of consumption. The implication of this is that the optimal investment policy is the ratio of the two asset values in the portfolio. When the model is modified to introduce proportional transactions costs a simple investment policy is determined by a region of no transactions, which is an interval on the real line: an investor refrains from transacting as long as the ratio of asset values lies in this interval. The region of no transactions is wide, and, therefore, an investor's demand for the assets is sensitive to the current composition of the portfolio.

Constantinides (1986) also discovers that the demand for one of the two assets over time, which is subject to transactions costs, is substantially reduced. This is due to the fact that investors accommodate large transactions costs by drastically reducing the frequency and volume of trade. In addition he finds that transactions costs have only a second-order effect on equilibrium asset returns. This is because investors' expected utility of the future consumption stream is insensitive to deviations of the asset proportions that are optimal in the absence of transactions costs. This suggests that a small liquidity premium is sufficient to compensate an investor for deviating significantly from the target portfolio proportions.

Two very important conclusions arise from the Constantinides (1986) study. First, transactions costs have only a second-order effect on equilibrium asset returns. This means that they can be ignored in the real asset pricing theory since they have only second-order effects on the theory's empirically testable implications.

Second, transactions costs have a first-order effect on the assets' demand, which implies that they effect the trading strategy of an investor.[5] This is because if they affect assets' demand then they directly effect the holding period of the asset. Therefore, from this analysis we can conclude that transactions costs are a relevant factor in explaining the holding period of a common stock, but are irrelevant in asset pricing.

The presence of the bid-ask spread complicates matters in several ways. Instead of one price for each security, there are now three: the bid price, the ask price, and the transaction price which need not be either the bid or the ask (although in some cases it is), nor need it lie in between the two (although in most cases it does). How should returns be calculated, from bid-to-bid, ask-to-bid, etc.? Moreover, as random buys and sells arrive at the market, prices can bounce back and forth between the ask and the bid prices, creating spurious volatility and serial correlation in returns, even if the economic value of the security is unchanged.

1.3.1 The Bid-Ask Bounce

To account for the impact of the bid-ask spread on the time-series properties of asset returns, Roll (1984) proposes the following simple model. Denote by $P_t{*}$ the fundamental value of a security in a frictionless economy at time t, and denote by S the bid-ask spread

[5] Trading strategy is defined as the holding period of a common stock.

(see Glosten and Milgrom [1985], for example). Then the observed market price P_t can be written as:

$$P_t = P_t^* + I_t \frac{S}{2} \tag{1.1}$$

$$I_t \ IID \qquad \begin{cases} = +1 \text{ with probability } \frac{1}{2} \text{ (buyer-initiated)} \\ = -1 \text{ with probability } \frac{1}{2} \text{ (seller-initiated)} \end{cases} \tag{1.2}$$

where I_t is an order-type indicator variable, indicating whether the transaction at time t is at the ask (buyer-initiated) or at the bid (seller-initiated) price. The assumption that P_t^*, is the fundamental value of the security implies that $E[I_t] = 0$, hence $\Pr(I_t = 1) = \Pr(I_t = -1) = \frac{1}{2}$. Assume for the moment that there are no changes in the fundamentals of the security; hence $P_t^* = P^*$ is fixed through time. Then the process for price changes ΔP_t is given by

$$\Delta P_t = \Delta P_t^* + (I_t - I_{t-1})\frac{S}{2} = (I_t - I_{t-1})\frac{S}{2}, \tag{1.3}$$

given that I_t is assumed to be IID the variance, covariance, and autocorrelation of ΔP_t can be easily computed as follows:

$$Var[\Delta P_t] = \frac{S^2}{2} \tag{1.4}$$

$$Cov[\Delta P_{t-1}, \Delta P_t] = -\frac{S^2}{4} \tag{1.5}$$

$$Cov[\Delta P_{t-k}, \Delta P_t] = 0 \quad k \succ 1 \tag{1.6}$$

$$Corr\left[\Delta P_{t-1}, \Delta P_t\right] = -\frac{1}{2}. \qquad (1.7)$$

Despite the fact that fundamental value P_t^*, is fixed, ΔP_t exhibits volatility and negative serial correlation as the result of bid-ask bounce. The intuition behind this is the following: If P^* is fixed so that prices take on only two values, the bid and the ask, and if the current price is the ask, then the price change between the current price and the previous price must be either 0 or S and the price change between the next price and the current price must be either 0 or $-S$. The same argument applies if the current price is the bid; hence the serial correlation between adjacent price changes is non-positive. From the above equations we can see that the larger the spread S, the higher the volatility and the first-order autocovariance, both increasing proportionally so that the first-order autocorrelation remains constant at -2. We can see from (1.6) that the bid-ask spread does not induce any higher-order serial correlation.

Now let the fundamental value P_t^* change through time, but suppose that its increments are serially uncorrelated and independent of I_t.[6] Then (1.5) still applies, but the first-order autocorrelation (1.7) is no longer $-\frac{1}{2}$ because of the additional variance of ΔP_t^*, in the denominator. Specifically if $\sigma^2(\Delta P^*)$ is the variance of ΔP_t^*, then

$$Corr\left[\Delta P_{t-1}, \Delta P_t\right] = \frac{S^2/4}{\left(S^2/2\right) + \sigma^2\left(\Delta P^*\right)} \leq 0. \qquad (1.8)$$

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[6] Roll (1984) argues that price changes must not be serially correlated in an informationally efficient market. However, Leroy (1973) and Lucas (1978) show that this need not be the case.

Although (1.5) shows that a given spread S implies a first-order autocovariance of $-S^2/4$, the logic may be reversed so that a given autocovariance coefficient and value of p imply a particular value for S. Solving for S in (1.5) gives the following solution

$$S = 2\sqrt{-Cov\left[\Delta P_{t-1}, \Delta P_t\right]}, \tag{1.9}$$

hence S may be easily estimated from the sample autocovariances of price changes.

Estimating the bid-ask spread may seem meaningless given the fact that bid-ask quotes are observable. However, Roll (1984) argues that the quoted spread may often differ from the effective spread, i.e., the spread between the actual market prices of a sell order and a buy order. In many instances, transactions occur at prices within the bid-ask spread, perhaps because market makers do not always update their quotes in a timely fashion, or because they wish to rebalance their own inventory and are willing to "better" their quotes momentarily to achieve this goal, or because they are willing to provide discounts to customers that are trading for reasons other than private information.[7] Roll's (1984) model is one measure of this effective spread, and is also a means for accounting the effects of the bid-ask spread on the time-series properties of asset returns.

1.4 Components of the Bid-Ask Spread

Although Roll's (1984) model of the bid-ask spread captures one important aspect of its effect on transaction prices, it is by no means a complete theory of the economic determinants and the dynamics of the bid-ask spread. In particular, Roll (1984) takes S as given, but in practice the size of the spread is the single most important quantity that market makers control in their strategic interactions with other market participants. In fact,

[7] See Eikeboom (1993), Glosten and Milgrom (1985) and Goldstein (1993) for further details.

Glosten and Milgrom (1985) argue convincingly that S is determined endogenously and is unlikely to be independent of P^* as we have assumed so far in our literature review.

Other theories of the market making process have decomposed the spread into more fundamental components, and these components often behave in different ways through time and across securities. Estimating the separate components of the bid-ask spread is critical for properly implementing these theories with transactions data. In this section of the literature review we shall turn to some of the econometric issues surrounding this task.

There are three primary economic sources for the bid-ask spread: order processing costs, inventory costs, and adverse-selection costs. The first two consist of the basic setup and operating costs of trading and recordkeeping, and the carrying of undesired inventory subject to risk.

1.4.1 Inventory and Order Processing Cost Component of the Bid-Ask Spread

Garman (1976) was the first study to review Inventory and Order Processing costs of the bid-ask spread. In Garman's (1976) model there is a single, monopolistic market maker that sets prices, receives all orders, and clears trades. The dealer's objective is to maximise expected profit per unit of time, subject to the avoidance of bankruptcy or failure. Failure arises in this model whenever the dealer runs out of inventory or cash. The market maker's only decision is to set the ask price, P_a, at which he will fill orders wishing to buy the stock, and a bid price, P_b, at which he will fill the orders wishing to sell the stock.

The dealer has an infinite horizon, but only selects the bid and ask prices once, at the beginning of time. The uncertainty in this model arises from the arrival of the buy and sell orders. These orders are represented as independent stochastic processes, where the arrivals of buy and sell orders are assumed to be Poisson distributed, with stationarity arrival rate functions $\lambda_a(p)$ and $\lambda_b(p)$. Buy (or sell) orders follow a Poisson process if the waiting time between arrivals of buy (sell) orders is exponentially distributed. More formally, letting t be the time of the last buy order, the probability of a buy order arriving in the interval $[t, t+\Delta t]$ is approximately $\lambda_a \Delta t$ for small Δt. Representing orders as Poisson processes allows the model to capture the randomness of the order arrival over time in a tactable manner.

At time period 0, the market maker is assumed to hold $I_c(0)$ units of cash and $I_s(0)$ units of stock. Let $I_c(t)$ and $I_s(t)$ be the units of cash and the stock at time period t. Let $N_a(t)$ be the cumulative number of shares that have been sold to traders up to time period t (these are the executed buy orders), and let $N_b(t)$ be the cumulative number of shares that have been bought from traders at time period t (these are executed sell orders). Then inventories are governed by

$$I_c(t) = I_c(0) + P_a N_a(t) - P_b N_b(t) \tag{1.10}$$

and

$$I_s(t) = I_s(0) + N_b(t) - N_a(t). \tag{1.11}$$

The model states that no matter what price the dealer sets, there is no guarantee that he will not fail. Of perhaps more interest is that under certain conditions the dealer fails with probability one. In order for the market maker to avoid certain failure, he must set P_a and P_b so that they simultaneously satisfy

$$P_a\lambda_a(P_a) \succ P_b\lambda_b(P_b) \tag{1.12}$$

and

$$\lambda_b(P_b) \succ \lambda_a(P_a), \tag{1.13}$$

provided that this is possible.

These conditions dictate that a single market maker sets a lower price when he buys stock and a higher price when he sells. This results in a spread developing, and it implies the spread has an inherent property of this exchange market structure. This spread protects the market maker from certain failure. What determines the size and placement of this spread is not obvious. Since both the market maker's inventory and cash positions have positive drift, characterizing price behaviour or the market maker's inventory position is complex. To investigate the problem further requires limiting the scope of uncertainty. Garman (1976) first simplifies the problem by assuming that the dealer pursues a zero-drift inventory policy.

Given this assumption, the dealer's pricing strategy has some interesting properties. First, by assumption, the dealer sets prices to equate the order arrival rates. There are multiple pricing strategies that satisfy this condition, however where the dealer sets his prices depends on factors other then inventory. Given the dealer's objective, the exact prices he sets are those which maximize the dealer's expected profit. An important property of these prices is that the dealer does not set a single market clearing price p^* but rather sets different buying and selling prices, P_a and P_b, respectively. This allows the dealer to extract large rents while still maintaining the zero-drift inventory requirement. As is typically optimal for a monopolist, this pricing strategy results in volume at the optimal prices being less then would occur in competitive prices.

This pricing strategy is reminiscent of that suggested by Demsetz (1968). Where the analyses differ is that the Demsetz (1968) model did not incorporate the intertemporal nature of the dealer's problem; nor, for that matter, did it include a dealer. To address the dealer's intertemporal inventory problem, Garman (1976) considers a second simplification in which the profit maximization assumption is relaxed. Here, the dealer is assumed to set a single market-clearing price p^*. With the dealer's pricing strategy specified, the effect of inventory on the dealer can be isolated. The problem is that if we pursue this simple pricing strategy, there will come a point when the dealer will fail with certainty. The reason for this is that the market maker fails if he runs out of inventory or cash. Since inventories follow a random walk, sooner or latter a sequence of trades will force either his stock position or his cash position to their boundary. When this happens, the process meets an "absorbing barrier" and failure occurs.

Garman's (1976) model of the market-making process is simplistic but provocative. While the behaviour of prices and inventories in this model is too mechanistic to be realistic, the demonstration of the dual complexity the dealer faces and its implications for market viability is insightful. As his analysis demonstrates, inventory determines the dealer's viability. Yet in his model, inventory plays no role in the dealer's decision problem since by assumption the dealer is allowed to set prices only at the beginning of trading. This restriction severely limits the applicability of this model to actual market settings in which prices continually evolve, and so the model's influence lies largely in its initial contribution.

A more realistic approach to the underlying problem is to consider how the dealer's price changes as his inventory position varies over time. This is the approach taken by Amihud and Mendelson (1980), who reformulate Garman's (1976) analysis to explicitly incorporate inventory into the dealer's pricing problem. Amihud and Mendelson (1980) show that the dealer's position can be viewed as a Semi-Markov process in which the inventory is the state variable. The dealer's decision variables, again his bid and ask prices, depend on the level of the state variable and thus change over time depending on the level of the dealer's inventory position. The Amihud and Mendelson (1980) model yields three main results.

First, the optimal bid and ask prices are monotone decreasing functions of the dealer's inventory position. As the dealer's inventory position increases, he lowers both bid and ask prices, and conversely he raises both prices as inventory falls. Second, the model implies that the dealer has a preferred inventory position. As the dealer finds his inventory departing from his preferred position, he moves his prices to bring his position back. Third, as was also the case in Garman (1976), the optimal bid and ask prices exhibit a positive spread.

Results two and three raise interesting questions about the behaviour of security prices and, by, extension, about the appropriateness of the model. Whereas in Garman (1976) the spread arose partially because of the need to reduce failure probabilities, the spread here reflects the dealer's efforts to maximize profit. Since the dealer is assumed to be risk neutral and a monopolist, the spread reflects the dealer's market power. In this model, however, if the dealer faces competition, then the spread falls to zero. Consequently, the spread plays no role in the viability of the market but acts essentially as a transaction cost.

Similarly, the dealer's preferred inventory position arises because of the nature of the order arrival processes. The underlying asset value is irrelevant. Hence, regardless of what is expected to happen to the value of the stock, the dealer holds the same preferred position. This may be an accurate depiction of the dealer's problem, but it seems likely that the preferred inventory position depends on factors other then the order arrival rates.

Analysing the dealer's decision problem requires specifying the dealer's objectives and constraints in more detail. Of paramount importance is the need to delineate the risks the dealer faces and how these risks affects his decision making. One way to characterize this approach is to recognize that the dealer must be rewarded for providing specialist's services, in the same way that any intermediary must be compensated. By focusing on the supply of intermediary services, the dealer's decision problem reduces to determining the appropriate compensation to offset the costs the dealer faces in providing such services. This is the notion of the dealer as a supplier of immediacy. Stoll (1978) first undertook a formal analysis of this dimension of the dealer's problem. Stoll (1978) considers a two-date model in which the dealer maximizes the expected utility of terminal wealth, where this wealth is a function of the dealer's initial wealth and his subsequent market-making positions.

The dealer's problem is to set prices for one transaction in which he will buy or sell the asset at time 1, with liquidation of the asset occurring at time 2. The dealer finances his inventory by borrowing at the risk free rate, R_f, and conversely can lend excess funds at R_f. As the time period considered is short and his borrowing ability is unlimited, the market maker's risk of bankruptcy is zero. Stoll (1978) then goes on to derive the optimal bid price P_b, and the optimal ask price P_a that maximise his wealth. There are several interesting features of these prices to consider. The model documents a linear positive relationship between the spread and trade size. Also the spread does not change in response to the dealer's trades. Where the dealer's inventory matters is in affecting the placement of the bid and ask prices. A large (positive) inventory causes the dealer to face a higher cost for absorbing more inventory, and this increased cost lowers both bid and ask prices by the same amount. A negative inventory moves prices in the opposite direction.

While this analysis characterizes the effects of the dealer's portfolio exposure on trading prices, there can be other costs affecting prices as well. Stoll (1978) extends the analysis to include order-processing costs, which are assumed to be a fixed fee per transaction. Such a fee structure results in a decreasing cost function with respect to order size. With portfolio costs increasing in trade size while processing costs decrease in trade size, the total dealer cost function becomes U shaped. This has the implication that there is an optimal cost minimizing scale, or preferred trade size, for the dealer. In this model, inventory matters largely because of the dealer's inability to hedge his inventory exposure. This risk aversion based spread contrasts with the market power role of the spread developed by Amihud and Mendelson (1980) or the defence against bankruptcy role described by Garman (1976). The simplicity of the Stoll (1978) model however raises concerns about its generality. The fundamental difficulty is that the model minimizes the intertemporal dimension of the dealer's problem by assuming that the stock is liquidated at time 2. In this sense, it is a one trade one period model because the dealer faces no uncertainty over how long he must hold his inventory position. If the order flow is random however, this length of exposure may be an important dimension to the problem. The other problem with the model is the assumed exogeneity of variables such as the stock's true price and the portfolio's return which further restricts the risk the dealer faces, because his ultimate return is not a random variable. Therefore, the generality of the results of the Stoll (1978) model are not apparent.

Ho and Stoll (1981) extend the Stoll (1978) model to a multiperiod framework in which both order flow and portfolio returns are stochastic. As in Garman (1976), buy and sell orders are represented by stochastic processes, whose order arrival rates depend on the dealer's pricing strategy. In this model, however, a monopolistic dealer is assumed to maximize the expected utility of terminal wealth, and consequently the dealer's attitude towards risk will affect the solution. This establishes a significant difference from the risk neutral intertemporal models of Garman (1976) and Amihud and Mendelson (1980). The model employs a finite horizon $(T \text{ period})$ dynamic programming approach to characterize the dealer's optimal pricing policy. The dealer's optimal pricing strategy is actually a function that specifies bid and ask prices, P_b and P_a, given the level of those variables which affect the dealer's future utility. In this model, these state variables are the dealer's cash, inventory, and base wealth positions. Since this is a finite horizon model, the time period itself also affects the dealer's choice.

The Ho and Stoll (1981) model demonstrates three important properties of the dealer's optimal pricing behaviour. First, the spread depends on the time horizon of the dealer. As the dealer nears the end of trading, the risks in acting as a dealer decrease since there is less time in which the dealer must bear any inventory or portfolio risk. For the limiting case where the time remaining is essentially zero, the dealer sets the risk neutral monopolistic spread. This spread depends on the elasticities of the supply and demand curves, with greater elasticity reducing the dealer's spread. As the time horizon lengthens, the spread increases to compensate the risk averse dealer for bearing inventory and portfolio risks. This demonstration that the spread can be decomposed into a risk neutral spread plus an adjustment for uncertainty. This is an important feature of this analysis.

This risk adjustment depends on the dealer's coefficient of relative risk aversion, the size of the transaction, and the risk of the stock as measured by its instantaneous variance. These factors are the same as those determined by Stoll (1978) in the one period model. One interesting finding in this model is that transactions uncertainty does not effect the spread. Although such uncertainty enters indirectly into the time horizon effects noted above, one might have expected a direct risk adjustment based on the variability of the order arrival processes.

Ho and Stoll (1981) argue that this does not occur because transactions variability has no direct effect on the dealer but rather works indirectly through its effect on the dealer's overall portfolio position. Such a direct effect would arise for example, if the dealer faced operating cost, so that having fewer transactions would pose cash flow problems for the dealer. As there is no such assumed cost, transaction uncertainty does not enter the spread.

The third property of this optimal pricing policy is that the spread is independent of the inventory level. This property, which was also a feature of Stoll's (1978) one period model, means that the spread is not affected by the dealer's inventory position or even his expected change in inventory (since transaction uncertainty also does not matter). Although individual prices depend on inventory, the dealer affects the order arrival processes by moving the placement of the spread relative to the true price rather then increasing or decreasing the spread itself. Thus if the true price is $40, the dealer may set first period prices of $38 and $42. If the next order is at the bid, then the dealer increases his inventory, and he shifts both prices down say to $37 and $41. How much the dealer shifts the prices is a function of his relative risk aversion, the risk of the stock, and his wealth.

1.4.2 Adverse Selection Component of the Bid-Ask Spread

Adverse selection costs arise because some investors are better informed about a security's value than the market maker, and trading with such investors will, on average, be a losing proposition for the market maker. Since market makers have no way to distinguish the informed from the uninformed, they are forced to engage in these losing trades and must be rewarded accordingly. Therefore, a portion of the market maker's bid-ask spread may be viewed as compensation for taking the other side of potential information-based trades. Because this information component can have very different statistical properties from the order-processing and inventory components, it is critical to distinguish between them in empirical applications. To do so, Glosten (1987) provides a simple asymmetric-information model that captures the salient features of adverse selection for the components of the bid-ask spread, and we shall present an abbreviated version of his elegant analysis here.[8]

1.4.2.1 Glosten's Decomposition

Denote by P_b and P_a the bid and ask prices, respectively, and let P be the "true" or common-information market price, the price that all investors without private information (uninformed investors) agree upon. Under risk-neutrality the common-information price is given by $P = E[P^*/\Omega]$ where Ω represents the common or public information set and P^* represents the price that would result if everyone had access to all information. The bid and ask prices may then be expressed as the following sums:

$$P_b = P - A_b - C_b \qquad (1.14)$$

$$P_a = P + A_a + C_a \qquad (1.15)$$

$$S = P_a - P_b = (A_a - A_b) + (C_a + C_b), \qquad (1.16)$$

[8] See, also, Glosten and Harris (1988) and Stoll (1989).

where $A_a + A_b$ is the adverse-selection component of the spread, to be determined below, and $C_a + C_b$ includes the order-processing and inventory components which Glosten (1987) calls the gross profit component and takes as exogenous. If uninformed investors observe a purchase at the ask, then they will revise their valuation of the asset from P to $P + A_a$ to account for the possibility that the trade was information-motivated, and similarly, if a sale at the bid is observed, then P will be revised to $P - A_b$. But how are A_a and A_b determined?

Glosten (1987) assumes that all potential market makers have access to common information only, and he defines their updating rule in response to transactions at various possible bid and ask prices as

$$a(x) = E\left[P^* / \Omega \cup \{\text{investor buys at } x\}\right] \tag{1.17}$$

$$b(y) = E\left[P^* / \Omega \cup \{\text{investor sells at y}\}\right]. \tag{1.18}$$

A_a and A_b are then given by the following relations:

$$A_a = a(P_a) - P, \qquad A_b = P - b(P_b). \tag{1.19}$$

Under suitable restrictions for $a(.)$and $b(.)$, an equilibrium among competing market makers will determine bid and ask prices so that the expected profits from market making activities will cover all costs, including $C_a + C_b$ and $A_a + A_b$; hence

$$P_a = a(P_a) + C_a = P + \left(a(P_a) - P\right) + C_a = P + A_a + C_a \tag{1.20}$$

$$P_b = b(P_b) - C_b = P - \left(P - b(P_b)\right) - C_b = P - A_b - C_b. \tag{1.21}$$

An immediate implication of (1.20) and (1.21) is that only a portion of the total spread, $C_a + C_b$, covers the basic costs of market making, so that the quoted spread $A_a + A_b + C_a + C_b$ can be larger than Stoll's (1985) "effective" spread (the spread between purchase and sale prices that occur strictly within the quoted bid-ask spread) the difference being the adverse-selection component $A_a + A_b$. This links in well with the common practice of market makers giving certain customers a better price than the quoted bid or ask on certain occasions, presumably because these customers are perceived to be trading for reasons other than private information, e.g., liquidity needs, index-portfolio rebalancing, etc.

1.4.2.2 Implications for Transaction Prices

To derive the impact of these two components on transaction prices, denote by $\hat{P}_n$ the price at which the nth transaction is consummated, and let

$$\hat{P}_n = P_a I_a + P_b I_b, \tag{1.22}$$

where $I_a\left(I_b\right)$ is an indicator function that takes on the value one if the transaction occurs at the ask (bid) and zero otherwise. Substituting (1.20) and (1.21) into (1.22) then yields the following

$$\hat{P}_n = E\left[P^* / \Omega \cup A\right] I_a + E\left[P^* / \Omega \cup B\right] I_b + C_a I_a + C_b I_b \tag{1.23}$$

$$= P_n + C_n Q_n \tag{1.24}$$

$$P_n = E\left[P^* / \Omega \cup A\right] I_a + E\left[P^* / \Omega \cup B\right] I_b \tag{1.25}$$

$$C_n \equiv \begin{cases} C_a & \text{if buyer-initiated trade} \\ C_b & \text{if seller-initiated trade} \end{cases} \tag{1.26}$$

$$Q_n \equiv \begin{cases} +1 & \text{if buyer-initiated trade} \\ -1 & \text{if seller-initiated trade} \end{cases} \tag{1.27}$$

where A is the event in which the transaction occurs at the ask and B is the event in which the transaction occurs at the bid. P_n is the common information price after the nth transaction.

Although (1.24) is a decomposition that is frequently used in this literature, Glosten's (1987) model adds an important new feature: correlation between P_n and Q_n. If P is the common information price before the nth transaction and P_n is the common information price afterwards, Glosten (1987) shows that

$$Cov\left[p_n, Q_n / P\right] = E\left[A / P\right] \quad \text{where } \mathrm{A} \equiv \begin{cases} A_a & \text{if } \mathrm{Q_n} = +1 \\ A_b & \text{if } \mathrm{Q_n} = -1. \end{cases} \tag{1.28}$$

P_n and Q_n must be correlated due to the existence of adverse selection. If $Q_n = +1$, the possibility that the buyer-initiated trade is information-based will cause an upward revision in P, and for the same reason, $Q_n = -1$ will cause a downward revision in P. There is only one case in which P_n and Q_n are uncorrelated: when the adverse-selection component of the spread is zero.

To derive implications for the dynamics of transaction prices, denote by ε_n the revisions in P_{n-1} due to the arrival of new public information between trades $n-1$ and n. If this is the case the nth transaction may be written as

$$P_n = P_{n-1} + \varepsilon_n + A_n Q_n \quad (1.29)$$

Taking the first differences of (1.24) then gives us the following solution

$$\hat{P}_n - \hat{P}_{n-1} = (P_n - P_{n-1}) + (C_n Q_n - C_{n-1} Q_{n-1}) \quad (1.30)$$

$$= A_n Q_n + \varepsilon_n + (C_n Q_n - C_{n-1} Q_{n-1}), \quad (1.31)$$

which shows that the transaction price changes are comprised of a gross-profit component which, exhibits reversals,[9] and an adverse-selection component that tends to be permanent. This leads us to conclude that Glosten's (1987) attribution of the effective spread to the gross-profits component is not coincidental, but well-motivated by the fact that it is this component that induces negative serial correlation in returns, not the adverse-selection component.

Glosten (1987) provides alternative relations between spreads and return covariances, which incorporate this distinction between the adverse-selection and gross-profits components. In particular, under certain simplifying assumptions Glosten (1987) shows that[10]

$$E\left[\bar{R}_k\right] = R(1+\gamma\beta), \quad Cov\left[\hat{r}_{k-1}, r_k\right] = -\frac{\gamma S^2{}_p}{4}, \quad (1.32)$$

where

$$S_p = \frac{P_a - P_b}{(P_a + P_b)/2}, \quad \gamma \equiv \frac{C}{C+A}, \quad \beta \equiv \frac{S^2{}_p / 4}{1 - (S^2{}_p / 4)}, \quad (1.33)$$

[9] The reversals discussed are very similar to the Roll (1984) model.

[10] He makes the following three mains assumptions. (1) True returns are independent of all past history. (2) The spread is symmetric about the true price. (3) The gross-profit component does not cause conditional drift in prices.

and where $\overline{R}_k$, R, are the per-period market and true returns, respectively, and $\hat{r}_k$ is the continuously compounded per-period market return. These relations show that the presence of adverse-selection $(\gamma \prec 1)$ has an additional impact on means and covariances of returns that is not captured by other models of the bid-ask spread. Therefore, the Glosten (1987) model shows that adverse selection can have very different implications for those statistical properties of transactions data than other components of the bid-ask spread.

In spite of this theoretical and analytical literature, a number of empirical studies tend to estimate only two components of the spread. Glosten and Harris (1988), Hasbrouck (1988), George et al (1991) and Kim and Ogden (1996) use models which decompose spreads into a combined inventory and order processing cost component – transitory costs, and an asymmetric information cost component. George et al (1991) and Kim and Ogden (1996), additionally argue that their estimate of the transitory cost should be interpreted as an estimate of order processing costs thus excluding inventory related costs.[11]

The only UK study to attempt a decomposition of realised spreads into asymmetric information and inventory costs components by Neuberger (1992) was unsuccessful, because his estimates were based on the Glosten and Harris (1988) model which implicitly assumes a zero inventory cost. Stoll (1989) on the other hand, decomposes the quoted spread into its three components.

[11] George et al's (1991, p 649) argument is based on their finding of a positive first order autocorrelation in bid-to-bid returns rather then the expected negative autocorrelation implied by the analytics of the problem. Kim and Ogden's (1996, p144, footnote 2) conclusion is based on their claim of the empirical difficulty of separating order processing and inventory costs.

This is accomplished by using a covariance model to estimate the realised spread attributable to order processing and inventory holding cost from transaction and quote data. He then develops an analytical and empirical model for separating the order processing and inventory cost components. The asymmetric cost component is then calculated as one minus the realised spread. This approach is consistent with the theoretical model of Garman (1976) which demonstrates that spreads should be inventory-dependant if the market maker is to avoid failure.

George et al (1991) criticised the Stoll (1989) estimator on the grounds that time variation in expected returns induces positive autocorrelation that leads to a downward bias in the estimation of the realised spread. They correct for this bias by using in their analysis, the difference between transaction returns and returns based on the bid-to-bid quotes which are unaffected by positive covariance generated by time varying expected returns. Kim and Ogden (1996), however, show that the George et al (1991) estimators are also biased because they assume that the spread is constant over time. They propose estimators that allow individual security spreads to vary over time. These modifications, therefore, relax the restrictive assumptions made in Stoll (1989). However, their estimates of the magnitude of asymmetric information costs are more in line with Stoll (1989) then the estimates of George et al (1991). This suggests that Stoll's (1989) assumptions only have a marginal impact on his empirical estimates and is consistent with the finding of Affleck-Graves et al (1994), that the magnitude of bias (about 4%) is small. Additionally, Brooks and Mason (1996) through simulations also conclude that the bias is only present in short time series and small sample cross-section estimates; it is immaterial in large cross-section and unbiased in a long time series.

Taking into account the above literature the cost components of the quoted spread should be estimated using the model proposed by Stoll (1989). Stoll's (1989) model which is based on the serial covariance of quoted prices (bid or ask) and transaction prices identifies all the three cost components in three steps. Firstly, the constants $(\alpha_0 \text{ and } \beta_0)$ and the slope coefficients $(\alpha_1 \text{ and } \beta_1)$ are estimated from equations (1.34) and (1.35):

$$\text{cov}_T = \alpha_0 + \alpha_1 S^2 + \mu, \tag{1.34}$$

and

$$\text{cov}_Q = \beta_0 + \beta_1 S^2 + \upsilon, \tag{1.35}$$

where S is the quoted proportional spread, cov_T is the covariance of transaction price changes, cov_Q is the serial covariance changes in ask (or bid) quotes, μ and υ are random error terms.

Under the assumption of an efficient market, one expects $\alpha_0 = \beta_0 = 0$. Stoll (1989) then goes on to estimate π, the probability of reversal in transaction (for instance, an ask transaction followed by a bid transaction), and δ, the size of the continuation in price as a fraction of the spread.[12] These parameters are calculated from equations (1.36) and (1.37) with the use of α_1 and β_1 estimated from equations (1.34) and (1.35):

$$\alpha_1 = \delta^2(1-2\pi) - \pi^2(1-2\delta) \tag{1.36}$$

and

$$\beta_1 = \delta^2(1-2\pi). \tag{1.37}$$

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[12] For instance, if a transaction at the ask price is followed by another transaction at the ask price (a continuation) the price change is given by $-\delta s$, where of the value of δ remains between 0 and 1.

Under this model the realised spread is given by $2(\pi-\delta)S$, which is the expected profit per trade (as a percentage of stock price) and covers only the order processing and inventory holding cost components. Finally, the cost components of the quoted spread could be estimated as:

- Order processing costs: $(1-2\delta)$.
- Inventory holding costs: $2(\pi-0.5)$.
- Asymmetric information costs: $(1-2(\pi-\delta))$.

In order to provide robustness of estimates with respect to model selection, we should re-estimate the components using the model proposed by George et al (1991) and improved by Kim and Ogden (1996). Their procedure for estimating the covariance overcomes the assumption of price independence implicit in Stoll's (1989) method. George et al's (1991) procedure estimates the realised spread as in equation (1.38)

$$S_{Bi}=2\sqrt{-\operatorname{cov}\left(RD_{i,t,}RD_{i,t-1}\right)}, \tag{1.38}$$

where $RD_{i,t}$ is the difference between transaction returns $R_{T\ i,t}$ and returns based on unobservable true prices $R_{M\ i,t}$ for security i at time t. The bid price subsequent to a transaction was used in the empirical estimates of the unobservable true price ($R_{M\ i,t}$). The spread components are then estimated as:

$$S_{Bi}=\beta_0+\beta_1 S_{Qi}+\varepsilon_i, \tag{1.39}$$

where β_1 is the cross-sectional estimate of order processing cost and $1-\beta_1$ is the unbiased estimator of the asymmetric information cost component.

However, Kim and Ogden (1996) have pointed out that if the bid-ask spread changes over time, the bid returns would include a variable element which could affect the estimate of the unobservable component of the spread due to order processing. They address the problem by using the average of bid and offer quotes as a proxy for the unobservable true price in equation (1.38) to measure S_i. The spread components (order processing and the asymmetric information) are then estimated in equation (1.40):

$$S_i = \beta_0 + \beta_1 S_{Qi} + \varepsilon_i. \tag{1.40}$$

Since the George et al (1991) and the Kim and Ogden (1996) estimators address some of the restrictive assumptions of Stoll (1989) in the calculation of realised spread, they should be applied to asses whether there are any qualitative changes to the components when alternative estimators are used. Although these methods do not split the spread into three components and assume that the inventory component is zero, they provide an opportunity to compare the estimates of asymmetric information costs with those obtained from the Stoll (1989) model.

1.5 Information Asymmetry and Trading Volume

In general, empirical research has identified a strong link between volume and the absolute value of price changes.[13] Empirical researchers have also established some asymmetric patterns to volume and the direction of price changes.[14] While the empirical link between price movements and volume appears strong, it is not obvious why this should be so. In the accounting literature, numerous researchers (for example Verrecchia (1981) and Kim and

[13] For further details on the link between trading volume and the absolute value of price changes see Karpoff (1987) and Stickel and Verrecchia (1993).

[14] Karpoff (1987) finds that trading volume is larger when prices move up than when they move down.

Verrecchia (1991)) have modelled the link between public information announcements and volume. The concern here is to explain why volume appears to increase around the announcement of public information. In the Kim and Verrecchia (1991) analysis, this change in volume is proportional to the precision of the public information signal and is decreasing in the amount of preannouncement public and private information.

In the microstructure literature in which private information is the concern, the price-volume link is less clear. In the Kyle (1985) model, for example, trading volume is not a factor in the price adjustment process. The reason is that the informed trader always adjusts his order amount to keep his relative fraction of trades the same. Consequently, the price path is independent of the scale of trading volume, and the empirical link between price movements and volume is not present. One reason as to why it is difficult to evaluate the link of price and volume is that it is not obvious what information volume, in itself, provides to the market. Just as traders can learn by watching prices, it seems likely they could learn by watching volume. In the extreme case, it is possible that volume alone could reveal underlying information, with prices playing a redundant information role. A more likely scenario is that the combination of price and volume could provide information to the market.

Wang (1994) examines how factors such as dividend information and private investment opportunities affect the price-volume relation. In his model, some traders are better informed of a risky asset's dividend process and the returns on private investment opportunities. These latter opportunities allow trading for liquidity-based reasons, while the former capture the familiar information based motive. There are also the uniformed traders who receive a noisy signal of the dividend process and who are not allowed access to private investment opportunities. This latter restriction means that only the informed traders face hedging needs, and it is these hedging-related trades that allow uninformed investors to trade without a certain loss.

In this model, volume is decreasing in the amount of the informational asymmetry. If the risk of information-based trading is too high, then uniformed traders opt not to trade given that there is little chance of not losing to the informed traders. This risk of information-based trading also dictates that volume and the absolute value of excess returns are positively correlated, reflecting the price movement necessary to induce uninformed traders to take the other side of the trade. An interesting feature of this model is that volume is also positively correlated with the arrival of public information.

Thus, as in Kim and Verrecchia (1991), public information stimulates trading. In the Wang (1994) model, this occurs because public information affects different investors in different ways. The greater the asymmetry between traders' information, the greater the trading volume. This provides one explanation for the puzzling increase in volume around predictable events such as earnings announcements.

1.6 The Bid-Ask Spread in the London Stock Exchange

The London equity market is a competitive dealership system,[15] similar to NASDAQ. Like NASDAQ, London Stock Exchange market makers quote bid and ask prices in order to attract order flow by posting their quotes and quantities on computer screens.[16] In London, the quotes should be firm for a minimum quantity known as the normal market size

[15] On 20 October 1997, the London Stock Exchange introduced an electronic order driven system for trading stocks in the FTSE 100 Index. However, all the other stocks were still traded under the quote driven system at the time of writing.

[16] The best bid and ask quotes and their corresponding quantities appear on a section of the screen known as the yellow strip.

(NMS)[17] mandated by the Exchange. The normal market size is set for each stock at 2.5% of the average daily customer turnover in the preceding quarter and can involve a substantial number of shares for highly liquid stocks.[18] In contrast NASDAQ dealers have mandatory quote sizes which are small relative to those required by London Stock Exchange dealers.[19] Order flow on the London Stock Exchange like NASDAQ does not necessarily go to the dealer with the most competitive quotes because of preferencing and internalisation by brokers. Preferencing involves a broker directing an order to a market maker not posting the best price but has agreed in advance to execute the order at the best quoted price. Internalisation involves a broker routing the order flow to a dealer belonging to the same firm rather then the market maker with the best quote.

It is evident from the foregoing that the mandated quote size as well as preferencing and internalisation on the London Stock Exchange may affect inventory and asymmetric information risks and hence the cost components of the spread.

The relatively high mandatory quote size of the London Stock Exchange provides incentives to market makers to post wide spreads (especially for stocks with high NMS) to finance inventory carrying cost as well as those induced by temporary imbalances during trading. On the other hand, the liquidity of high NMS stocks encourages a narrower spread because positions can be unwound quickly to reduce inventory risks. Moreover, on the

[17] Market makers can also post quotes for quantities larger then the mandatory quote sizes.

[18] For instance the normal market size for BT in June 1995 was 100,000, which at a price of £3.92 per share involved a trade of £392,000. On the other hand, British Biotech had a normal market size of 2000 shares valued at £982.80 per transaction.

[19] The minimum quote size required of market makers used to be 100 shares. This has now been increased to the maximum of the Small Order Execution (SOES) trades which varies with the volume of trades but has an upper limit of 1000 shares for the most active shares of large companies.

London Stock Exchange, dealers have a variety of ways to reduce costs associated with inventory imbalances in dynamic trading conditions. Like, NASDAQ, this may involve public trades, trading with other market makers or trading through the inter-dealer brokerage (IDB) system anonymously with other market makers. Such trades involve quote revisions to induce trades to revert to desired inventory positions and minimise the costs associated with inventory imbalances. The structural models of Snell and Tonks (1995, 1998) provide evidence consistent with the view that London Stock Exchange market makers are strongly influenced by inventory control considerations when revising their quotes during trading. Their finding is reinforced by Hansch et al (1998) who report that dealer inventories affect the quote placement and order flow execution. This means that, the relative inventory position of market makers is significantly related to their ability to execute large trades with the result that changes in quotes and inventories are strongly correlated. Additionally their finding that higher levels of inventories are associated with higher levels of IDB trades agrees with the results of Reiss and Werner (1998) that inter dealer trading is used extensively during periods of extreme inventory imbalances (when spreads widen) by market makers to share inventory risk. The above evidence highlights inventory risk as an important cost component which London Stock Exchange market makers should take into account when setting their spreads. The inventory cost element of spread is, however, likely to be small relative to the other cost components because of the variety of options, such as IDB trades open to dealers to share their risks.

Preferencing and internalisation may affect inventory risks and costs of market makers to the extent that they may require dealers to buy (sell) when their inventory positions suggest that they should sell (buy). On the other hand since preferenced market makers receive a higher proportion of buy and sell orders they may be able to better manage their inventories then non-preferenced dealers. The potential effect of preferencing and internalisation on the inventory cost component of spreads, is therefore an empirical issue. Hansch et al (1999) find that for the top 102 London Stock Exchange Stocks, effective spreads on preferenced trades are higher then those on non preferenced trades. On the other hand, internalised trades receive better execution then non-internalised trades. Such findings imply that preferencing leads to higher inventory risks and costs, which dealers recover through higher effective spreads. As pointed by Hansch et al (1999), however, it does not imply collusion by London Stock Exchange market makers to systematically charge high spreads but is consistent with "costly negotiation with heterogeneous dealers and customer-dealer trading relationship" because dealers do not systematically make higher profits on preferenced trades relative to non-preferenced trades.

The relatively high minimum trade sizes on the London Stock Exchange also implies that dealer losses will be high in transactions with informed traders in contrast with NASDAQ where minimum trade sizes do not exceed 1000 shares. In such an environment, it can be argued that spreads will widen to enable market makers to cover their losses from informed traders with gains from liquidity traders to ensure normal profit to the market making function. Snell and Tonks (1995, 1998) using data for only a two-week period, unsurprisingly, find very weak evidence of the impact of asymmetric information on the quote behaviour of London Stock Exchange dealers. Hansch et al (1999), on the other hand, find that dealers make profits on small trades, break even on large trades but lose on medium sized trades.

This is consistent with the presence of asymmetric information cost on the London Stock Exchange and its concentration in medium sized transactions as predicted by the stealth trading hypothesis of Barclay and Warner (1993). It contradicts the evidence of Lee (1998, p.171), that "almost all the traders think that there are very few informed traders".

On the other hand, the customer-dealer relationship reinforced through preferencing and internalisation suggests that such trades are likely to be liquidity rather then information motivated. Hence on the London Stock Exchange, like NASDAQ (see Huang and Stoll, 1996), the asymmetric information cost component of such trades may be relatively smaller then those of auction markets.

1.7 Estimates of the Effective Bid-Ask Spread in Equity Markets

Roll (1984) estimates the effective spreads of NYSE and AMEX stocks year by year using daily returns data from 1963 to 1982, and finds the overall effective spread to be 0.298% for NYSE stocks and 1.74% for AMEX stocks.[20] However, these figures should be interpreted with caution since 24,358 of the 47,414 estimated effective spreads were negative, suggesting that there are substantial specification errors. Additional evidence of these specification errors comes from the fact that estimates of the effective spread based on weekly data differ significantly from those based on a daily data. Nevertheless, the magnitudes of these effects are clearly important for empirical applications of research into transactions costs.

Glosten and Harris (1988) refine and estimate Glosten's (1987) decomposition of the bid-ask spread using transactions data for 250 NYSE stocks and conclude that the permanent adverse-selection component is present in the data. Stoll (1989) develops a similar decomposition of the spread, and using transactions data for National Market System securities on the NASDAQ from October to December of 1984, he concludes that 43% of the quoted spread is due to adverse selection, 10% is due to inventory-holding costs, and the remaining 47% is due to order-processing costs. Menjah and Paudyal (2000) replicate the Stoll (1989) model for the UK stock market. They look at transaction data on the

London Stock Exchange between the time period of January 1995 to December 1995. They conclude that 47% of the quoted spread is due to adverse selection, 23% is due to inventory-holding costs, and the remaining 30% is due to order-processing costs.

They go on to say that the high London Stock Exchange normal market size at which dealers have to offer firm quotes together with the practice of preferencing and internalisation generate relatively higher inventory costs and risks then the NASDAQ.

George et al (1991) allow the expected return of the unobservable true price to vary through time and, and using both daily and weekly data for NYSE and AMEX stocks from 1963 to 1985 and NASDAQ stocks from 1983 to 1987, they obtain a much smaller estimate for the portion of the spread attributable to adverse selection, from 8% to 13% with the remainder due to the order-processing costs, and no evidence of inventory costs. Huang and Stoll (1995a) propose a more general model that contains these other specifications as special cases and estimate the components of the spread to be 21% adverse-selection costs, 14% inventory-holding costs, and 65% order-processing costs using 1992 transactions data for 19 of the 20 stocks in the Major Market Index.

Trade costs are influenced by such factors as trade difficulty, or the availability of a particular stock and investment styles. Trade difficulty relates to how liquid a stock is and, consequently, how difficult it is to find ready buyers or sellers. At a basic level, trade difficulty can be represented by trade size and the market capitalisation of the stock being traded. Large orders demand more liquidity and so have higher trade costs than small orders. Averaged over all market capitalisation levels, the round-trip (purchase and sale) trade costs of exchange-listed shares were 2.32% for the largest trades and 0.64% for the

[20] AMEX stocks tend to be lower-priced; which means that they should have larger percentage spreads.

smallest.[21] Trade costs are inversely related to market capitalisation, a proxy for liquidity. Keim and Madhaven (1998) found the average round-trip cost for the smallest market-cap quintile of exchange-listed stocks to be 3.81%. The same cost for the largest market-cap quintile was 0.57%. Transactions costs tend to be larger for NASDAQ stocks than for exchange-listed stocks, but differences have narrowed because of regulatory changes and competition from electronic communications networks. Allowing for trade difficulty is vital in assessing broker performance. For example, a full-service broker, who slowly "works" an order for an illiquid stock, may incur explicit costs of 0.9% and implicit costs of 2%. Compare this with a discount broker dealing with a highly liquid stock, who may incur explicit costs of 0.2% and implicit costs of 0.4%.

Without allowing for trade difficulty, one cannot conclude that the broker with the higher total costs is a worse performer. What if the assignments were reversed? Using a full-service broker for a liquid stock might be as bad as using a discount broker for an illiquid stock. Investment style (such as active or passive, index or momentum) also affects transactions costs because it proxies for unobservable factors, such as the trader's time horizon or aggressiveness. Aggressive traders, such as those who chase short-run price movements and some indexers, have high expected costs because they demand (and pay for) immediacy. Less-aggressive traders, such as value managers whose strategies are based on fundamental analysis, have lower turnover and lower costs because their longer investment horizon allows them to trade patiently.

Keim and Madhaven (1998) estimated round-trip costs of 0.45% for value traders, 1.09% for index traders and 2.04% for momentum (or technical) traders. Even within a particular investment style, differences in order-submission strategy may affect costs. For example,

[21] The figures quoted are from the NYSE.

two traders, both using value-based strategies, may have significant differences in the number of trades needed to fill an order, which may translate into cost differences. A study of 22,000 block trades in DJIA stocks found strong evidence that traders' reputation also affects transactions costs.[22] Traders who have a reputation for liquidity trading may be able to obtain better prices because the adverse-selection costs associated with their trades are likely to be minimal. This advantage is especially likely for trades that are negotiated away from the exchange floor, because this "upstairs" market is less anonymous than the exchange floors or NASDAQ.

The fact that these estimates vary so much across studies makes it difficult to regard any single study as conclusive. The difference comes from two sources. First, different specifications for the dynamics of the bid-ask spread and secondly, the use of different datasets.

There is clearly a need for a more detailed and comprehensive analysis in which all of these specifications are applied to a variety of datasets to test the explanatory power and the stability of each model.

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22 See Madhaven and Chang (1997).

Chapter 2

Transactions Costs and Holding Periods for Common Stocks: Evidence from the UK

2.1 Introduction

Demsetz (1968) was the first to examine the importance of transactions costs and in particular the bid-ask spread, for investment decisions. Subsequently research in the area was focused on transactions costs as measured by the bid-ask spread. Studies focused on the determinants of the bid-ask spread[23], its size in different markets[24], the role of the spread in explaining stock market anomalies[25], and its effect on pricing models for common stocks.[26] The accumulated empirical evidence suggested that the bid-ask spread caused "a clientele effect". That is, it affects the frequency with which investors trade securities and causes investors with longer expected holding periods to hold the assets with the higher transactions costs and vice versa.

Amihud and Mendelson (1986) examine the effect of bid-ask spreads on investor's holding periods and present a formal proof of their proposition 1, which states on page 228 that "Assets with higher spreads are allocated in equilibrium to portfolios with (the same or) longer holding periods". This implies that in equilibrium a higher (lower) bid-ask spread results in the stock being held by the investor for a longer (shorter) period of time.

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[23] Tinic (1972), Benston and Hagerman (1974) and Stoll (1978).

[24] Branch and Freed (1977), Hamilton (1976), and Marsh and Rock (1986).

[25] Stoll and Whaley (1983), Keim (1989), and Atkins and Dyl (1990).

[26] Amihud and Mendelson (1986,1989), Constantinides (1986), Chen and Kan (1989), and Eleswarapu and Reinganum (1993).

In a similar line of argument Constantinides (1986) investigates the effect of transactions costs on capital market equilibrium and finds that investors accommodate transactions costs by reducing the frequency and the volume of trade (page 859).

Amihud and Mendelson (1986) provide empirical evidence consistent with their proposition 2, which states, " In equilibrium, the observed market (gross) return is an increasing and concave piecewise-linear function of the (relative) spread." Their proposition 1 relating investors' holding periods and bid-ask spreads has been tested empirically by Atkins and Dyl (1997). They examine average holding periods and bid-ask spreads for NASDAQ stocks from 1983 through 1991 and for NYSE stocks from 1975 through 1989 and find strong evidence that, as predicted by Amihud and Mendelson (1986), the length of investors' holding periods is positively related to bid-ask spreads.

Empirical evidence widely agrees with the basic proposition that the cost of transacting affects the volume of trade and therefore in turn affects investors' holding periods. For example, Bhide (1993) attributes the relatively short holding periods observed for common stocks in the USA to lower transactions costs in USA markets versus foreign stock markets.[27] Umlauf (1993) presents evidence that the imposition of the Securities Transactions Tax (STT) in Sweden reduces the rate of turnover in Swedish stock markets. Epps (1976) looks at transactions costs and trading volumes for a random sample of 20 common stocks in 1968 and estimates that a 10% increase in the cost of transacting would lead to a decline in trading volume of 2.5%. Jarrell (1984) observes that average brokerage commissions fell by about 30% from 1975-1978 and that share turnover from 1975-1981 was 30% higher then it was during the period of 1968-1975.

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[27] Other studies that support this claim are Stiglitz (1989), Summers and Summers (1989), Grundfest and Shoven (1991), and Schwert and Seguin (1993).

Additional evidence of a relationship between transactions costs and trading volume can be found on the research done on bid-ask spreads. As previously mentioned Demsetz (1968) discovers that spreads are inversely related to trading volume, the number of transactions per day, and the number of shareholders. Demsetz (1968) goes on to conclude that trading costs decline as trading activity increases. In the same vein Tinic (1972) finds an inverse relationship between spreads and daily trading volume, and concludes that transactions costs are lower for stocks that are traded heavily and continuously and Benston and Hagerman (1974) conclude that there is evidence of economies of scale in trading. Finally Stoll (1978) also finds an inverse relationship between spreads and trading volume.

The contribution of this study is that it provides empirical evidence concerning the relationship between the bid-ask spreads of common stocks and the average length of time that investors hold these stocks, for the U.K stock market. In addition, this study provides an alternative rationale for the postulated positive relationship between the bid-ask spread and the 'holding period' in a simple optimizing framework. It also incorporates the skewness of returns in the model of the average holding period as well as more traditional variables such as the market value of firms and the variance of returns. In the following section, section 2.2, we discuss in some detail the rationale for the chosen specification. The data are discussed in section 2.3. The adopted econometric methodology and the results are presented in section 2.4. Finally section 2.5 contains our conclusions.

2.2 Theoretical Considerations

Following Wilcox (1993), we abstract from risk consideration by postulating that each stock is drawn from a population of stocks of similar risk. The continuous rate of return expected is R_p. To motivate trading, R_p is augmented by a premium A_0 if the stock is actively traded. Thus the total return for a traded stock at time t once selected, is:

$$R_t = R_p + A_0 e^{-kt} \tag{2.1}$$

Where R_t is the rate of return expected at time t after selection and the term e^{-kt} denotes the rate of decay in A_0, the premium to be acquired due to the information arrival that induces trade. Accordingly, k is a positive number that gives the time rate of decay in the active return A_0.

When traded the stocks are subject to transactions costs denoted by C. The rate of growth of the value of the investor's portfolio is given by:[28]

$$e^{R_a t} = (1-C)e^{\left[R_p t + \frac{A_0}{k}\left(1-e^{-kt}\right)\right]} \tag{2.2}$$

Expected active return decays until refreshed by selection of a new stock based on new information. As a result unless there is continuous trading at zero cost, the average return, equation (2.2), will be less than the sum of the passive return plus the initial active return.

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28 Define $A_0 e^{-kt} = r_t$, over the time interval (t,t+dt) the change in wealth (w) is given by $dw_t = r_t w_t dt$.

The rate of growth of wealth is $\log(\frac{w_t}{w_0}) = A_0 \int_0^t e^{-kt} dt = \frac{A_0}{k}(1-e^{-kt})$, therefore $w_t = w_0 e^{-\frac{A_0}{k}(1-e^{-kt})}$.

The difference implies an opportunity cost that grows larger as the holding period lengthens. We will now attempt to derive implications of this model.

From equation (2.2) we deduce that in the presence of transactions costs continuous trading is not optimal. To calculate the optimal holding period, first we take logs of (2.2)

$$R_a = R_p + \ln\frac{(1-C)}{t} + \frac{(A_0 / kt)}{\left(1-e^{-kt}\right)} \tag{2.3}$$

and set the derivative of (2.3) with respect to time equal to zero. The optimal holding period (t*) is given by

$$\frac{(1+kt^*)}{e^{kt^*}} = 1 + \frac{\ln(1-C)}{(A_0 / k)} \tag{2.4}$$

Where t* denotes the optimal holding period.

Equation (2.4) is non-linear in t* and thus the nature of the relationship between t* and C is ambiguous. Fortunately an approximate solution can be obtained with the use of the solution of a Lambert function. The analytical solution to this type of function is very complex, but a good approximation is given by: [29]

$$w(x) \approx 0.665 * (1 + 0.0195 * \ln(x+1)) * \ln(x+1) + 0.04 \qquad : 0 \le x \le 500; \quad (2.5a)$$

$$w(x) \approx \ln(x-4) - \left(1 - \frac{1}{\ln(x)}\right) * \ln(\ln(x)) \qquad : x \succ 500. \quad (2.5b)$$

[29] The derivation of the Lambert Function approximation was obtained by Ringwald and Schrempp (1999).

Where x measures the time period of the data set. For our data set x is equal to 1 since we have annual data. We can now attempt to calculate $t*$ for different values of C. We let C vary from 0 to 3 since transactions costs above 3% are unrealistic in equity markets. Before we can solve for t* we assign fixed values to the variables A_0 and k. In this instance we use, $A_0 = 5\%$ and $k = 0.5$. The results of these simulations can be seen in Table 2.1.

TABLE 2.1. Simulation Results for the Optimal Holding Period under Different Levels of Transactions Costs

C	$t*$
0	0
0.5	1.050125
1.0	1.100503
1.5	1.151136
2.0	1.202027
2.5	1.253178
3.0	1.304592

There is clear evidence from Table 2.1 that there is a positive relationship between holding periods and transactions costs. There is also evidence from Table 2.1, that for the chosen values of the parameters there is an almost linear relationship between the optimal holding period and the transactions costs[30].

In addition to the model above that links optimal holding periods and transactions costs Karpoff (1986) develops a model that combines trading volume, transactions costs and volatility.

[30] The almost linear specification between optimal holding periods and transactions costs remains when we assign different values for A_0 and k. A graphical representation of the results can be seen in figure A in the appendix.

To explain the model, denote i as a seller and j as a buyer. In equilibrium, the seller's demand price must exceed the buyer's demand price such that $p_i \succ p_j$. A trade will then occur in the next time period $(t=1)$ if the change in the buyer's demand price δ_{jt} exceeds the change in the seller's demand price δ_{it} by an amount sufficient to offset the demand price differential at $t=0$. Thus, a trade will occur in $t=1$ if:

$$p_{j1} \geq p_{i1}$$

or $$p_{j0} + \delta_{j1} = p_{i0} + \delta_{i1}$$

or $$\delta_{j1} - \delta_{i1} \geq p_{io} - p_{j0}. \tag{2.6}$$

The net price change for a general investor (g) will appear as $\delta_{\Omega 1}\left(\delta_{\Omega 1} = \delta_{j1} - \delta_{i1}\right)$. If the revision in demand prices follows a stochastic process with mean μ and variance σ^2, then:

$$\delta_{\Omega 1} = \mu_{\Omega} + \sigma\varepsilon_{\Omega} \tag{2.7}$$

Where ε_{Ω} is a zero-mean variable and is independent across investors such that $E\left(\varepsilon_{\Omega}\varepsilon_{g}\right) = 0$ for all $\Omega \neq g$. Thus, the net price revision has two components. First, there is a demand price revision incorporated in the mean μ_{Ω}. Second, there is an investor specific idiosyncratic term ε_{Ω}, which captures changes in individual investor expectations and liquidity desires. In the absence of any new public information, μ_{Ω} is the expected return on the stock. Hence, for any pair of buyers and sellers:

$$\theta = \delta_{j1} - \delta_{i1} = (\mu_j - \mu_i) + \sigma(\varepsilon_j - \varepsilon_i)$$

$$\mu_\theta = E(\theta) = \mu_j - \mu_i$$

$$\sigma^2\theta = E(\theta - \mu_\theta)^2 = 2\sigma^2. \tag{2.8}$$

Therefore, trades will occur because of movements in μ_θ or $\sigma^2\theta$ or a combination of both. This model leads to a number of predictions, concerning the relationships between transactions costs, trading volume and volatility. First, transactions costs (including bid-ask spreads) reduce expected trading volume as the change in demand prices $(\delta_{j1} - \delta_{i1})$ must now exceed the original price difference $(p_{i0} - p_{j0})$ plus the transactions costs. Consequently this implies a positive relationship between the bid-ask spread and the average holding period. Second, if demand prices are revised by market agents (increase in volatility) in unpredictable ways trading volume will increase, and as a consequence the holding period will decrease as agents are trading more often. The intuition behind this is that, as information is interpreted differently by market agents, this adds to the normal "jumbling up" of demand prices that originates from investors' liquidity and speculative trading. This increases the variance of the demand-price revision, process, σ^2, and therefore increases $\sigma^2\theta$. This suggests that as volatility increases, trading volume will also increase resulting in shorter holding periods.

The market value of a firm is an important determinant of average holding periods because larger firms are assumed more likely to be considered investment grade than smaller firms, so we may observe longer holding periods for larger firms than for smaller firms. According to Karpoff (1986) volume is high when investors' expectations are diverse. Large firms are followed by more analysts, which ceteris paribus may reduce the divergence of investors' expectations. This results in less trading and hence longer holding periods. In addition, studies have shown that larger firms are generally less risky then smaller firms, which may affect holding periods.[31] The stocks of large firms may also have greater stability in the parameters of their return distributions. If so, investors need to do less portfolio rebalancing with large firms' stocks, and the average holding periods will be longer.

Hong and Stein (2000) suggest that the skewness of returns may be a determinant of the average holding period of a common stock. They argue that investor heterogeneity is central to this explanation. The Hong-Stein (2000) model rests on two key assumptions: First, there are differences in opinion among investors as to fundamental value; and second some, though not all, investors face short-sales constraints. The constrained investors can be thought of as mutual funds, whose charters typically prohibit them from taking short positions; the unconstrained investors can be thought of as hedge funds or other arbitrageurs.[32] When differences of opinion are initially large, those bearish investors who are subject to the short-sales constraint will be forced to a corner solution, in which they sell all of their shares and just sit out of the market. As a consequence of being in a corner, their information is not fully incorporated into prices. However, if this information is hidden, other, previously more bullish investors have a change of heart and bail out of the market, the originally more bearish group may become the marginal "support buyers" and hence more will be learnt about their signals. Thus accumulated hidden information tends

[31] Stoll and Whaley (1983) document that both total risk, measured as the standard deviation of stock returns, and systematic risk, measured by beta, are a decreasing function of a firm's size.

[32] Brown et al (1999) document that roughly 70% of mutual funds explicitly state that they are not permitted to sell short. This is obviously a lower bound on the fraction of funds that never take short positions.

to come out during market declines, which is another way of saying that returns are negatively skewed.

With this focus on differences of opinion, the Hong-Stein (2000) model has distinct empirical implications that are not shared by the representative-investor theories. In particular, the Hong-Stein (2000) model predicts that negative skewness in returns will be most pronounced after periods of heavy trading volume. This is because like in many models with differences of opinion, trading volume proxies for the intensity of disagreement.[33] When disagreement (and hence trading volume) is high, it is more likely that bearish investors will be at a corner, with their information incompletely revealed in prices. It is precisely this hiding of information that sets the stage for negative skewness in subsequent periods, when the arrival of bad news to other, previously more bullish investors can force the hidden information to come out. This therefore suggests that investors' will have a longer average holding period for positively skewed stocks.[34]

A dummy is also incorporated in our model, to capture the possible effect of time-specific events on average holding periods. In order to do this we include a separate dummy variable in our regression model denoting each year in our estimation period.

Based on the above arguments the regression model to be estimated will be:

$$HldPer_{iT} = \beta_1 + \beta_2 Spread_{iT} + \beta_3 MktVal_{iT} + \beta_4 Var\mathrm{Re}t_{iT} + \beta_5 Skew_{iT} + \sum_{j=6}^{15} \beta_j D_T + \varepsilon_{iT} \tag{2.9}$$

[33] See Varian (1989), Harris and Reviv (1993), Kendel and Pearson (1995) and Odean (1998a) for other models with this feature.

[34] A Theoretical discussion of the importance of skewness with respect to the risk premium can be seen in appendix A.

Where, $HldPer_{iT}$ is the average length of time that investors hold the stock for firm i during year T. $Spread_{iT}$ is an estimate of the average percentage bid-ask spread on firm i's shares during year T, and is positively related to the holding period. $Mktval_{iT}$ is the average market value of firm i's shares during year T, and is positively related to the holding period. $Var\,\mathrm{Re}t_{iT}$ is the variance of return of firm i's daily stock returns during year T, and is negatively related to the holding period. $Skew_{iT}$ is the skewness of return of firm i's daily stock returns during year T, and is positively related to the holding period. The $D_T S$ are 0,1 dummy variables denoting year T, β's are parameters of the model, and ε_{iT} is an error term.

2.3 Data Definition and Collection

In this study we collect annual data for all the firms that are listed on the FTSE All Share Index from the time period of 1990-1999, with the use of Datastream. We will now show the procedure used to obtain all the variables displayed in equation (2.9).

The average holding period, HldPer

We calculate the average holding period as

$$\text{Holding Period}_{iT} = \frac{\text{Shares outstanding in year T}}{\text{Trading volume in year T}}. \qquad (2.10)$$

Thus the average holding period of each firm's investors for each year is computed by dividing the number of outstanding shares in the firm by the firm's annual trading volume.

This average holding period, observed ex post, is a proxy for the average investors' ex ante investment horizon. The computation of investors' average holding period is only a crude approximation of investors' time horizons, because a particular firm's investors are unlikely to hold the firm's shares for the same length of time. Although Amihud and Mendelson's (1986) proposition is stated in terms of investors holding periods, Constantinides' (1986) result is simply that higher transactions costs result in lower trading volume. Since trading volume appears in the denominator of equation (2.10), our investigation of the relationship between holding periods and spreads also provides evidence regarding the proposition by Constantinides (1986).

The bid-ask spread, Spread

Datastream provides the bid and ask quotes originally used to compute the bid-ask spread for our data set. The average annual bid-ask spread for each stock in the data set is estimated by averaging the two observations of bid-ask spreads surrounding each year. That is, the average spread for each stock i for each year T is computed as follows:[35]

$$Spread_{iT} = \left[\frac{Ask_{iT} - Bid_{iT}}{(Ask_{iT} + Bid_{iT})/2} + \frac{Ask_{iT-1} - Bid_{iT-1}}{(Ask_{iT-1} + Bid_{iT-1})/2} \right] / 2 \qquad (2.11)$$

Where Ask_{iT} and Bid_{iT} are the ask and bid prices for the ith stock on the last trading day in year T.

Market Value, MktVal

The market values for all the firms that are listed on the FTSE All Share Index from the time period of 1990-1999 are obtained with the use of Datastream.

The Variance Of Returns, $Var\,\mathrm{Re}t$

Daily prices of all the firms that are listed on the FTSE All Share Index from the time period of 1990-1999 are obtained with the use of Datastream. We then calculate the

[35] We use the formula proposed by Atkins and Dyl (1997) to calculate average annual bid-ask spreads for our data set.

variance of the returns during the year of all the firms that are listed on the FTSE All Share Index from the time period of 1990-1999.

The Skewness of Returns, Skew

We calculate the skewness of returns for all the firms that are listed on the FTSE All Share Index from the time period of 1990-1999 using the same methodology, as the variance of returns.

The descriptive statistics for $Spread, MktVal, Var\mathrm{Re}t$ and $Skew$ for all the firms that are listed on the FTSE All Share Index from 1990 through 1999 are given in Table 2.2. One noticeable aspect of the Table is the presence of excess skewness and excess kurtosis in the $Spread, MktVal, Var\mathrm{Re}t$ and $Skew$ variables. Our approach is to take natural logs of the variables in the regressions to minimize the impact of these features. Therefore, we estimate our empirical model in logs.

Table 2.2. Descriptive statistics for the bid-ask spread $(Spread)$, the market value of firms $(MktVal)$, variance of returns $(Var\mathrm{Re}t)$, and the skewness of returns $(Skew)$, for all the firms listed on the FTSE All Share Index from 1990 through 1999

	$Spread$	$MktVal$	$Var\mathrm{Re}t$	$Skew$
Mean	1.13	8048	6.78	5.64
Standard Deviation	0.0017	753.23	14.53	0.043
Minimum	1	2371	1.13	1.21
Maximum	2.08	97644	10.87	9.54
Skewness	5.75*	9.482*	4.63*	9.48*
Kurtosis	22.56*	21.16*	22.76*	22.01*
No of observations	7240	7240	7240	7240

Notes:

The descriptive statistics for the $MktVal$ variable are expressed in millions, whereas the descriptive statistics for all the other variables are expressed in percentages.

* Indicates that the test of the null hypothesis of no skewness and no kurtosis is rejected at the 5% level of significance. The tests used for skewness and kurtosis are those proposed by Jacque and Bera (1980).

2.4 Econometric Methods and Results

Following Atkins and Dyl (1997) who find that the investors' holding period and the bid-ask spread for each stock are simultaneously determined and adopt an IV estimator we need to determine the appropriate estimator for this model. To this purpose we use the Hausman (1978) test statistic to establish the choice of the estimator. The inappropriate use of Instrumental Variables (IV) will result in severe loss of efficiency compared to the least squares estimator. The test statistic is based on the difference between the two estimators that are consistent under the null hypothesis but only one of them, the IV estimator is consistent under the alternative. The test statistic is given by :

$$H = (b_{IV} - b_{LS})' \left\{ \left(\hat{X}'\hat{X}\right)^{-1} - \left(X'X\right)^{-1} \right\}^{-1} (b_{IV} - b_{LS}) / s^2 \tag{2.12}$$

Where $\hat{X}$ denotes the matrix of regressors where the 'endogenous' variables have been instrumented, X the original matrix of regressors and s^2 the variance estimate. This Wald statistic follows the chi-square distribution with P, the number of instrumented variables, degrees of freedom. Using as additional instruments current and lagged returns and lagged spread, the resulting value of the statistics was 2.89. We were therefore unable to reject the null hypothesis that both estimators were consistent, and given that the Ordinary Least Squares Estimator is efficient we proceed to estimate the model by Ordinary Least Squares. The results can be seen in Table 2.3.[36]

[36] Since we are estimating a Panel regression we have to either estimate a fixed effects or random effects model. Our choice is based on the Hausmann (1978) test. When we apply this test we obtain a test statistic of 4.74 with a corresponding p value of 0.3149. This leads us to conclude that the random effects model is the optimal econometric model. We therefore proceed and estimate the random effects model.

Table 2.3. Holding Period Panel Estimation

This Table shows the relationship between average holding periods, bid-ask spreads, market values, variances and skewness for FTSE All Share common stocks for the time period of 1990-1999. The results are from the following Panel Estimation.

$$HldPer_{iT} = \beta_1 + \beta_2 Spread_{iT} + \beta_3 MktVal_{iT} + \beta_4 Var\mathrm{Re}t_{iT} + \beta_5 Skew_{iT} + \sum_{j=6}^{15} \beta_j D_T + \varepsilon_{iT}$$

Period	N	β_1	β_2	β_3	β_4	β_5	$\overline{R}^2$
1990-1999	7240	0.324 (16.41)*	0.52 (2.14)*	0.140 (2.24)*	-0.231 (-2.46)*	0.112 (1.11)	0.334

Notes:

The t statistics are shown in brackets and * indicates significance at the 5% level.

All the variables in the above equation are expressed as natural logarithms.

Diagnostic Results

	Heteroscedasticity	Serial Correlation	Normality	Functional Form
Test Statistic	0.644	1.641*	1.821	1.367

Notes:

All the diagnostic statistics that are reported are based on the Lagrange Multiplier statistic.

The heteroscedasticity test is based on a regression of squared residuals on squared fitted values. The test used was the one proposed by White (1980).

The serial correlation test is based on the Durbin Watson test (1950, 1951), * indicates the rejection of the null hypothesis of no serial correlation of the errors at the 5% level of significance.

The normality test is based on a test of skewness and kurtosis of the residuals. The test we used is the one proposed by Jacque and Bera (1987).

The functional form test is a test to see whether the model is linear or not. The test used is Ramsey's 1969 reset test, which uses the square of the fitted values.

The problem with the results in Table 2.3 is that our panel data regression model suffers from serial correlation. This results in inconsistently estimated standard errors. Driscoll and Kraay (1998) present conditions under which a simple extension of common nonparametric covariance matrix estimation techniques yields standard error estimates that are robust to very general forms of serial correlation in panel data estimations. In their study they proved the following result:

Result 1 (page 552): Suppose that $h_{it}(\mathrm{M})$, $t = 1,......,T$ $i = 1,........,N(T)$, is an α mixing random field of size $r/(r-1)$, $r > 1$. Then

$$h_t(M) = \frac{1}{N(T)} \sum_{i=1}^{N(T)} h_{it}(M) \tag{2.13}$$

is an α mixing sequence of the same size as $h_{it}(M)$ for any $N(T)$. Moreover, it is immediate that if $E\lfloor\ /h_{it}\ /^{\delta}\rfloor < D$, for finite constants δ and D, then

$E\lfloor\ /h_t\ /^{\delta}\rfloor < D$.

Based on this result, they apply the standard Newey and West (1987) heteroscedasticity and serial correlation consistent covariance estimator, to the sequence of cross-sectional averages of the $h_{it}(M)$. We apply the Driscoll and Kraay (1998) correction to our data set in order to give us robust standard errors in the presence of serial correlation. The results are presented in Table 2.4.

Table 2.4. Robust Estimation of the Holding Period Panel Estimation

This Table shows the relationship between average holding periods, bid-ask spreads, market values, variances and skewness for FTSE All Share common stocks for the time period of 1990-1999. The results are from the following Panel Estimation.

$$HldPer_{iT} = \beta_1 + \beta_2 Spread_{iT} + \beta_3 MktVal_{iT} + \beta_4 Var\mathrm{Re}t_{iT} + \beta_5 Skew_{iT} + \sum_{j=6}^{15} \beta_j D_T + \varepsilon_{iT}$$

Period	N	β_1	β_2	β_3	β_4	β_5	$\overline{R}^2$
1990-1999	7240	0.424 (16.71)*	0.72 (5.16)*	0.156 (5.19)*	-0.239 (-6.89)*	0.222 (2.11)*	0.376

Notes:

The t statistics are shown in brackets and * indicates significance at the 5% level.

All the variables in the above equation are expressed as natural logarithms.

The coefficient on the bid-ask spread variable is positive and significant at all levels of significance with a t-statistic of 5.16. This finding provides strong support for the hypothesis that investors' holding periods for common stocks are related to the level of transactions costs in the manner predicted by Amihud and Mendelson (1986), Constantinides (1986) and Wilcox (1993). The regression coefficients on firm size and the return variance also have the expected signs and are highly significant. Longer holding periods are associated with larger firms, and shorter holding periods are associated with more volatile firms. Our results for the FTSE All Share common stocks are consistent with the NYSE and the NASDAQ stock exchanges[37]. The regression coefficient on the return skewness also has the expected sign and is significant. Longer holding periods are also associated with positively skewed stocks. The coefficients (not reported) on eight of the ten dummy coefficients denoting the particular years are also significant. The $\overline{R}^2$ of the regression is 0.376, indicating that a substantial portion of the variation in investors' holding periods for FTSE All Share common stocks is explained by the explanatory variables in the regression.

[37] Atkins and Dyl (1997) find the same empirical relationship between annual holding periods and annual bid-ask spreads for the NYSE and the NASDAQ stock exchanges.

As documented earlier our results are consistent with the NYSE and with the NASDAQ since we document the same empirical findings as Atkins and Dyl (1997). We do however have some notable differences with the results in Atkins and Dyl (1997). Both the magnitude and the significance of the coefficient associated with $Spread_{iT}$ is lower for FTSE All Share stocks than it is for NASDAQ and for NYSE stocks. These differences between the relationships found for FTSE All Share, NASDAQ and NYSE firms are not surprising, given the levels of bid-ask spreads in the three markets. Atkins and Dyl (1997) found the mean of the bid-ask spread for the stocks in the NASDAQ sample to be 5.14%, and they found the mean of the bid-ask spread for the stocks in the NYSE sample to be 1.38%. We found the mean of the bid-ask spread for the stocks in the FTSE All Share sample to be 1.13%. Transactions costs do not have as great an influence on investors' behaviour when transactions costs are relatively low.

To test whether the relationship between investors' holding periods and bid-ask spreads has been stable over time, we also estimate equation (2.9) for each year. These results are shown in Table 2.5. The coefficient on the bid-ask spread variable has the expected sign and is significant in each year. The coefficients on $MktVal_{iT}$, $Var\mathrm{Ret}_{iT}$ and $Skew_{iT}$ are also of consistent sign and significant from year to year. The $\overline{R}^2$'s range from 0.108 in 1991 to 0.592 in 1996.[38]

[38] The diagnostic results of the annual holding period regressions can also be seen in Table 2.5. The regressions do not suffer from any diagnostic problems at any point in time. The regression coefficients are also stable throughout the entire time period that is estimated. This means that the regression model is well specified, which leads us to conclude that the results concerning the regression coefficients are robust.

Table 2.5. Annual Holding Period Regressions

This Table shows the relationship between average holding periods, bid-ask spreads, market values, variances and skewness for FTSE All Share common stocks for the time period of 1990-1999, for each individual year. The results are from the following least squares regression.

$$HldPer_i = \beta_1 + \beta_2 Spread_i + \beta_3 MktVal_i + \beta_4 Var\,\mathrm{Re}\,t_i + \beta_5 Skew_i + \varepsilon_i$$

Period	N	β_1	β_2	β_3	β_4	β_5	$\overline{R}^2$
1990	724	0.358	0.48	0.148	-0.383	0.173	0.264
		(6.45)*	(3.39)*	(2.73)*	(-2.49)*	(2.01)*	
1991	724	0.399	0.475	0.137	-0.312	0.114	0.108
		(2.96)*	(2.47)*	(2.85)*	(-2.21)*	(2.07)*	
1992	724	0.3	0.89	0.113	-0.256	0.106	0.167
		(3.21)*	(2.02)*	(2.06)*	(-2.62)*	(2.63)*	
1993	724	0.385	0.64	0.138	-0.237	0.103	0.250
		(4.38)*	(2.71)*	(2.55)*	(-2.99)*	(2.57)*	
1994	724	0.395	0.67	0.149	-0.293	0.189	0.271
		(4.36)*	(2.74)*	(2.72)*	(-2.29)*	(2.31)*	
1995	724	0.447	0.46	0.161	-0.231	0.144	0.334
		(4.74)*	(2.48)*	(2.29)*	(-2.93)	(2.64)*	
1996	724	0.237	0.27	0.141	-0.241	0.188	0.592
		(2.86)*	(2.33)*	(2.36)*	(-2.63)*	(2.45)*	
1997	724	0.327	0.21	0.150	-0.225	0.195	0.126
		(3.59)*	(2.37)*	(2.42)*	(-2.11)*	(2.42)*	
1998	724	0.238	0.88	0.143	-0.217	0.095	0.279
		(3.72)*	(2.10)*	(2.28)*	(-2.95)*	(2.77)*	
1999	724	0.368	0.58	0.141	-0.217	0.121	0.276
		(2.75)*	(2.09)*	(2.02)*	(-2.94)*	(2.32)*	

Notes:

The t statistics are shown in brackets and * indicates significance at the 5% level.

All the variables in the above equation are expressed as natural logarithms.

Diagnostic Results

Period	Functional Form Test	Heteroscedasticity Test	Normality Test	Stability Test
1990	2.77	0.017	2.40	1.03
1991	2.65	0.907	2.42	1.06
1992	0.627	0.391	3.50	0.96
1993	0.044	0.855	0.818	0.87
1994	2.45	0.048	0.03	1.04
1995	1.32	0.181	2.31	1.12
1996	1.22	0.972	3.85	0.85
1997	0.466	0.632	3.00	0.94
1998	2.28	0.425	0.420	1.08
1999	0.185	0.189	0.434	0.84

Notes:

All the diagnostic statistics that are reported are based on the Lagrange Multiplier statistic.

The heteroscedasticity test is based on a regression of squared residuals on squared fitted values. The test used was the one proposed by White (1980).

The normality test is based on a test of skewness and kurtosis of the residuals. The test we used is the one proposed by Jacque and Bera (1987).

The functional form test is a test to see whether the model is linear or not. The test used is Ramsey's 1969 reset test, which uses the square of the fitted values.

The stability test is a test for the stability of the regression coefficients in the model through time. The test is based on the Chow (1960) test.

2.5 Discussion and Conclusions

Amihud and Mendelson (1986), Constantinides (1986) and Wilcox (1993) provide a theoretical basis for the proposition that, in equilibrium, assets with higher transactions costs will be held by investors with longer holding periods and vice versa. Atkins and Dyl (1997) examine average holding periods and bid-ask spreads for NASDAQ stocks from 1983 through 1991 and for NYSE stocks from 1975 through 1989 and find strong support for this proposition.

In this chapter we look at two aspects concerning the holding period and transactions costs for common stocks for the UK. First, we look at the theoretical relationship between the optimal holding period and transactions costs of a common stock. We do this by optimising the holding period of a stock under transactions costs with the use of a Lambert function. We find a positive, and an approximately linear relationship between the optimal holding period and transactions costs.

Second, we estimate a specification similar to the one tested by Atkins and Dyl (1997) whilst augmenting it with higher order moments of stock returns. In addition we estimated the model both in panel form and repeated cross-section. We find that investors on the FTSE All Share who buy high-spread common stocks exhibit, on average, longer investment time horizons than investors who buy low spread stocks. The relationship is weaker than the one estimated for the US, in the low spread environment of the FTSE All Share than in the high spread environment of NASDAQ and NYSE. The panel estimation inferences are robust to mis-specification and the obtained coefficient estimates consistent with the predictions of the theory as both the variance and the skewness of returns are entering the specification with the correct sign and are statistically significant.

Using the repeated cross sectional regressions we established that the positive relationship between the two variables is stable over the ten-year period, and we also find that the regression results are robust since none of the regressions suffer from diagnostic problems.

The results provide additional econometric evidence on the importance of transactions costs on investor behaviour and portfolio construction. It is remarkable that in the presence of stock return characteristics (such as volatility, skewness, size, etc) the bid-ask spread has an independent and consistently significant influence on the holding period of stocks traded in the London Stock Exchange.

This clearly provides evidence that transactions costs may be a factor, which determine asset prices as they affect the frequency of trades necessitated by information. An obvious extension of the work would be to investigate whether there is evidence that transactions costs are incorporated in equilibrium asset pricing models.

Chapter 3

Transactions Costs and Asset Pricing: Evidence from the UK

3.1 Introduction

The first formal asset pricing model was the Capital Asset Pricing Model (CAPM) which was developed by Sharpe (1964) and Lintner (1965). They suggested that we should price assets in the following way.

$$E(R_i) = R_f + [E(R_M) - R_f]\beta_i \qquad (3.1)$$

Where: $E(R_i)$ is the expected return on the portfolio i

R_f is the return on the risk free asset

β_i is the covariance of returns on portfolio i relative to the risk on the market.

According to the basic CAPM model the single most important factor that drives returns is the level of risk The higher the level of risk, the greater the reward for taking the risk and the higher the expected return on the portfolio, and vice versa.

Black (1972) relaxes the assumption of a risk-free asset. This leads to the following model

$$E(R_i) = E(R_z) + [E(R_M) - R_f]\beta_i \qquad (3.2)$$

where $E(R_z)$ is the return on a zero-beta portfolio. This zero-beta portfolio is a minimum variance portfolio chosen to be uncorrelated with the market portfolio. In this model β is still the appropriate measure of risk and the model is still linear.

In 1973 Merton produced a significant development in the theory of the CAPM. He derived the CAPM in continuous time. This model became known as the Intertemporal CAPM (ICAPM). Under a non-stochastic interest rate the ICAPM is the same model as the Sharpe (1964) model. This implies that the model is the same in continuous time.

However, the nonstochastic interest rate is a very unrealistic assumption. This is because we are assuming that there is no random effect in the interest rate. We are assuming that the interest rate is the same as the risk free rate in the economy. In reality this is not the case. Merton realised this and he derived the following ICAPM model with a stochastic interest rate.

$$E(R_i) = E(R_z) + [E(R_M) - R_f]\gamma_{1i} + [E(R_N - R_f]\gamma_{2i} \tag{3.3}$$

Under the ICAPM the investor faces another source of risk. Since we have continuous time there is a risk of shifts in the investment opportunity set that the investor faces. Therefore as we can see from equation (3.3), there are now three funds that are used to price assets. The risk-free asset, the market portfolio, and a portfolio that has perfect negative correlation with the risk-free asset.

Jagannathan and Wang (1986) extended the CAPM to be able to include nonmarketable assets such as human capital. They found that when investors hold nonmarketable risky assets such as human capital (which may be a risky component of wealth) we have the following model.

$$E(R_i) = R_f + \lambda[V_M \sigma_{iM} + \sigma_{iHC}] \tag{3.4}$$

Where λ is the covariance between the market and human capital

V_M is the value of marketable assets

HC denotes human capital which is a nonmarketable asset.

In 1976 Ross developed an alternative asset pricing model to the CAPM which was called the Arbitrage Pricing model (APT). Ross's reason for the use of the APT model rather then the CAPM was the following.

The CAPM is a single index model. We can see this in the following equation.

$$R_{it} = \alpha_i + b_i R_{Mt} + \upsilon_{it} \tag{3.5}$$

We are assuming that an investor holds portfolio i at time period t. The return on his portfolio depends on a single factor, which is the return on the market. So it is a single index model.

Ross's argument is that the return of the portfolio depends on more then one factor. In fact, he claims that the return on the portfolio depends on k factors, which are many factors. So he proposes that assets should be priced using the following k factor model.

$$R_{it} = \alpha_i + b_{i1}F_{1t} + b_{i2}F_{2t} + ... + b_{ik}F_{kt} + e_{it} \tag{3.6}$$

Where F_k is the K th common factor affecting returns;

b_{ik} is the sensitivity (β) of returns to F_k ;

e_i is idiosyncratic risk.

The APT model is essentially a k-factor model and is very similar to the above k-factor model. Ross's APT model states that the expected return can be written as

$$E(R_i) \approx \lambda_0 + \sum_{j=1}^{k} b_{ij}\lambda_j$$

or

$$E(R) \approx \lambda_{0i} + \beta_k \lambda_k \tag{3.7}$$

where: λ_0 is the return on the risk-free asset

i is the $N \times 1$ vector of one's

λ_k is the $K \times 1$ vector of prices of risk.

The central idea of the APT model is the following. In equilibrium, all portfolios that use no wealth (this can be achieved by selling some assets and using the proceeds to buy others) and have no risk must on average earn no return.

Such portfolios are called arbitrage portfolios. Therefore, the model implies that if assets are not priced correctly, arbitrage occurs in the market until they are priced correctly. A further implication of the APT theory is that the prices of risk (λ) are the same for all securities. The only thing that differs across securities is their sensitivity to the k factors. This means that the b differs across assets.

During the 1960's and the 1970's the CAPM and the APT models were used as the asset pricing models. However in the 1980's more sophisticated models were considered, so the obvious question is why were these models considered? They were considered because the static models considered so far have the following problems.

- Consumption is ignored.
- Preferences are defined over wealth one period in the future.
- Investors consume all their wealth after one period.
- Defining preferences over wealth is the same as defining them over consumption.

Therefore the solution is to consider multi-period consumption based asset pricing models. Before, we can go into the use of these models we have to look at the stochastic discount factor of any general asset pricing model.

According to Campbell, Lo and Mackinlay (1997) virtually all asset pricing models imply the following:

$$E_t(M_{t+1}R_{it+1}) = 1 \tag{3.8}$$

if returns are defined as $R_{it+1} = \dfrac{P_{it+1} + D_{it+1}}{P_{it}}$

where: E_t is the conditional expectations operator

M_{t+1} is a stochastic discount factor

The next question that must be asked is why is the stochastic discount factor important? It is important for the following reasons:

- M_{t+1} gives the general asset pricing expression economic content.
- If $\ni M_{t+1}$ that satisfies $E_t(M_{t+1}R_{it+1}) = 1$ then all assets with the same payoff have the same price (the law of one price).
- If M_{t+1} is a strictly positive random variable then $E_t(M_{t+1}R_{it+1}) = 1$ is equivalent to a no arbitrage condition
  - all portfolios of assets with payoffs that cannot be negative but are positive with positive probability must have positive prices.
  - if markets are complete, this no arbitrage condition identifies M_{t+1} uniquely: it is the ratio of state prices divided by state probabilities.

- the form of M_{t+1} gives $E_t(M_{t+1}R_{it+1}) = 1$ empirical content.
- in an equilibrium asset pricing model , $E_t(M_{t+1}R_{it+1}) = 1$ arises as a first order condition for a representative consumer-investor's intertemporal optimization problem M_{t+1}, defined by the model.

The agent faces the following maximization problem

$$\max E_t[\sum_{j=0}^{\infty} \partial^j U(C_{t+j})] \tag{3.9}$$

subject to a budget constraint

$U(.)$ the utility function

C_t consumption at time t

∂ discount factor

The next question we have to ask is what links equation (3.9) to $E_t(M_{t+1}R_{it+1}) = 1$. There is a first order condition known as an Euler equation that links consumption and portfolio choice for this problem, which is the following

$$U'(C_t) = \partial E_t[R_{it+1}U'(C_{t+1})]. \tag{3.10}$$

This equation can be rearranged to give

$$E_t(R_{it+1})\partial \frac{U'(C_{t+1})}{U'(C_t)} = 1. \tag{3.11}$$

Defining $M_{t+1} = \partial \frac{U'(C_{t+1})}{U'(C_t)}$ yields $E_t(M_{t+1}R_{it+1}) = 1$. In this case, M_{t+1} is the intertemporal marginal rate of substitution (IMRS).

The next step is to define the utility function. The literature tends to assume a power utility function because it gives us a constant relative risk aversion. Therefore we assume the following utility function:

$$U(C) = \frac{C^{1-\gamma} - 1}{1-\gamma} \tag{3.12}$$

Where γ is the coefficient of relative risk aversion. This implies that the marginal utility is:

$$U'(C_t) = C_t^{-\gamma} \tag{3.13}$$

By substitution we get the following consumption- based asset pricing model.

$$E_t\left[R_{it+1}\partial\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\right] = 1 \tag{3.14}$$

The asset pricing model displayed in equation (3.14) can be extended in the following way. Assuming that a random variable, X, is conditionally lognormal and conditionally homoscedastic, we can define $r_{it} = \log(1 + R_{it})$ where

$R_{it} = \frac{P_{it} + D_{it}}{P_{it-1}} - 1$. We can write the asset pricing model as.

$$E_t\left[(1 + R_{it+1})\partial\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\right] = 1 \tag{3.15}$$

Assuming returns and consumption are jointly conditionally lognormal, take natural logs of the asset pricing model to give.

$$E_t(r_{it+1}) + \log\partial - \gamma E_t(\Delta C_{t+1}) + \frac{1}{2}(\sigma^2{}_i + \gamma^2\sigma^2{}_c - 2\gamma\sigma_{ic}) = 0 \tag{3.16}$$

The asset pricing model above implies the following about the risk premium for real excess returns.

$$\log E_t\left(\frac{1+R_{it+1}}{1+R_{ft+1}}\right)=\gamma\sigma_{ic} \tag{3.17}$$

Equation (3.17) is known as the equity premium. Given observed average stock returns, risk-free rate returns, consumption growth, and the covariance of stock returns with consumption growth, according to Mehra and Prescott (1985) the value of γ required to fit the equity premium is too high. This is known as the " Equity Premium Puzzle ".

This chapter explores the impact on the equity premium of a financial sector which charges a bid-ask spread on individual agents'asset trades. This is done by analyzing the Fisher (1994) asset pricing model where agents are restricted from trading securities directly with each other and instead are required to conduct their investment activities through a "mutual fund" operated by an external financial sector. Agents are permitted to trade riskless bonds at zero cost or invest in a portfolio of stocks through the financial sector as disparate bid and ask prices.

A crucial distinction is drawn in the transaction environment between the gross returns agents appear to earn in financial markets verses the net returns an agent actually receives for consumption. The chapter argues that, if asset trading is costly, then agents must be fairly compensated in the form of higher expected gross returns. It is argued that the equity premium should consist of two components, a risk component and compensation for trading costs.

This chapter investigates whether market frictions should be included in asset pricing models in the UK stock market. The investigation adopts a three-stage research strategy. First, we discuss the simple equilibrium transaction cost asset pricing model that was derived by Fisher (1994). Second, the equilibrium asset pricing relations from the model are formally tested using Hansen's (1982) Generalized Method of Moments (GMM) estimation technique with historic returns and transactions costs data for the UK stock market using monthly data for the time period 1980 to 2000. Third, we estimate the C-CAPM that incorporates transactions costs using the Vector Autoregressive (VAR) approach proposed by Campbell and Shiller (1988a). Two models are estimated using different measures of transactions costs in order to establish the robustness of the econometric evidence.

It was shown (Hansen, 1982) that expanding the set of variables that included in the orthogonality condition cannot increase the covariance matrix of the estimator, but it is important to note that this is an asymptotic result. Tauchen (1986) has investigated the small sample properties of the GMM estimator with a different number of instruments. The overall conclusion is that the best performance of the GMM estimator is obtained with a limited number of instruments. Even if the quality of the instruments appears to be statistically satisfactory within the sample, we still have the problem of the fact that GMM estimation deals with unconditional moments in the model. So a long time series is required to deliver consistent estimates. Restricting the model to small samples will affect the precision of the estimates and tests of the overidentifying restrictions on the model.

Therefore, in order to establish that the influence of transactions costs is not model dependent and that the results are robust, we also estimate the C-CAPM with transactions costs using the VAR methodology proposed by Campbell and Shiller (1988a) and compare the results.

The chapter is organized in the following way. Section 3.2 discusses the Fisher (1994) asset pricing model. Section 3.3 presents the empirical tests of the Fisher (1994) model using GMM estimation. Section 3.4 extends the C-CAPM model proposed by Campbell and Shiller (1988a) to include transactions costs and presents empirical tests of the extended model using a VAR methodology. Section 3.5 provides a summary and conclusion of our main findings.

3.2 The Fisher Equilibrium Model of Expected Returns with a Bid-Ask Spread

An agent in an economy is assumed to maximize expected utility over random consumption paths of an infinite time horizon i.e.

$$Max_{c_t s_t b_t} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{3.18}$$

Subject to:

$$c_t + P^a{}_t x_t + q_t b_t \leq s_{t-1} d_t + \Omega_t s_{t-1} P^b{}_t + b_{t-1} + F_t \qquad \text{for all } t \tag{3.19}$$

$$s_t = (1-\Omega) s_{t-1} + x_t \qquad \text{for all } t \tag{3.20}$$

Where c_t is per capita consumption, s_t are per capita share holdings at date t, b_t are per capita bond holdings at date t, β is the subjective discount rate and E_0 the expectations operator at date 0. d_t is a stochastic dividend stream accruing to stock holders and the risk-less bond holdings, b_t, denotes the payoff of one unit of consumption one period ahead. Ω_t is the proportion of an agent's stock portfolio liquidated in the financial sector and x_t represents the re-investment of funds in the mutual fund. q_t, $P^b{}_t$, and $P^a{}_t$ represent the frictionless bond price, the bid price, and the ask price for the share portfolio which are announced by the financial sector, with $P^a{}_t \geq P^b{}_t$. F_t denotes the lump sum per capita transfer payment from the financial sector.

The budget constraint presented in equation (3.19) restricts the agent to the following behaviour. The agent enters the period with s_{t-1} shares of stock and instantly collects his dividend, d_t, plus his bond payoffs. The cash flow from the liquidation of an agent's stock portfolio by the financial sector at the bid price is given as $\Omega_t s_{t-1} P^b{}_t$. The right-hand side of the constraint represents the agent's free cash flow consisting of dividends, the liquidated value of his share portfolio, bond receipts, and the transfer from the financial sector, F_t. The agent next considers how to allocate his wealth between consumption, new riskless bond issues, and rebalancing his mutual fund holdings. New shares must be purchased at the ask price, $P^a{}_t$, while bonds can be purchased at q_t.

Equation (3.20) specifies the law of motion governing mutual fund holdings. Since $\Omega_t s_{t-1}$ units of stock are liquidated within the financial sector, $(1-\Omega_t)s_{t-1}$ units remain untraded in the agent's portfolio. The desired level of stock holdings to carry forward into the next period, s_t, is attainable with the re-investment of x_t units in the fund.

Equations (3.18) to (3.20) describe the agent's maximisation problem. The agent must choose consumption, bond holdings, and share holdings to maximise expected utility subject to his budget constraint in each period. Calculating efficiency conditions with respect to c_t, b_t, and s_t, optimal asset choice in this economy can be shown to result in the following system.

$$\beta E_t u'(c_{t+1}) - u'(c_t)q_t = 0 \tag{3.21a}$$

$$\beta E_t u'(c_{t+1})\{\Omega_{t+1}P^b{}_{t+1} + (1-\Omega_{t+1})P^a{}_{t+1} + d_{t+1}\} - u'(c_t)P^a t = 0 \tag{3.21b}$$

$$b_{t-1} + s_{t-1}d_t + s_{t-1}P^b{}_t + F_t - q_t b_t - c_t - s_t P^a{}_t = 0 \qquad \text{for all } t \tag{3.21c}$$

The determination of the bid and ask prices takes place in the financial sector. It is assumed that the financial sector calculates the bid and ask prices by applying a proportional transaction cost to equity trades. This per transaction service charge is added or subtracted from the market price so that the bid and ask prices can be represented as:

$$P^b{}_t = P_t(1-\alpha) \tag{3.22a}$$

$$P^a{}_t = P_t(1+\alpha) \tag{3.22b}$$

Where α is the proportional transaction costs. To close the model the financial sector is constrained to rebate its earnings to agents each period and so obeys the following budget constraint.[39]

$$F_t = x_t P^a{}_t - \Omega_t s_{t-1} P^b{}_t \tag{3.23}$$

[39] This assumption has two purposes: (1) it ensures the existence of a suboptimal competitive equilibrium and (2) it simplifies the solution method used to simulate the model. Alternative rebating schemes will not affect the equilibrium provided they are not related to the investment decision.

The right-hand side of equation (3.23) represents the net per capita cash flows of the financial sector generated in the stock and bond markets from the agents' trading activity.

The objective of this model is to derive expressions determining expected gross returns. Accordingly, substituting equations (3.22a), (3.22b) and (3.23) into equations (3.21a)-(3.21c) and imposing the asset market-clearing conditions that $s_{t-1} = s_t = 1$ and $b_{t-1} = b_t = 0$ provides an equilibrium pricing relation of the form.

$$u'(c_t)q_t = \beta E_t u'(c_{t+1}) \tag{3.21a'}$$

$$u'(c_t)P_t = \beta E_t u'(c_{t+1})\left(\frac{d_{t+1}}{1+\alpha} + \left[1 - \frac{2\alpha\Omega_{t+1}}{1+\alpha}\right]P_{t+1}\right) \tag{3.21b'}$$

$$c_t = d_t \tag{3.21c'}$$

Equation (3.21a') is the familiar pricing equation for a security, which pays off one unit of consumption one period ahead under uncertainty. Equation (3.21c') ensures that, consistent with equilibrium in an endowment economy, output is consumed each period.

Equation (3.21b') deserves careful consideration. This expresses the equilibrium pricing relation in terms of the market price of the stock portfolio P_t. From the agents point of view this pricing equation has two crucial features. First, the capital gains and the dividend components of the expected gross return on the share portfolio are treated differently by the agent. To receive an additional unit of income in the form of dividends one period ahead an agent must purchase shares at the ' ask price'. However, since future dividends are paid to the shareholder directly, there are no transaction costs incurred on receiving a security's payoffs in this form. Equation (3.21b') shows that dividend income is discounted by the factor $(1/1+\alpha)$ to adjust for the marginal transaction cost of share purchases out of future dividends. The capital gains component of an agent's cash flow, alternatively, is earned by liquidating securities in the secondary market.

From the agent's viewpoint, the possibility of future liquidations of stock by mutual fund managers is a cost of holding equity in addition to the marginal cost of purchasing shares. Whilst the non-liquidated proportion of a stock portfolio may be carried forward into future periods. Thus the capital gains component of share ownership is discounted by the factor

$$\left[1-\frac{2\alpha\Omega_{t+1}}{1+\alpha}\right]$$

in equation (3.21b').[40]

In the same equation it is apparent that prices also depend upon the expected future turnover rate (Ω_{t+1}). This is unlike most asset pricing models that do exhibit such dependence upon a measure of turnover. The inclusion of this measure provides for the distinction between expected asset returns and implied asset trades. That is expected returns must reach a threshold for a trade to occur. Conventional models do not allow for this thus implying 'too frequent' trading.

Equation (3.21b') shows that when liquidating assets is costly, the proportion of a portfolio that is traded is an important determinant of the price of an asset in equilibrium. Expected returns should reflect the expected costs of trading assets. The pricing equation provides a link between turnover in financial markets and the price an optimizing agent is prepared to pay for an asset in the market. A model that breaks the separation between

[40] In the certainty case, capital gains are discounted at a higher rate than dividends when $\Omega_{t+1} \succ 0.5$, reflecting the high costs of liquidating claims each period.

asset prices and trading volume is appealing once it is recognized that portfolio reallocation is costly. Higher asset turnover must necessarily generate higher transaction costs which agents should expect to be compensated for in the form of higher expected returns.

The effect of introducing the bid-ask spread and asset turnover into the agent's optimization problem will lead ceteris paribus to a higher expected return on risky equity to compare to the case of a zero bid-ask spread. The quantitative significance of the effects of these variables requires a formal estimation and this is the focus of the next section.

3.3 Generalized Method Of Moments Estimation

This section formally tests the Fisher (1994) model discussed is section 3.2 using the GMM technique set out in Hansen (1982). Section 3.3.1 expresses the gross equity premium as a function of the state variables and exogenous parameters in the model to deliver a reduced form amenable to testing the GMM. Section 3.3.2 describes the data employed to test the model. Section 3.3.3 presents the results of the tests.

3.3.1 Calculating the Equity Premium

Define $R_t = (P_{t+1} + d_{t+1}) / P_t$ and $R^f{}_t = (1/q_t)$. Then equations (3.21a') and (3.21c') combine to give:

$$1 = \beta E_t \frac{u'(d_{t+1})}{u'(d_t)} R^f{}_t \qquad (3.24)$$

Similarly, equations (3.21b') and (3.21c') result in the following expression.

$$1 + \alpha = \beta E_t \frac{u'(d_{t+1})}{u'd_t} R_t + \beta E_t \left\{ \frac{u'(d_{t+1})}{u'(d_t)} \frac{P_{t+1}}{P_t} (\alpha - 2\alpha\Omega_{t+1}) \right\} \qquad (3.25)$$

We assume that agents' utility is given by a time-separable, constant relative risk aversion utility function of the form.

$$u(c_t) = \frac{c_t^{1-\gamma} - 1}{1-\gamma} \qquad \gamma \succ 0, \ \neq 1$$

$$= \log c_t \qquad \gamma = 1$$

The marginal rate of substitution can be represented as:

$$\frac{u'(d_{t+1})}{u'(d_t)} = \left(\frac{d_{t+1}}{d_t}\right)^{-\gamma}$$

Making this substitution and subtracting equation (3.24) from equation (3.25) gives the following solution:

$$\beta E_t \left(\frac{d_{t+1}}{d_t}\right)^{-\gamma} \left\{ (R_t - R^f{}_t) + (\alpha - 2\alpha\Omega_{t+1}) \frac{P_{t+1}}{P_t} \right\} - \alpha = 0 \qquad (3.26)$$

Equation (3.26) is a nonlinear stochastic Euler equation of the form

$$E_t h(x_{t+1,} \lambda_0) = 0$$

Where:

$$x_{t+1} = \left[\frac{d_{t+1}}{d_t}, R_t - R^f{}_t, \frac{P_{t+1}}{P_t}, \Omega_{t+1} \right]$$

is a vector of variables observed at date $t+1$, while $\lambda_0 = [\alpha, \beta, \gamma]$ is an unknown parameter vector to be estimated. E_t is the expectations operator at date t conditioned on all variable information.

The estimation procedure described in Hansen and Singleton (1982) can be implemented in two steps using standard gradient methods for nonlinear least squares estimation. This is undertaken for the reduced form (3.26).

3.3.2 Data Description

Monthly data are collected for the FTSE All Share Index for the time period 1980-2000.[41] Following Brown and Gibbons (1985), the variable $d_{t+1} - d_t$ is proxied using the growth rate of private consumption. UK stock returns on the FTSE All Share Index and the returns on 3-month treasury bills are used to generate the series for $R_t - R^f{}_t$.

Following the methodology suggested by Fisher (1994) we obtain a measure of stock market price growth, P_{t+1} / P_t, using the FTSE transportation and industrial indices from 1980 to 2000. We calculate a composite FTSE Index by combining the transportation and industrial indices with weights calculated to reflect the number of stocks represented by each index.[42]

Finally the data used to calculate the turnover rate are taken as a proxy for Ω_t and Ω_{t+1} in x_{t+1}. We calculate the turnover rate using data from the FTSE All Share Index as

$$\Omega_t = \frac{(\text{Total number of shares traded})_t}{(\text{Total number of shares outstanding})_t}.$$

[41] The problem with monthly data is that it may suffer from seasonal effects. In order to overcome this problem we collect seasonally adjusted data.

[42] Nominal stock prices and consumption are deflated by the implicit consumption deflator.

Theoretically, an infinite number of potential instruments are contained in individuals' information sets but these are not specified by the theory. This study follows Hansen and Singleton (1982) by using a constant, c, and lagged values of the state vector, so that $z_t = [c, x_1, x_{t-1}, \ldots\ldots\ldots, x_{t-n+1}]$ for n lags.[43] In practice the lag length is set at $n = 1$, 2, and 4.[44] The sensitivity of these results to the choice of instruments is investigated using the methods recommended by Pagan and Jung (1993) and Staiger and Stock (1993).[45]

3.3.3 Results

For the optimization algorithm to converge it is necessary to restrict one of the parameters. Since the subjective discount factor is the parameter of least interest in the present study, it is restricted to assume the value $\beta = 0.99$ in line with economically acceptable values for this parameter.[46] The results therefore report estimates for $\hat{\lambda}_0$ conditional on one element being fixed. Restricting β places restrictions on other aspects of the model. Equation (3.21a') shows, for instance, that β is a major determinant of the level of the risk-free rate.

Table 3.1 shows the parameter estimates of the following model for the entire samples from 1980 to 2000.

$$\beta E_t \left(\frac{d_{t+1}}{d_t} \right)^{-\gamma} \left\{ (R_t - R^f{}_t) + (\alpha - 2\alpha\Omega_{t+1}) \frac{P_{t+1}}{P_t} \right\} - \alpha = 0$$

---

[43] The turnover rate is differenced in the instrument vector to ensure stationarity so that Ω_t and Ω_{t-1} appear in the z_t vector as $\Omega_t - \Omega_{t-1}$.

[44] This is the lag length that was suggested by Fisher (1994).

[45] We collect all the data with the use of Datastream.

[46] Mehra and Prescott (1985) calculate the discount rate to be equal to 0.99 using US historical data from 1900-1985.

Table 3.1 is arranged to report the values of $\hat{\alpha}$ and $\hat{\gamma}$ together with the chi-square statistic testing the overidentifying restrictions of the model and its p-value. The null for this test is that the overidentifying orthogonality restrictions are satisfied.

TABLE 3.1. GMM estimates for the period 1980-2000

NLAG	NOBS	$\hat{\alpha}$	$\hat{\gamma}$	χ^2	Degrees of freedom	p-value
1	239	0.013 (2.10)*	2.79 (2.62)*	2.61	3	0.106[a]
2	238	0.022 (2.09)*	2.997 (2.89)*	4.33	7	0.227[a]
4	236	0.076 (2.42)*	3.86 (2.49)*	4.96	15	0.664[a]

Notes:

$\hat{\gamma}$ is the estimate of the coefficient of relative risk aversion.

$\hat{\alpha}$ is the estimate of the coefficient of transactions costs.

The subjective discount factor is restricted to assume the value of β=0.99.

White consistent adjusted t-statistics shown in brackets () and * indicates significance at 5% level.

Instrumental variables used are [z_t = constant, $x_t,\ldots,x_{t-n}+1$] for n=n lag and

$$x_t=\left[\frac{d_{t+1}}{d_t}, R_t-R^f{}_t, \frac{P_{t+1}}{P_t}, \Omega_t-\Omega_{t-1}\right]$$

representing, respectively, output growth, the equity premium, FTSE price index growth, and the difference of the FTSE turnover rate and its lag.

[a] Do not reject the hypothesis that the overidentifying restrictions are orthogonal to the errors at the 5% level of significance.

For the full sample Table 3.1 reports estimates of $\hat{\alpha}$ which range between 0.013 and 0.076 depending upon the number of instruments selected. This corresponds to an estimated bid-ask spread of 1.3% to 7.6%. Estimates of the risk aversion parameter lie between 2.79 and 3.86.

The Wald test of the overidentifying restrictions of the model never rejects the null hypothesis at the 5% level of significance. The exact impact of the transactions costs embedded in the null hypothesis depends on the lag structure of the chosen instrument set. The test for the overidentifying restrictions cannot be rejected at conventional levels of significance for the chosen information structures.

When the instrument set is reduced to the first lag, the first row of the Table reports estimates of $\hat{\alpha} = 0.013$ and $\hat{\gamma} = 2.79$. This implies a bid-ask spread of 1.3%, which seems low compared to Fisher's (1994) estimate of 9.4% and Stoll and Whaley's (1983) estimate of 2.79%.[47] The effect of adding more instruments is inconclusive. If two lags of the instrument set are employed, the p-value is 0.227, while the value of $\hat{\alpha} = 0.022$, which implies a bid-ask spread of 2.2%. If four lags of the information are used, the estimate $\hat{\alpha} = 0.076$ implies an implausibly large value of the bid-ask spread of 7.6%.

On the whole our results are realistic when we compare them to other studies. According to Stoll and Whaley (1983) the estimate for the bid-ask spread should be around 2.9%.

The most important result in our study are the significance of the transactions costs in the estimated equation. The parameter α is significantly different from zero based on t-statistics, indicating that transactions costs are important in asset pricing. We also find that γ is significantly different from zero irrespective of the chosen instrument set. Our estimates of the parameter appear very reasonable in terms of economic theory and close to ones estimated by Fisher (1994) for the US. The stability, the estimates, (vis-a-vis the information set) and statistical significance indicate that risk aversion is important and must be included in asset pricing. The results are suggestive of strong support of the hypothesis that transactions costs are important determinants in asset pricing.

[47] Stoll and Whaley (1983) estimate the bid-ask spread on the NYSE between the time period of 1961-1981.

Since the GMM results are based on an instrumental variables estimation procedure, the credibility of the results depend on the quality of the instruments that are used. Pagan and Jung (1993) point out instances where the performance of the GMM estimator in small samples is poor due to poor instruments, and suggest diagnostic tests to evaluate the efficiency of the procedure. In the present context, the tests of the overidentifying restrictions and the parameter estimates reported in Table 3.1 might be misleading if the instruments are weakly correlated with the endogenous components of the stochastic Euler equations comprising the restrictions from the model.

Pagan and Jung (1993) suggest that (1) calculating the R-squared from regressing the derivatives of the Euler equations with respect to the estimated parameters against the instrument set and (2) an examination of the cross-correlations of these derivatives provide a check on the likely performance of the GMM estimator.[48] The results of these diagnostics are reported in Table 3.2 for the derivatives of the moment conditions with respect to α and γ for each set of instruments.

[48] In applied work such as this, Pagan and Jung (1993) recommend that the derivatives be evaluated using the point estimates from the GMM estimator. In addition, the correlations of the derivatives with respect to each parameter will influence the performance of the estimator.

TABLE 3.2. Diagnostic tests examining the efficiency of the instruments employed in the GMM estimates of the model

Instrument set NLAG	$R_\alpha^{\ 2}$	$R_\gamma^{\ 2}$	$Cor\left(\frac{\partial h_t}{\partial \alpha}, \frac{\partial h_t}{\partial \gamma}\right)$
1	0.049	0.007	-0.69
2	0.016	0.042	-0.71
4	0.011	0.002	-0.77

Notes:

$R_\alpha^{\ 2}$ denotes the R-squared from the regression of $\frac{\partial h_t}{\partial \alpha}$, against the instrument set.

$R_\gamma^{\ 2}$ denotes the R-squared from the regression of $\frac{\partial h_t}{\partial \gamma}$, against the instrument set.

$Cor\left(\frac{\partial h_t}{\partial \alpha}, \frac{\partial h_t}{\partial \gamma}\right)$ is the correlation of the partial derivatives evaluated at the point estimates from each instrument set.

Denoting $R_\alpha^{\ 2}$ and $R_\gamma^{\ 2}$ as the R-squared from the regression of the derivatives against the bid-ask spread and the risk aversion parameter respectively, $R_\alpha^{\ 2}$ peaks at 0.049 with 1 lag of the instrument set while $R_\gamma^{\ 2}$ peaks at 0.042 with 2 lags of the instrument set. The correlations of the partial derivatives reported in the final column of Table 3.2 are quite strong at around an average of –0.72, so that it is difficult to make independent statements about the efficiency of each parameter estimate.

Based on the results of Table 3.2, the instrument sets employed in the GMM estimation do not diminish confidence in the estimation procedure. The diagnostics do suggest, however, that the estimate of the bid-ask spread parameter is relatively more efficient then that of the risk-aversion parameter.

The results so far are indicate that as we vary the instrument lag structure the estimates of the parameters (especially those of α) change. The resulting test statistics cannot provide us with an unambiguous choice of α. It appears to us the estimate of 2.2% is the one most consistent with observation.

3.4 Present Value Tests of the CCAPM including Transactions Costs

In the presence of the problem that was discussed above, Lund and Engsted (1996) suggest that the only way to obtain robust results of the C-CAPM is to estimate the model using both the GMM methodology and the VAR methodology proposed by Campbell and Shiller (1988a). The difference between the two methodologies is that the GMM methodology is based on the orthogonality condition given by the first order condition of the inter-temporal optimization problem (the Euler equation). The VAR approach is based on the linearised present value model that can be derived from the Euler equation. In other words, the difference between the two methodologies is the following.

The GMM uses information in order to derive an estimate of the bid-ask spread. From this estimate a t-statistic is calculated and the significance of the bid-ask spread in asset pricing models is evaluated. The GMM has two shortcomings; first, the results depend on the quality of the instruments that are used to proxy for the information, and second, the coefficient and the significance of the bid-ask spread variable are sensitive to the lag structure of the instruments.

However, the VAR approach differs from the GMM because it uses actual data on the bid-ask spread to calculate a test statistic to evaluate the significance of the bid-ask spread in asset pricing models. The VAR approach estimates the C-CAPM with the bid-ask spread included as an additional explanatory variable. The bid-ask spread is then tested for significance. The VAR approach provides further corroborative evidence, to the GMM based model, as the econometric results do not depend on instruments, as they are not required for the estimation.

In the next section of this chapter we extend the VAR approach proposed by Campbell and Shiller (1988a) to include the bid-ask spread as an explanatory variable in the CCAPM. We then perform statistical tests to determine whether the bid-ask spread should be included in the CCAPM.

3.4.1 The Model

Following Lucas (1978) we assume the existence of a representative investor who chooses to consume and invest in a single asset (a stock index) so that at each time t she maximizes expected lifetime utility

$$MaxE_t\left[\sum_{\tau=0}^{\infty}\beta^{\tau}U(C_{t+\tau})\right]; \tag{3.27}$$

Subject to the budget constraint

$$C_t + S_t W_t = R_t S_t W_{t-1}; \qquad R_t = \frac{(P_t + D_t)}{P_{t-1}}, \tag{3.28}$$

Where:

W_t is the wealth invested in the stock index, at time period t.

C_t is the real consumption, at time period t.

P_t is the ex-dividend real stock price, at time period t.

D_t is the real dividend received between time $t-1$ and t.

S_t is the bid-ask spread at time period t.[49]

[49] Transactions costs are proxied by the bid-ask spread. Transactions costs are included as a single variable because both the Augmented Dickey Fuller (ADF) test (1981) and the Phillips Peron (PP) test (1988) suggest that the ask price minus the bid price follows a stationary process.

We include transactions costs in the budget constraint of the investor. In this set-up the investor now has two budget constraints, the usual wealth constraint and the transactions costs that are incurred whenever she decides to trade the asset.

The first-order condition in this maximization problem is the stochastic Euler equation (Lucas, 1978).

$$E_t\left[\beta\frac{U'(C_{t+1})}{U'(C_t)}R_{t+1}S_{t+1}-1\right]=0 \tag{3.29}$$

Lucas (1978) considers a pure exchange economy with one perishable consumption good. This implies that we can ignore consumption decisions because by definition the representative investor must consume the entire income. However, with the utility function used below the equation above also obtains in the general production economy of Breeden (1979) and Cox et al (1985) where consumption and investment decisions are made jointly. In order to obtain testable implications we must specify a utility function for the representative investor. As in most other studies Campbell and Shiller (1988a) use the constant relative risk aversion (CRRA) utility function: We can now go on and test the C-CAPM under transactions costs using the present value test suggested by Campbell and Shiller (1988a).

We begin by defining h_{1t} as the logarithm of the utility-adjusted return, which is expressed by the following equation[50]:

$$h_{1t}=\log\left(\frac{U'(C_{t+1})}{U'(C_t)}R_{t+1}(S_{t+1})\right)=\log\left(\left(\frac{P_{t+1}+D_{t+1}}{P_t}\right)-\left(\frac{S_{t+1}}{S_t}\right)\right)+\alpha\left(\frac{C_{t+1}}{C_t}\right) \tag{3.30}$$

[50] The derivation of the utility adjusted return can be seen in appendix B.

$$= \log\left(\exp(\delta_t - \delta_{t+1}) + \exp(\delta_t)\right) + \Delta d_{t+1} - \Delta S_{t+1} + \alpha \Delta c_{t+1},$$

Where $\delta_t = \log\left(\frac{D_t}{P_t}\right)$, $d_t = \log(D_t)$, $S_t = \log(S_t)$ and $c_t = \log(C_t)$

Next, we linearize (3.30) around the point $\delta_t = \delta_{t+1} = \delta$:

$$h_{1t} \approx \delta_t - \rho\delta_{t+1} + \Delta d_{t+1} - \Delta S_{t+1} + \alpha\Delta c_{t+1} + K = \xi_{1,t}. \tag{3.31}$$

Here, $\rho = \frac{1}{(1+\exp(\delta))}$; while K is an inessential constant from the linearization.

Define variable ξ_1, by the sum of $\xi_{1,t}$ we have

$$\xi_1 = \sum_{j=0}^{i-1} \rho^j \xi_{1,t+j} = \delta_t - \rho^i \delta_{t+i} + \sum_{j=0}^{i-1} \rho^j \left(\Delta d_{t+j+1} - \Delta S_{t+j+1} + \alpha\Delta c_{t+j+1}\right) + \frac{1-\rho^i}{1-\rho} K. \tag{3.32}$$

We assume that $E_t(\xi_{1,y+j})$ is equal to a constant c for all $j \geq 0$. In equation (3.30) we expect $E_t(\xi_{1,y+j})$ to be close to $-\log(\beta)$, so the linearisation is a good approximation of (3.30). Given that this holds, we take conditional expectations on both sides of (3.32) and whilst we allow $i \to \infty$. After some manipulations we obtain the following equation.

$$\delta_t = -\sum_{j=0}^{\infty} \rho^j E_t\left(\Delta d_{t+j+1} - \Delta S_{t+j+1} + \alpha\Delta c_{t+j+1}\right) + \frac{c-K}{1-\rho}, \tag{3.33}$$

Since lim $\rho^i E_t(\delta_{t+i}) = 0$ as $i \to \infty$ (otherwise δ_t is non-stationary with an explosive root indicating that stock prices are driven by a rational bubble).[51]

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[51] Note that by letting the VAR model be formulated in terms of changes in dividends and consumption in terms of the dividend-price ratio instead of stock prices themselves, the results are robust to possible nonstationarity of p_t, d_t, S_t and c_t.

With the use of equation (3.33) we can perform a statistical test to discover whether transactions costs should be incorporated in the C-CAPM. If transactions costs should be included, then the coefficient associated with ΔS_t will be statistically significant in the VAR model. We can employ this test by testing the cross-equation restrictions implied by the underlying theory on a VAR model. We define a limited information set H_t containing past and present values of $x_t = (\delta_t, \Delta d_t, \Delta c_t, \Delta S_t)'$, and assume that expectations conditional on H_t are linear projections on the information set.

This corresponds to the $\text{VAR}(p)$ specification:

$$z_{t+1} = Az_t + u_{t+1} \tag{3.34}$$

Where $z_t = \left(x_t - E(x), \ldots, x_{t-p+1} - E(x)\right)$ is a $4p \times 1$ vector and A is the $4p \times 4p$ companion matrix of the $\text{VAR}(p)$ system. See Campbell and Shiller (1987, 1988a) for details.

3.4.2 Data Description

For this application we are using monthly seasonally adjusted aggregate consumption expenditure data for the UK. For the dividend to price ratio we collect data on the price and dividend yield of the FTSE All Share Index. The bid-ask spread is calculated by collecting data on the bid price and the ask price on the FTSE All Share Index. Nominal stock prices, dividends and consumption are deflated by the implicit consumption deflator. The time period of the data is between 1980-2000. All the data are collected from Datastream.

3.4.3 Results

We can test if transactions costs are statistically significant in the C-CAPM by employing the Granger-Causality tests proposed by Lund and Engsted (1996).[52] If past values of the changes in the bid-ask spread predict the dividend-price ratio, one can say that bid-ask spreads "Granger-cause" dividend yield. This would imply that transactions costs are statistically significant in the C-CAPM, which would therefore suggest that transactions costs are important in asset pricing models. We test this hypothesis in the context of the following regression:

$$\delta_t = \sum_{k=1}^{2} \alpha_k Z_{t-k} - \sum_{k=1}^{2} \beta_k \Delta S_{t-k} + u_t \qquad (3.35)$$

where Z denotes all other information

Where k represents the number of months each variable is lagged and the variables are as defined earlier and test the restriction:

$$\sum \beta_k = 0, \ \forall k$$

In this case the lags of both Z and ΔS are equal to 2[53]. The test results in an F-statistic of 5.04 with a p-value of 0.02. The null hypothesis is rejected, implying that past values of the change in bid-ask spreads do affect the dividend yield. This leads us to conclude that transactions costs should be included in the C-CAPM.[54]

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[52] For more details on Granger-Causality tests see Granger (1969).

[53] Both the Akaike information criterion and the Schwartz Bayesian criterion suggest that the optimal lag for Z and ΔS is equal to 2.

[54] The estimation of the entire equation (3.35) accompanied with diagnostic tests can be seen in Table 3.3, which can be found in appendix C.

We can obtain a measure of transactions costs by solving equation (3.35) for the expectation of δ with respect to ΔS, given the fact that ΔS is stationary.

From equation (3.35) we find that when δ is equal to 4.02% p.a.(the sample mean), transactions costs are equal to 2.64% p.a.. This estimate mimics closely our previously obtained value of 2.2% (under GMM with two lags).

It is very encouraging that using two different methodologies result in almost identical estimates regarding the importance of transactions costs in the UK equity market. Transactions costs were shown to have an independent influence in the presence of other market information and their inclusion in the pricing model does not depend neither upon the chosen functional form nor the chosen estimator.

3.5 Discussions and Conclusions

In this chapter we tested if transactions costs should be included in asset pricing models. We tested this hypothesis by using two different methodologies. First, we apply the equilibrium asset pricing model proposed by Fisher (1994). The Fisher (1994) model is unique from other asset pricing models because it includes the bid-ask spread as a variable that influences excess returns, whereas the more traditional asset pricing models include only the level of risk as the factor that influences excess returns.

We estimate the Fisher (1994) model with the GMM estimation technique of Hansen (1982) using seasonally adjusted monthly data for the UK stock market over the time period of 1980-2000. The formal GMM tests of the model yield economically plausible values of the unknown parameters, and tests of the overidentifying restrictions of the model could not be rejected.

The model appears to perform relatively well when confronted with data. The parameter associated with our chosen proxy for the bid-ask spread as well as the risk-aversion parameter was found to be significant for all the different instrument sets that we tested. This lead us to conclude that both transactions costs and risk should be included in asset pricing models, due to our evidence from the UK stock market. Fisher (1994) has also found similar evidence of the importance of transactions costs in asset pricing with respect to the US stock market.

As the GMM estimation procedure relies heavily on the quality of the instruments, we therefore tested the quality of the instruments of our model using the diagnostic tests proposed by Pagan and Jung (1993). We found the instruments to be adequate, a result that for our estimation period and sample overcame a fundamental problem with the GMM estimation technique. In order to establish the robustness of our results we tested the same hypothesis in the context of the C-CAPM under transactions costs using a different methodology that does not suffer from the problems of the GMM.

We provide further evidence of the relationship between the dividend to price ratio and the bid-ask spread. We found that when transactions costs are equal to 2.64%. pa. the resulting dividend yield equals to 4.02% pa. (for any given total return).

Our findings would appear to have important implications for the many empirical studies that use some version of the CAPM to adjust for risk. Databases such as those compiled by the Center of Research in Security Prices only report gross returns on a daily, monthly or annual basis. This means that researchers using gross returns data to adjust for risk without specifying structural assumptions on the transactions technology may bias their results. We very rarely see such assumptions being stated explicitly.[55]

The many studies that document anomalies in financial markets as well as the many that are consistent with market efficiency may have been predicted upon data that do not fit the specifications of the hypotheses being tested. The empirical findings in this chapter give evidence to suggest that this criticism cannot be dismissed.

[55] Deechow (1990) makes this point with reference to the detection of accounting anomalies.

Chapter 4

Information Asymmetry and the Bid-Ask Spread: Evidence from the UK

4.1 Introduction

One of the most important characteristics that investors look for in an organized financial market is liquidity. Liquidity is the ability to buy or sell significant quantities of a security quickly, anonymously, and with relatively little price impact. To maintain liquidity, many organized exchanges use market makers, who are individuals who stand ready to buy or sell whenever the public wishes to buy or sell. In return for providing liquidity, market makers are granted monopoly rights by the exchange to post different prices for purchases and sales. They buy at the bid price, P_b and sell at a higher ask price P_a. This ability to buy low and sell high is the market makers' primary source of compensation for providing liquidity. Their compensation is defined as $P_a - P_b$, which is defined as the bid-ask spread.

The quoted spread covers the costs of order processing, holding the inventory and adverse information costs. Empirical studies, Stoll (1989), Glosten and Harris (1988) and more recently, Atkins and Dyl (1997) and Menyah and Paudyal (2000) relate the spread or the change in the spread to a vector of characteristics that are associated with the individual securities such as trading volume, the risk of the security (normally approximated by the standard deviation of returns over a given period), the stock price and the firm's market value. This set of characteristics is augmented by the addition of factors that relate to the specific market where the stocks are traded.

The influence of new, firm specific, information on market liquidity (the bid-ask spread) and volume is examined in two papers by Kim and Verrecchia (1994, 2001). In their first paper they show that just prior to earnings disclosure by firms, the spread increases as market makers protect themselves from the informed traders. When firms defer reporting of performance, this is perceived as evidence of 'extreme' results, that will endow informed traders with additional informational advantage they will try to exploit. Faced with this situation market makers will attempt to infer the appropriate signals from the trading volume, and discourage trading by reducing liquidity.

The relevant literature suggests a variety of determinants of the bid-ask spread in equity markets. These include volume and some measure of risk associated with the returns of the particular share. In this study we argue for the formulation of a model that incorporates in addition to volume and risk, the range of analysts' forecasts as proxies for the uncertainty surrounding the performance of the shares beyond the year-end, related to the probability of disclosure deferral. Daley, Senkow and Vigeland (1988) find that the implied volatility in option prices is associated with the variance of analysts' forecasts. This suggests that investor's find that the disagreement among analysts is a useful indicator of the market's uncertainty. Such uncertainty may be interpreted by investors as meaning that the company will report poorer than expected performance, and also that there could be some delay in disclosing the year end results.

Whittred and Zimmer (1984) find that the reporting of results is significantly delayed by companies with poor performance. Therefore analysts' disagreement may be interpreted by market makers as information about the likelihood of a deferred report which would heighten adverse selection as suggested by Kim and Verrecchia (2001).

The contribution of this study is the robust estimation of a spread equation for the UK FTSE-100 stocks that incorporates the variance of analysts' forecasts over different horizons and the firm's market value, in addition to the more traditional variables such as volume and the variance of returns. In the following section, section 4.2, we discuss in some detail the rationale for the chosen specification. The data are discussed in section 4.3. The adopted econometric methodology and the results are presented in section 4.4. Finally section 4.5 contains our conclusions.

4.2 Theoretical Considerations

Atkins and Dyl (1997) model the bid-ask spread as a linear function of the market value of the firm and the volatility of returns:

$$Spread_i = \beta_1 + \beta_2 MktVal_i + \beta_3 Var\,\mathrm{Re}t_i + \varepsilon_i \qquad (4.1)$$

Where $Spread_i$ is the average percentage bid-ask spread of firm i over a given period, $Mktval_i$ is the average market value of firm i over the period, $Var\,\mathrm{Re}t_i$ is the variance of firm *i's* daily stock returns over the period, and ε_i is an error term. All of the variables are expressed as natural logarithms.

The market value of the firm is an important determinant of the spread since it reflects the depth of the demand for the stock. Traditionally high value firms enjoy deep markets for their stock. Their equity is traded frequently by a large number of agents, performance is closely monitored by analysts reducing the incidence of potential information asymmetry. These stocks are therefore highly liquid, as market makers need not expose their portfolios to the risk of adverse selection and unwanted inventory. We therefore expect that the equity of large firms will enjoy lower spreads.

The link between the spread and the variance of a firm's daily stock returns can be seen by the following simple model in Roll (1984). Denote by $P_t{*}$ the time t fundamental value of a security in a frictionless economy (an economy with no transactions costs i.e. no bid-ask spread), and denote by S the bid-ask spread. Then the observed market price P_t may be written as:

$$P_t = P_t{*} + I_t \frac{S}{2} \tag{4.2}$$

$$I_t \approx IID^{56} \tag{4.3}$$

Where I_t is an order-type indicator variable, indicating whether the transaction at time period t is at the ask (buyer-initiated) or at the bid (seller-initiated) price. We assume that the probability of the transaction occurring at either price is equal, which implies that each outcome has probability of $\frac{1}{2}$. If the transaction occurs at the buyer-initiated price then the value of I_t will be equal to 1. If however, the transaction occurs at the seller-initiated price then the value of I_t will be equal to -1. The assumption that $P_t{*}$ is the fundamental value of the security implies that $E[I_t]=0$, hence $\Pr(I_t=1)=\Pr(I_t=-1)=\frac{1}{2}$. If there are no changes in the fundamentals of the security; hence $P_t{*}=P{*}$ is fixed through time, then the process for price change ΔP_t is given by.

$$\Delta P_t = \Delta P_t{*} + (I_t - I_{t-1})\frac{S}{2} = (I_t - I_{t-1})\frac{S}{2} \tag{4.4}$$

Under the assumption that I_t is IID the variance of ΔP_t can be readily computed as.

[56] IID means independent and identical distribution.

$$Var[\Delta P_t] = \frac{S^2}{2} \tag{4.5}$$

Equation (4.5) provides the positive link between volatility and the bid-ask spread.

In this study we suggest to enrich the model by including an information asymmetry variable. A theoretical motivation for this extension is suggested by Kim and Verrecchia (1994). In essence the variance of returns captures the price risk associated with holding the stock, but it does not capture the information asymmetry between traders and market makers. In their model the market participants differ in their ability to process information regarding the performance of the firm. The market maker is unable to identify the type of agent that she is dealing with. She uses the total demand order to make inferences regarding the potential private information content residing in her total demand:

Proposition 1 states:

"The market is less liquid at the earnings announcement date than at nonearnings announcement dates. Moreover, market liquidity (the spread is lower) is increasing in the precision of public information, decreasing (the spread is higher) in the diversity of opinion among information processors and increasing in the number of non-discretionary liquidity traders..." (Kim and Verrecchia 1994, p. 53)

When there is disagreement amongst market participants, then market makers are unlikely to have an information advantage over those traders who follow the stock closely. Therefore the market makers will increase the spread in order to protect themselves against those with an information advantage. Although this behaviour is predicted in the context of earnings announcements the rationale is also applicable at other times.

Further motivation for the inclusion of a similar variable is given in Scherbina (2001). She finds that stocks about which there is high disagreement amongst analysts earn lower returns (than otherwise similar stocks) in view of the need to resolve the uncertainty. If this is the case, then market makers will increase the spread to compensate for this reduction in return.

In order to measure the exposure, we include the extent of disagreement amongst analysts about the stock, following Daley, Senkow and Vigeland (1988) that find that the variance of analysts' forecasts is a proxy for the level of uncertainty surrounding the stock.

In the presence of asymmetric information market makers use also volume signals to predict future returns and thus the direction of trade that they are likely to experience. The relationship between expected returns and trading volume in the context of non-disclosure is examined by Kim and Verrecchia (2001). They derive rules that a rational market maker will employ in using volume information to minimise her potential loses.

Based on the above arguments the model to be estimated will be.

$$Spread_i = f(\underset{+}{Var\mathrm{Re}t}, \underset{+}{VarF}, \underset{-}{MrkVl}, \underset{-}{Vol}) \qquad (4.6)$$

Therefore, in this model, the spread is influenced positively by (i) the expected volatility, that is proxied by the ex post volatility of the stock over the forecast horizon (VarRet); (ii) the likely exposure of market makers to the superior information of some traders, which is proxied by the divergence of beliefs amongst analysts concerning the next earnings announcement (VarF). The firm's market value (MktVal) and trading volume (Vol) exert a negative influence on the spread thus increasing liquidity.

4.3 Data Definition and Collection

The companies and the years for which the required data are available are listed in appendix D.

4.3.1 The Variance of Analysts' Forecasts, VarF

The forecasts used are from the I/B/E/S Detail file, which gives information on company forecasts for the period 1990 and 1999. For these years, forecasts for 26 of the FTSE 100 companies are available for at least one year during the period. A total of 203 company-year observations were available, each having at least 3 forecasts at all the horizons investigated (h = 2, 4, 6, 8, 10 and 12 months before the year end).

The variance of the forecasts for each company-year observation (VarF) is calculated from all the forecasts available during the month, the end of which is h months prior to the year end. At each horizon, for all of the company-year observations, at least 3 forecasts were available for the construction of the variance.

4.3.2 The Bid-Ask Spread, S

The bid-ask spread is calculated using the bid and the ask prices from Datastream. For all of the 203 company year combinations, the monthly bid and ask price was collected for the month, the end of which is h months prior to the year end.

4.3.3 Market Value, MktVal

The market value is calculated from Datastream. For all of the 203 company-year combinations, the monthly market value was collected for the month, the end of which is h months prior to the year end.

4.3.4 Trading Volume, Vol

The trading volume data are calculated from Datastream. For all of the 203 company-year combinations, the monthly trading volume was collected for the month, the end of which is h months prior to the year end.

4.3.5 The Variance of Return, VarRet

The variance of return is calculated from prices collected from Datastream. For all of the 203 company year combinations, the variance of return was estimated over the current month (the month for which all the other variables were collected) and the horizon h to the year end.

The descriptive statistics for VarRet and VarF and the other regressors for the sample of 203 company year observations taken from the FTSE 100 companies are given in Table 4.1. One noticeable aspect of the Table is the presence of skewness and kurtosis in both VarF and VarRet. Our approach to this is problem is to take natural logs of the variables in the regressions to minimise the impact of these features.

TABLE 4.1. Descriptive Statistics for the Explanatory Variables for horizons of 2, 4, 6, 8, 10, and 12 months

Statistic	Horizon					
VarF	*2 months*	*4 months*	*6 months*	*8 months*	*10 months*	*12 months*
Mean	2.51	5.83	3.71	3.54	3.21	3.13
Standard Deviation	8.51	13.20	11.87	11.62	11.51	11.46
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	67.72	108.82	81.10	64.24	65.67	66.78
Skewness	5.42*	4.30*	4.42*	4.75*	4.23*	4.64*
Kurtosis	31.60*	23.19*	22.42*	23.76*	21.12*	19.82*
No of observations	203	203	203	203	203	203
VarRet	*2 months*	*4 months*	*6 months*	*8 months*	*10 months*	*12 months*
Mean	5.64	6.78	6.26	7.67	7.51	7.62
Standard Deviation	12.76	14.53	13.80	16.39	14.67	16.04
Minimum	0.00	0.00	0.00	0.00	0.01	0.00
Maximum	99.21	83.87	95.29	99.44	119.08	95.68
Skewness	4.73*	4.63*	4.43*	4.82*	4.65*	4.68*
Kurtosis	23.23*	22.76*	21.54*	22.20*	24.78*	19.32*
No of observations	203	203	203	203	203	203
	Horizon					
MtkVal	*2 months*	*4 months*	*6 months*	*8 months*	*10 months*	*12 months*
Mean	8048.293	8069.331	8800.68	8900.16	89600.76	9901.21
Standard Deviation	754.45	799.69	811.01	832.46	843.23	873.43
Minimum	2371.1	2381.39	2400.12	2432.89	2554.32	2764.76
Maximum	97644.13	93354.18	95544.12	99233.65	120032.21	131032.21
Skewness	0.83	-0.60	0.72	0.65	-0.54	0.82
Kurtosis	-0.68	-0.044	0.58	0.28	-0.067	0.70
No of observations	203	203	203	203	203	203
Vol	*2 months*	*4 months*	*6 months*	*8 months*	*10 months*	*12 months*
Mean	622572	732570	742679	753565	777433	876231
Standard Deviation	215480	226440	237480	246540	278340	288231
Minimum	446920	446920	446920	446920	446920	446920
Maximum	899630	999630	999687	1096300	1145300	1165542
Skewness	0.45	0.55	0.65	0.65	0.76	0.82
Kurtosis	-0.79	-0.69	-0.65	-0.86	-0.45	-0.99
No of observations	203	203	203	203	203	203

Notes:

* indicates that the test of the null hypothesis of no skewness and no kurtosis is rejected at the 5% level of significance. The tests used for skewness and kurtosis are those proposed by Jacque and Bera (1980).

4.4 Econometric Methods and Results

Our adopted linear specification is of the form:

$$Spread_{ih} = \beta_1 + \beta_2 VarF_{ih} + \beta_3 Var\mathrm{Re}t_{ih} + \beta_4 MktVal_{ih} + \beta_5 Vol_{ih} + \varepsilon_{ih} \qquad (4.7)$$

Where:

$Spread_{ih}$ is the bid-ask spread for stock i at horizon h before the year end.

$VarF_{ih}$ is the variance of analysts forecasts for stock i at horizon h before the year end.

$Var\mathrm{Re}t_{ih}$ is the expost variance of monthly returns for stock i, at horizon h before the year end.

$MktVal_{ih}$ is the market value of firm i at horizon h before the year end.

Vol_{ih} is the trading volume of stock i at horizon h before the year end.

Given the previous analysis we expect that $\beta_4, \beta_5 \prec 0$ and $\beta_2, \beta_3 \succ 0$. The possible endogeneity of trading volume requires the Hausman (1978) test statistic to establish the choice of a consistent estimator. The inappropriate use of Instrumental Variables (IV) will result in severe loss of efficiency compared to the least squares estimator. The test statistic is based on the difference between the two estimators that are consistent under the null hypothesis but only one of them, the IV estimator is consistent under the alternative. The test statistic is given by:

$$H = (b_{IV} - b_{LS})' \left\{ \left(\hat{X}'\hat{X}\right)^{-1} - \left(X'X\right)^{-1} \right\}^{-1} (b_{IV} - b_{LS}) / s^2 \qquad (4.8)$$

Where $\hat{X}$ denotes the matrix of regressors where the 'endogenous' variables have been instrumented, X the original matrix of regressors and s^2 the variance estimate. This Wald statistic follows the chi-square distribution with K, the number of instrumented variables, degrees of freedom. Using as additional instruments current and lagged returns and lagged spread, following the methodology of Atkins and Dyl (1997), the resulting value of the statistics was 2.34. We were therefore unable to reject the null hypothesis that both estimators were consistent, and given that the Least Squares Estimator (LS) is efficient we proceed to estimate the model by LS. The results of our model for horizons 2, 4, 6, 8, 10, and 12 are given in Table 4.2. For horizons 2, 4 & 6 all the variables are significant and have the correct a priori sign.

TABLE 4.2. OLS Estimates of the Exposure Model of Bid-Ask Spread

$$Spread_{ih} = \beta_1 + \beta_2 VarF_{ih} + \beta_3 Var\,\mathrm{Re}\,t_{ih} + \beta_4 MktVal_{ih} + \beta_5 Vol_{ih} + \varepsilon_{ih}$$

Horizon	β_1	β_2	β_3	β_4	β_5	$\overline{R}^2$	N
2	0.52(0.08) **6.5***	0.14(0.03) **4.67***	0.18(0.07) **2.57***	-5.24(2.31) **-2.27***	-0.62(0.23) **-2.70***	0.153	203
4	0.51(0.08) **6.34***	0.15(0.06) **2.50***	0.17(0.03) **5.85***	-3.97(1.91) **-2.08***	-0.51(0.23) **-2.22***	0.185	203
6	0.53(0.08) **6.63***	0.15(0.06) **2.50***	0.19(0.03) **6.33***	-3.58(1.71) **-2.09***	0.57(0.24) **-2.38***	0.190	203
8	0.46(0.08) **5.75***	0.06(0.05) **1.20**	0.17(0.07) **2.43***	-4.47(2.14) **-2.09***	-0.71(0.34) **-2.09***	0.149	203
10	1.89(0.37) **5.11***	0.24(0.17) **1.41**	0.39(0.08) **4.78***	-3.79(1.72) **-2.20***	-0.77(0.31) **-2.48***	0.147	203
12	0.53(0.08) **6.63***	0.05(0.03) **1.50**	0.16(0.07) **2.29***	-3.78(1.85) **-2.04***	-0.76(0.34) **-2.24***	0.10	203

Notes:

The standard errors are shown in brackets.

The t statistics are shown in bold, * indicates significance at the 5% level.

All the variables are expressed as natural logarithms.

Diagnostic Results

Horizon	Heteroscedasticity Test	Normality Test	Functional Form Test
2	1.02	33.43*	0.71
4	1.02	54.91*	1.27
6	0.67	141.40*	1.28
8	1.20	5.24	0.60
10	1.72	15.81*	0.65
12	1.38	3.38	0.15

Notes:

All the diagnostic statistics that are reported are based on the F statistic.

The normality test is based on the test proposed by Jacque and Bera (1987) * indicates rejection of the null hypothesis of normality at the 5% level of significance.

The heteroscedasticity test is based on the test proposed by White (1980).

The functional form test is based on the Ramsey (1969) test.

Consistent with Atkins and Dyl (1997), the coefficient on market value, *MktVal,* is negative, indicating that larger companies have a smaller spread, and the coefficient on ex post volatility, *VarRet,* is positive, indicating that market makers anticipate the relative volatility's of stocks and use this information in setting their spreads. It is of interest that the elasticity with respect to MktVal is large, indicating that size variations are important even within the FTSE100.

In addition to the market value, the trading volume, *Vol,* is significant and negative indicating that a larger volume of trade is associated with a smaller spread. There is support for this in Glosten and Harris (1988). They also find that the spread reacts to volume as market makers adjust it to maintain their inventory targets.

The variance of analysts' forecast *VarF* which is intended to capture the disagreement amongst traders about the future of the stock, is also significant and positive. This suggests that as disagreement rises, market makers increase the spread to protect themselves against any temporary information advantage which investors may have. This provides strong support for the hypothesis of the Kim and Verrecchia (1994) model of how market makers respond to disagreement.

However, VarF is not significant for horizons of 6 months or more. Why is this? One possibility is that market makers do not believe that they will provide liquidity beyond this period. Another relates to a well known characteristic of analysts' forecasts identified by Brown and Rozeff (1978), Dimson and Marsh (1984) and Stickel (1989), that any superior information held by analysts relates to the short term (i.e. the next few months). This means that for long horizons the market maker does not infer information from the disagreement amongst analysts.

Table 4.2 also reports diagnostic statistics. There are no signs of heteroscedasticity or non linearity, but there is evidence of non normality in the residuals (for horizons 2, 4, 6 & 10). Non normality in the residuals may mean that the distribution is "fat-tailed" or contains outliers.

In the general linear model

$$y_i = X_i\beta + u_i \tag{4.9}$$

when the errors are not normally distributed the least squares estimator b is no longer efficient or asymptotically efficient although it is still consistent. As the respective distribution of b and $(T-K)\left(\frac{\hat{\sigma}^2}{\hat{\sigma}}\right)$ are no longer normal and chi-square respectively, the usual F and t-tests on β are not necessarily valid in small samples, as they may suffer loss of power due to severe deviation from normality. This has led to the adoption of a class of estimators that are more robust than least squares in the sense that maintain their efficiency irrespectively of the underlying error distribution (Judge et al 1988 p836). In general these estimators obtain an estimate of β by solving the asymmetric least absolute deviations

$$\min\ T^{-1}\sum_{i=1}^{T} l_p\left|y_i - \beta' X_i\right| \tag{4.10}$$

where p denotes the pth conditional quantile of y_i given $X_i = x$ and

$l_p(u) = \left[p - 1\{u \prec 0\}\right]|u|$, for $p = 0.5$ we obtain the function shown in equation (4.10).

A solution to the above is called the Least Absolute Deviations (LAD) or median regression estimate. It can be shown that

$$\sqrt{T\left[b(.5)-\beta\right]} \rightarrow N\left(0,\{2f(0)\}^{-2}Q^{-1}\right) \tag{4.11}$$

where $Q=T^{-1}(X'X)$ and $\{2f(0)\}^{-2}$ denotes the asymptotic variance of the sample median, this class of estimator will be more efficient than the least squares estimators in distributions where 'outliers' are prevalent.

Given that the exact form is unknown we use the LAD regression to obtain robust results for horizons 2, 4, 6 and 10.These results are given in Table 4.3.

TABLE 4.3. Robust (Least Absolute Deviation) Estimation of the Exposure Model of Bid-Ask Spread

$$Spread_{ih} = \beta_1 + \beta_2 VarF_{ih} + \beta_3 Var\mathrm{Re}t_{ih} + \beta_4 MktVal_{ih} + \beta_5 Vol_{ih} + \varepsilon_{ih}$$

Horizon	β_1	β_2	β_3	β_4	β_5	$\overline{R}^2$	N
2	0.37(0.06) **6.17***	0.14(0.02) **7.00***	0.28(0.05) **5.6***	-1.41(0.68) **-2.27***	-0.35(0.13) **-2.69***	0.183	203
4	0.47(0.06) **7.83***	0.16(0.02) **2.50***	0.26(0.05) **5.20***	-2.29(0.91) **-2.52***	-0.65(0.23) **-2.83***	0.195	203
6	0.45(0.06) **7.50***	0.16(0.02) **8.00***	0.25(0.05) **5.00***	-2.60(0.94) **-2.77***	-0.67(0.24) **-2.79***	0.206	203
10	1.29(0.27) **4.81***	0.62(0.75) **0.83**	0.20(0.08) **2.50***	-2.07(0.72) **-2.88***	-0.69(0.28) **-2.46***	0.150	203

Notes:

The standard errors are shown in brackets.

The t statistics are shown in bold, * indicates significance at the 5% level.

All the variables are expressed as natural logarithms.

By and large the results presented in Table 4.2 hold. There is a modest increase in the equations' explanatory power, but the size and standard errors of the estimated coefficients remain unaltered. One noticeable difference is that the coefficient on "MktVal" is considerably reduced. As no other form of mis-specification has been detected in these results we can conclude that the results are robust to non-normality and that the model's explanatory power although modest is not due to outliers or particular features of the sample.

4.5 Discussions and Conclusions

In this study we have estimated by robust methods a linear equation that explains the bid-ask spread in the UK equity market for a number of FTSE100 companies over a period of 10-years (1990-1999). Its contribution lies in the establishment of the statistical significance of the variance of the analysts' forecasts in the presence of other exogenous variables that are regularly included in similar studies. We postulate the inclusion of this variable in order to act as a proxy for the unobserved uncertainty surrounding asset returns beyond the year-end period driven by the increased probability of deferring the disclosure of performance. We find that published disagreement amongst analysts affects the behaviour of market makers and they act to prevent trade from informed traders by increasing the spread. This result provides strong support for proposition 1 in Kim and Verrecchia (1994). To our knowledge this is the first study that such a result has been obtained.

In our estimated model we have extended the model of Atkins and Dyl (1997) where they find that both the volatility of returns variable reflects the risk to which the market maker is exposed and market size are important by adding trading volume and the disagreement among analysts regarding earnings. The role of volatility in explaining the spread is a dual one: first, disagreement leaves market makers at a disadvantage with respect to informed traders (Kim and Verrecchia, 1994) and secondly, high dispersion stocks earn lower returns whilst the uncertainty is being resolved (Scherbina, 2001) this is because these stocks have to be held for longer time periods thus reducing their liquidity.

We find that both volatility of returns and disagreement amongst analysts are significant (with the hypothesised signs) in explaining FTSE 100 company spreads. The volatility captures information uncertainty concerning the current period to the year end. Since company returns are affected by the market in general, it is also likely that volatility reflects economy wide aspects of uncertainty. However, our results show that the disagreement amongst analysts is also significant. What interpretation should be placed on this? First, it is worth noting that disagreement is more likely to be related to firm specific issues in contrast to the volatility measure which is likely to be driven by market wide factors. As a consequence, we suggest that disagreement by investors is potentially related to the probability of poor results beyond the information contained in the volatility of returns. Such performance is well known to cause delays in reporting the year end results and causes additional information asymmetry between market makers and investors. The market makers in turn increase their spread in order to protect themselves as modelled in Kim and Verrecchia (2001).

Extensions of the work along similar lines is to incorporate higher order moments of the analysts' forecasts in the context of a model that attempts to explain both volume and spread simultaneously taking into account 'bad' (profit warnings) and 'good news'.

Chapter 5

Liquidity Effects due to Information Costs from Changes in the FTSE 100 List

5.1 Introduction

The Efficient Market Hypothesis (EMH) predicts that security prices reflect all publicly available information. Therefore, one corollary of the EMH is that "you can sell (or buy) large blocks of stock at close to the market price as long as you can convince other investors that you have no private information".[57] This statement assumes that securities are near perfect substitutes for each other. If so, the excess demand for a single security will be very elastic, and the sale or purchase of a large number of shares will have no impact on price. Therefore the prediction of this hypothesis is that quoted prices are independent of whether the stock is listed in some index or not and simply traded in the exchange.

It has been observed that listed stocks tend to be traded more heavily and more frequently than non-listed ones. In contrast to the EMH, Scholes (1972), Kraus and Stoll (1972), Hess and Frost (1982) and others suggest that a large stock sale (purchase) will cause the price to decrease (increase) even if no new information is associated with the transaction. They attribute this effect to portfolio re-balancing as investors mimic the composition of the 'important' index. An alternative explanation of this empirical regularity, that is consistent with the EMH is that listing in the index attracts increased attention thus reducing the information disparity between 'informed' and 'uninformed' traders that results in lower transactions costs, see for example (Kim and Verrecchia (1994)).

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[57] Brealey and Myers (1984, p279).

The purpose of this chapter is to establish whether the inclusion or deletion of firm from the FTSE100 (the most frequently traded index in the UK) has a significant effect on both price and traded volume of the stock. In addition we investigate whether the effects if any can be attribute to the reasons mentioned above.

The chapter is organised as follows; the theoretical background to the debate is presented in section 5.2 along with some discussion of the empirical evidence pertinent to the USA. Section 5.3 provides details of the data and methodology used to examine the changes in the FTSE 100 list whilst section 5.4 presents the statistical evidence. We discuss the explanations for the empirical results in section 5.5. Finally, the conclusions of the study are in section 5.6.

To our knowledge this is the first study that examines stock price and volume effects associated with changes in the composition of the FTSE 100 list[58].

5.2 Theoretical Background

The explanations for the observed price-volume relationship as the 'status[59]' of the stock changes are falling into two broad categories.

The imperfect substitutes hypothesis (ISH), Shleifer (1986), assumes that securities are not close substitutes for each other, and hence, that long-term demand is less than perfectly elastic. Under this hypothesis, equilibrium prices change when demand curves shift to eliminate excess demand. Price reversals are not expected because the new price reflects a new equilibrium distribution of security holders.

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[58] By changes we are referring to additions (deletions) to (from) the FTSE 100 list.

[59] By 'status' we imply inclusion (deletion) to (from) the index.

The price pressure hypothesis (PPH), Harris and Gurel (1986), assumes that investors who accommodate demand shifts must be compensated for the transaction costs and portfolio risks that they bear when they agree to immediately buy or sell securities which they otherwise would not trade. These passive suppliers of liquidity are attracted by immediate price drop (rises) associated with large sales (purchases). They are compensated for their liquidity service when prices rise (drop) to their full information levels. The PPH like the EMH assumes that long run demand is perfectly elastic at the full information price. It differs from the ISH in that it recognizes that immediate information about non-information motivated demand shifts may be costly, and hence that short term demand curves may be less then perfectly elastic.

Empirically both Harris and Gurel (1986) and Shleifer (1986) present evidence for a strong positive stock price reaction to the announcement of listing in the Standard and Poor's 500 (S&P 500) Stock Index. Both studies indicate that the price increase is not due to the release of new information but rather to the increased demand resulting from index funds and others adding the stock to their portfolio.[60] Consistent, with this Pruitt and Wei (1989) show that institutional holdings increase when listing occurs.

[60] The S&P's selection mechanism of the composition of their list does not depend on forecast security returns. Since changes are based only on publicly available information and on well-known criteria, they should not reveal new information about future return distributions.

Although Harris and Gurel (1986) and Shleifer (1986) study the same phenomenon over roughly the same time period, their findings differ. Harris and Gurel (1986) argue that the evidence supports the PPH, which requires that the price go back down, while Shleifer (1986) finds support of the ISH, in which long run demand is not perfectly elastic, so that the price change is permanent.

In any event, these studies are an important challenge to the EMH. Dhillon and Johnson (1991) use both stock and option data and argue that their results are inconsistent with the price pressure hypothesis, but are consistent with the imperfect substitutes.

Although Harris and Gurel (1986), and Shleifer (1986) both point out that the listing criteria are such that listing per se must be informationless, one can still make an argument that listing conveys information to the market. Harris and Gurel (1986) note that the "increased volume makes the added stock more liquid and the expectations of this benefit can account for the ... price rise" (p.825). Alternatively, firms in the S&P may receive "closer scrutiny ... by analysts and investors" (Shleifer, 1986; p. 588), thereby lowering bid-ask spreads. Further evidence of this is provided by Arbel and Strebel (1982), and Barry and Brown (1984), who find that changes in information availability can lead to price changes by changing the costs borne by investors to collect, analyze, and disseminate information about a stock. Also, Amihud and Mendelson (1986), show that investors require higher expected returns for higher bid-ask spreads, and vice versa. If stocks are not held indefinitely (Amihud and Mendelson (1986) report that the average holding period for NYSE stocks is two years), trading costs represent a cost stream to shareholders.

Empirically, Beneish and Gardner (1995) examine the stock market effect of changes in the composition of the Dow Jones Industrial Average (DJIA). Unlike the S&P 500 findings, they find that the price and the trading volume of newly listed DJIA firms are unaffected. They attribute this result to a lack of index fund rebalancing, since index trading is limited because index funds mimic the S&P 500, not the DJIA. They discover, however that firms removed from the index experience significant price declines. They explain this finding with the use of the information cost/liquidity explanation, which states that investors demand a premium for higher trading costs and for holding securities that have relatively less available information.

5.3 Data and Methodology

The data for the additions (deletions) to (from) the FTSE 100 list from the time period of 1984-2001, were obtained from Datastream. The full list of all the additions and deletions of the list can be seen in appendix E.[61] We also collect daily stock price data and trading volume data from the same source. Data are collected for a 121-trading-day period around the date of change.[62] Daily returns are calculated and are adjusted for cash and stock dividends and one stock split. The stock price reaction to changes in the FTSE 100 list is estimated using market-adjusted prediction errors (PE_{it}),

$$PE_{it} = R_{it} - R_{mt}, \tag{5.1}$$

where:

R_{it} = continuously compounded rate of return on the common stock of firm i on day t,

and

R_{mt} = continuously compounded rate of return on the FTSE 100 Index on day t.

[61] There were 258 additions (deletions) to (from) the FTSE 100 list during the time period of 1984-2001.

[62] Beneish and Gardner (1995) recommend a 121 trading day period around the date of change since it is long enough to capture any type of pre or post announcement drift that may occur.

Following the methodology used in Beneish and Gardner (1995), for each sample observation, calendar time is converted to event time be defining the date on which the London Stock Exchange announces the FTSE 100 list change as event day 0[63]. Prediction errors are estimated over a 121-day period that extends from event days –60 to +60. The prediction errors, PE_{it}, are averaged across the N firms in the sample on each day t to form an average prediction error, APE_t. An estimate of the variance of this series (an equally-weighted portfolio variance), S^2_{APE}, is calculated over 80 trading days (-61, -21 and +21, +61). The variance estimate is

$$S^2_{APE} = \frac{1}{79}\sum_{t=1}^{80}\left(APE_t - \overline{APE}\right)_t^2 \tag{5.2}$$

where $\overline{APE}$ is the mean average prediction error for the 80-trading-day estimation period. We cumulate the average prediction errors over intervals of k days from t through $t+k$ to obtain cumulative average prediction errors, $CAPE_{t,t+k}$, where,

$$CAPE_{t,t+k} = \sum_{T=t}^{t+k} APE_T. \tag{5.3}$$

The t-statistic used to test whether cumulative average prediction errors differ significantly from zero is based on the time-series variance of portfolio average prediction errors, S^2_{APE}, for the 80-day estimation period, which has 79 degrees of freedom, and incorporates any cross-sectional dependence in the daily prediction errors. The t-statistic is calculated as:

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[63] The event date is the date on which the London Stock Exchange announces the change and the date at which the change occurs. The two dates are the same since when the London Stock Exchange announces the change, the change occurs on that same date.

$$t = \frac{CAPE_{t,t+k}}{\left[kS^2_{APE}\right]^{\frac{1}{2}}}. \tag{5.4}$$

5.4 Results

The discussion of the empirical results is divided into two sections. Section 5.4.1 presents tests of stock price effects associated with announcement of changes in the FTSE 100 list. Section 5.4.2 presents tests of trading volume effects associated with announcement of changes in the FTSE 100 list.

5.4.1 Stock Price Response to Announcement of FTSE 100 List Changes

We assess the stock price reaction to announcement of FTSE 100 list changes using individual firm estimations.[64] The results are summarised in Table 5.1.

[64] We also form equally-weighted portfolios of all changes occurring on a given day and asses average abnormal performance at the portfolio level. This test is conducted because the prediction errors of firms sharing the same event date in calendar time are likely to be correlated, and the t-statistics on average abnormal performance are likely to be biased away from zero (see Beneish (1991)). The portfolio estimations confirm the individual firm estimations. The results of the portfolio estimations can be seen in Table 5.1A in appendix F.

TABLE 5.1. Stock Price Reaction to Announcement of Changes in the FTSE 100 List, between the time period of 1984-2001. Cumulative Average Prediction Errors (CAPE) and t-statistics are reported

Panel A. Additions			Panel B. Deletions		
Days Relative to Event	CAPE (%)	t-statistic	Days Relative to Event	CAPE (%)	t-statistic
-60, -2	1.27	0.32	-60, -2	-3.43	-0.61
-60, -41	1.47	0.39	-60, -41	-2.49	-0.37
-40, -21	-2.23	-0.67	-40, -21	-1.63	-0.94
-20, -11	1.93	0.45	-20, -11	-2.55	-1.12
-10	-0.73	-0.98	-10	-0.52	-0.46
-9	0.54	0.32	-9	1.09	0.97
-8	2.23	1.23	-8	0.81	0.93
-7	0.169	0.47	-7	1.17	0.70
-6	-1.40	-1.23	-6	0.92	0.89
-5	1.03	0.22	-5	0.65	0.59
-4	2.68	1.08	-4	-0.27	-1.12
-3	2.55	1.01	-3	-1.50	1.02
-2	3.41	2.24*	-2	-1.05	-2.01*
-1	2.85	1.99*	-1	-1.74	-2.74*
0	1.26	2.44*	0	-2.33	-3.39*
1	2.39	2.77*	1	-0.95	-2.18*
2	1.09	2.22*	2	-1.35	-2.44*
3	-0.46	-0.80	3	-0.76	-1.23
4	2.06	1.34	4	-1.32	-1.01
5	1.31	0.50	5	-1.09	-1.36
6	-0.92	-0.24	6	-0.09	-1.49
7	0.59	0.53	7	1.35	1.36
8	-0.74	-0.99	8	-0.71	-1.02
9	-0.26	-1.23	9	-0.98	-1.22
10	-1.89	-1.07	10	-0.31	-1.34
+11, +20	-2.87	-1.23	+11, +20	-1.56	-0.64
+21, +40	-3.78	-1.34	+21, +40	1.25	1.30
+41, +60	-3.89	-1.58	+41, +60	-3.86	-1.42
+2, +60	-4.06	-1.60	+2, +60	-4.37	-1.58
CAPE(-1, +1)	6.5	2.52*	CAPE(-1, +1)	-5.02	-2.63*

Notes:

Day 0 is the day on which the changes in the FTSE 100 list are announced on the London Stock Exchange.

* Significant at the 5% level (two-tailed test).

Panel A indicates that stock returns of firms added to the FTSE 100 list are affected by the inclusion. The CAPE from day –1 to +1 of 6.5 is distinguishable from zero with a t-statistic of 2.52.[65] Moreover, the behaviour of stock prices one to three months subsequent

[65] We use a standard three-day period to assess abnormal performance.

to the announcement suggests that the price increase for FTSE 100 list additions is permanent. This is due to the fact that the CAPE for days +2 to +60 of –4.06 percent is not significant with a t-statistic of –1.60.

Panel B indicates that stock returns of firms deleted from the FTSE 100 list are affected by the deletion. The CAPE from day –1 to +1 of –5.02 is distinguishable from zero with a t-statistic of –2.63. Moreover, the behaviour of stock prices one to three months subsequent to the announcement suggests that the price decline for FTSE 100 list deletions is permanent. This is due to the fact that the CAPE for days +2 to +60 of –4.37 percent is not significant with a t-statistic of –1.58.

From our results we report significant positive stock price reactions to the announcement of new listings on the FTSE 100 list. This agrees with the literature on the S&P 500 since Shleifer (1986), Harris and Gurel (1986) and Dhillon and Johnson (1991) report significant positive stock price reactions to the announcement of new listings on the S&P 500.

We also report significant negative stock price reactions to the announcement of new deletions from the FTSE 100 list. This agrees with the literature on the DJIA since Beneish and Gardner (1995) report significant negative stock price reactions to the announcement of deletions from the DJIA. A further interesting observation from Table 5.1 is the asymmetry in the results. There is clear evidence of additions having a greater impact on prices around the announcement period than the deletions. Possible explanations for the asymmetric results are explained further on in the chapter.

5.4.2 Trading Volume Response to Announcement of FTSE 100 List Changes

To determine the possible presence of liquidity effects we proceed with the analysis of the impact of listing/de-listing on trading volume. The analysis of the trading volume permits us to establish whether the liquidity explanation can be supported.[66]

To assess whether trading activity changes when a firm is added (deleted) to (from) the FTSE 100 list, trading volumes, adjusted for market volume, are analyzed in event time.[67] Cross-sectional means are computed using the Harris and Gurel (1986) estimation technique, and are as follows:

$$MVR_t = \frac{1}{N}\sum i \; VR_{it}. \qquad (5.5)$$

Where

$$VR_{it} = \frac{V_{it}}{V_{mt}} \cdot \frac{V_m}{V_i} \qquad (5.6)$$

Where V_{it} and V_{mt} are the trading volumes of security i and of the total FTSE 100 Index in event-time period t, respectively, V_i and V_m are the average trading volumes of the security and of the total FTSE 100 Index in the 8 weeks preceding the announcement week. The volume ratio, VR_{it}, is a standarized measure of period t trading volume in security i, adjusted for market variation. The volume ratio has an expected value that is

[66] Beneish and Gardner (1995) first provided empirical evidence concerning the liquidity explanation for changes in trading volume.

[67] We collect the trading volume data with the use of Datastream. When a stock experiences a split, we divide all subsequent volume data by the split factor.

equal to 1, if there is no change in volume in event-period t relative to the prior 8 weeks. Results of tests of trading volume effects are presented in Table 5.2.

TABLE 5.2. Trading Volume Reaction to Announcement of Changes in the FTSE 100 List, between the time period of 1984-2001

Panel A. Additions			Panel B. Deletions		
MVR	STD	t-statistic	MVR	STD	t-statistic
1.21	0.78	3.62*	-1.14	0.88	-2.74*

Notes:

We calculate the trading volume effects for days 1 to 5 after the announcement of the change on the London Stock Exchange.

MVR stands for the mean volume ratio.

STD stands for the sample standard deviation of the volume ratios.

The t-statistics are testing whether the mean of the volume ratios is different to 1 (two-tailed test).

* Significant at the 5% level (two-tailed test).

Panel A indicates that trading volume increases when firms are added to the FTSE 100 list. This is because on average, trading volume on the first day on which trading is possible after the announcement is 1.21 times as large as the daily mean volume over the 8 weeks prior to the announcement. Tests of whether these mean volume ratios are equal to 1 reject equality since we obtain a t-statistic of 3.62. Therefore this leads us to conclude that when firms are added to the FTSE 100 list, trading volume increases.

Panel B indicates that trading volume decreases when firms are deleted from the FTSE 100 list. This is because on average, trading volume on the first day on which trading is possible after the announcement is 1.14 times smaller then the daily mean volume over the 8 weeks prior to the announcement. Tests of whether these mean volume ratios are equal to 1 reject equality since we obtain a t-statistic of –2.74. Therefore this leads us to conclude that when firms are deleted from the FTSE 100 list, trading volume decreases.

At this point in this study we have found the following empirical results. First, when firms are added to the FTSE 100 list, the stock price and the trading volume for these firms increase. Second, when firms are deleted from the FTSE 100 list, the stock price and the trading volume for these firms decrease. In addition the impact of inclusion on the stock price is more pronounced (in proportional terms) than that of deletion, no such asymmetry was observed for trading volumes.

5.5 Explanations of the Results

5.5.1 Price-pressure hypothesis and the imperfect substitutes hypothesis

Previous literature on the S&P 500 found that stock prices increased (decreased) when firms were added (deleted) to (from) the S&P 500. They also found that when firms were added (deleted) to (from) the list, that trading volume for these firms increased (decreased). A number of reasons (discussed in the beginning of the chapter) have been offered as a possible explanation to these results. In this section we discuss these possible explanations with reference to their applicability to our empirical results.

Harris and Gurel (1986) argue in favour of the price-pressure hypothesis. They say that when a firm is added (deleted) the stock price goes up (down) accordingly. Once this initial trading has taken place the price goes back down (up) if a firm is added (deleted).

In our results we find no evidence to suggest that the listings (deletions) to (from) the FTSE 100 list follow a price-pressure hypothesis. The reason for this is that we find the price increase (decrease) for the added (deleted) firms to be permanent. If there was evidence of the price-pressure hypothesis, we would expect the price for the added (deleted) firms to go back down (up) after the change had taken place.

Shleifer (1986) finds evidence of the imperfect substitutes hypothesis. He argues that investor's hold on to stocks that are on the FTSE 100 list and when a firm is deleted from the list they sell the stock in that firm and buy stock in a firm that is on the list. They therefore treat stocks as imperfect substitutes for each other. In the imperfect substitutes hypothesis the long-run demand is not perfectly elastic, implying that the price change is permanent. In our results we find that the price change is permanent, which brings support to the imperfect substitutes hypothesis. However, the problem with the imperfect substitutes hypothesis is that it is assuming that the listing (delisting) per se must be informationless. However, we can make an argument that listing (delisting) conveys information to the market. The reason as to why we can portray such an argument comes from our results with respect to trading volume.

Recall that we find that when a firm is added (deleted) that trading volume increases (decreases). According to Harris and Gurel (1986) the increased (decreased) volume makes the added (deleted) stock more (less) liquid and the expectations of this benefit (loss) can account for the price rise (fall). Alternatively, firms in the FTSE 100 list may receive more attention by analysts and investors' resulting in lower bid-ask spreads. This also applies for deleted firms, since deleted firms will receive less attention by analysts and investors' resulting in higher bid-ask spreads.[68] This analysis leads us to propose an information cost/liquidity explanation for our empirical results.

[68] This line of argument comes from Schleifer (1986). The only difference is that he mentions the S&P 500 instead of the FTSE 100 list. We would expect the impact of both lists to be very similar since both lists are traded very frequently.

5.5.2 An Information Cost/Liquidity Explanation

If inclusion in (exclusion from) the FTSE 100 list is followed by increased (decreased) scrutiny by analysts, investors and institutions, the firm's information environment is richer (poorer) and the stock will be traded more (less) widely and become more (less) liquid. In this section of the chapter we discuss various aspects of this possible explanation, namely whether there are changes in the information environments and the liquidity of the added (deleted) FTSE 100 firms.

If changes in the FTSE 100 list are associated with changes in information environment, stock price of FTSE 100 list change firms adjust to reflect changes in future levels of available information.

Given evidence that information availability is priced (Arbel and Strebel (1982), Barry and Brown (1984)), changes in information availability can lead to price changes by changing the costs borne by investors to collect, analyze, and disseminate information about a stock. Our tests are based on the number of analysts following the stock.[69] Table 5.3 presents the results of our analysis.

[69] We are grateful to I/B/E/S for access to their data of analysts' forecasts.

TABLE 5.3. Information Availability Pre and Post FTSE 100 List Changes

	Panel A. Additions	Panel B. Deletions
Mean No of Analysts' following the stock Pre Change	5.92	5.92
Mean No of Analysts' following the stock Post Change	7.24	3.26
t-test of Mean Differences	16.99*	18.26*

Notes:

By Pre change we mean 8 weeks before the announcement of the additions (deletions).

By Post change we mean 8 weeks after the announcement of the additions (deletions).

We use an 8 week time span to make sure that we capture any Pre or Post announcement drift that may occur.

* Significant at the 5% level (two-tailed test).

In Panel A, we compare the average number of analysts' that follow the stocks before and after the additions take place. We find a significant increase in the number of analysts' that follow the firms once they are added to the FTSE 100 list. In Panel B, We compare the average number of analysts' that follow the stocks before and after the deletions take place. We find a significant decrease in the number of analysts' that follow the firms once they are deleted from the FTSE 100 list. This means that when firms are added to the list, they operate in a richer information environment.

Following Amihud and Mendelson (1986), who show that investors require higher expected returns for higher bid-ask spreads, we examine whether changes in the composition of the FTSE 100 list are associated with changes in bid-ask spreads.

Assessing whether spreads change requires the estimation of effective spreads pre and post changes in the FTSE 100 list. We can calculate the 'effective spread' using two types of methodology. The first method that we can use is the Roll (1984) serial covariance spread estimator. However, this method provides us with a problem because FTSE 100 list firms are large and we observe negative spread estimates that are impossible to interpret. For this reason we calculate effective spreads by using the second method.

The second method uses intraday data to obtain quoted bid-ask spreads. We then calculate estimates of effective spreads with the use of intraday data that is available from Datastream. We are able to collect data on all quotations by FTSE specialists from Datastream. Using quotation data from a period of 50 trading days before and 50 trading days after the FTSE 100 list change announcement period, we compare actual spreads computed as the difference between ask and bid prices. The results can be seen in Table 5.4.

TABLE 5.4. Effective Bid-Ask Spreads Pre and Post FTSE 100 List Changes

	Panel A. Additions	**Panel B. Deletions**
Bid-Ask Spread Pre Change	0.31%	0.34%
Bid-Ask Spread Post Change	0.2%	0.45%
t-test of Mean Differences	2.02*	2.01*

Notes:

The bid-ask spread computed is the Mean Percentage Effective Spread. Mean spread is the mean spread (ask price – bid price) on all quotations by FTSE specialists in that day. The periods before and after refer to a maximum of 50 trading days before (after) and excluding the three-day FTSE 100 list change announcement period. Mean Percentage spread is computed as (ask price – bid price) / (ask price + bid price) / 2 in the same period.

* Significant at the 5% level (two-tailed test).

In Panel A, we compare the average effective bid-ask spread before and after the additions take place. We find a significant decrease in the bid-ask spread after the additions have taken place. This was to be expected, in the light of the discussion above as, when firms are added to the FTSE 100 list they operate in a richer information environment. This new status increases the trade of these stocks, which results in them becoming more liquid (Harris and Gurel (1986)).

In Panel B, we compare the average effective bid-ask spread before and after the deletions take place. We find a significant increase in the bid-ask spread after the deletions have taken place. This is logical since when firms are deleted from the FTSE 100 list investors operate in an environment where information is relatively scarce.

5.5.3 Cross-Sectional Test

Our analysis would not be complete without a simultaneous consideration of all competing explanations. We specify a cross-sectional model with the event window performance as the dependent variable to simultaneously evaluate the potential competing explanations. Regressors are proxies for change in bid-ask spread (liquidity), abnormal volume (imperfect substitutes) and change in quantity of publicly available information (information costs). The model, similar in spirit to that of Beneish and Gardner (1995) is specified as follows,

$$CPE_i = \alpha_0 + + \alpha_1 \Delta SPREAD_i + \alpha_2 ABVOL_i + \alpha_3 \left(MV_{t+5} / MV_{t-1} \right) + \varepsilon_i, \qquad (5.7)$$

Where

$CPE =$ Cumulative prediction error on days -1 to $+1$ relative to the date of the announcement of the FTSE 100 list change,

$\Delta SPREAD =$ Change in the mean percentage effective bid-ask spread in the 50 trading days surrounding and excluding the announcement of the FTSE 100 list change,

$ABVOL =$ Abnormal volume as defined in equation (5.5) for the three-day period from days -1 to $+1$ relative to the day of FTSE 100 list change, and

MV_{t+5} / MV_{t-1} = ratio of market value (price multiplied by the number of common shares) at the end of year $t+5$ verses market value at the end of year $t-1$: used as a proxy for future growth.[70]

TABLE 5.5. A Cross-Section Regression Test of Alternative Explanations for the Stock Price Reaction to Changes in the FTSE 100 List

$$CPE_i = \alpha_0 + +\alpha_1 \Delta SPREAD_i + \alpha_2 ABVOL_i + \alpha_3 \left(MV_{t+5} / MV_{t-1} \right) + \varepsilon_i,$$

Variable	α_0	α_1	α_2	α_3	$\overline{R}^2$
Coefficient Estimates (t-statistics)	-0.04 (-1.28)	-0.0066 (-2.48)*	0.731 (2.09)*	0.0097 (2.34)*	10.28%

Notes:

* Significant at the 5% level (two-tailed test).

Diagnostic Results

Heteroscedasticity Test	Normality Test	Functional Form Test
1.04	3.42	0.74

Notes:

All the diagnostic statistics that are reported are based on the F statistic.

The heteroscedasticity test is based on the test proposed by White (1980).

The normality test is based on the test proposed by Jacque and Bera (1987).

The functional form test is based on the Ramsey (1969) test.

The results of the cross-sectional regression test can be seen in Table 5.5 along with the appropriate diagnostic tests. We can see that all the explanatory variables in the regression are statistically significant, and that the equation is well specified. These results clarify our previous findings in this chapter.

[70] We collect the data for the ratio of market value with the use of Datastream.

The variable $ABVOL$ is positive and significant since abnormal trading volume explains stock price reaction to changes in the FTSE 100 list. There is evidence of this from Table 5.2. We find that trading volume increases when firms are added to the FTSE 100 list and we also find that trading volume decreases when firms are deleted from the FTSE 100 list. This result provides empirical evidence of the imperfect substitutes hypothesis proposed by Schleifer (1986).

The variable MV_{t+5} / MV_{t-1} is positive and significant since the amount of publicly available information, effects stock price reaction to changes in the FTSE 100 list. There is evidence of this in Table 5.3. We found that when a firm is added (deleted) to (from) the FTSE 100 list that the number of analysts' that follow that stock significantly increases (decreases). The increase (decrease) in the publicly available information on the stock causes a positive (negative) stock price reaction to the announcement of the change. The finding that stock prices increase (decrease) when the quantity of available information increases (decreases) is consistent with evidence in Arbel and Strebel (1982), Barry and Brown (1984), and Merton (1987) that investors demand higher returns for holding stocks with less available information.

The $\Delta SPREAD$ variable is negative and significant. There is evidence of this in Table 5.4. We found that spreads decreased (increased) when firms were added (deleted) to (from) the FTSE 100 list. This result is consistent with evidence in Amihud and Mendelson (1986) that investors require higher expected returns for higher trading costs.

Overall, the results suggest the positive (negative) stock price reaction to listings (deletions) to (from) the FTSE 100 list is consistent with a decrease (increase) in trading costs. The shareholder wealth gain (loss) represents the present value of the expected change in bid-ask spreads.

Therefore, from our analysis we find that trading costs provide a plausible explanation for the stock price reaction to listings (deletions) to (from) the FTSE 100 list. This provides an explanation for our empirical results. It does not, however, provide an explanation for the asymmetric results that we find in our analysis. It does not account for why additions to the FTSE 100 list have a greater stock price reaction than the deletions from the FTSE 100 list. A possible source for the asymmetric results will be sought within the specification of equation (5.7). We re-estimate equation (5.7) for the additions and for the deletions separately[71]. The results can be seen in Table 5.6.

TABLE 5.6. A Cross-Section Regression Test of Alternative Explanations for the Stock Price Reaction to Additions and Deletions in the FTSE 100 List

$$CPE_i = \alpha_0 + +\alpha_1 \Delta SPREAD_i + \alpha_2 ABVOL_i + \alpha_3 \left(MV_{t+5} / MV_{t-1} \right) + \varepsilon_i,$$

Coefficient	Additions	Deletions	t-test of Mean Differences
α_1	-0.022	-0.0011	2.21*
α_2	1.24	0.64	2.04*
α_3	0.095	0.0032	2.17*

Notes:

* Significant at the 5% level (two-tailed test).

We can see from Table 5.6 that all the coefficients in equation (5.7) are significantly larger for the additions then they are for the deletions. This is because the additions carry more publicly available information than the deletions. Deleted firms up to their date of de-listing were the focus of attention of 'experts'. When de-listed the information about them

[71] We re-estimate equation (5.7) using a three day event window. The reason for this is that from Table 5.1 we can see that the stock price reaction to the additions and to the deletions is only significant for the three day event window around the announcement date.

did not depreciate immediately, only gradually they lost their attractiveness to 'analysts'. So de-listing does not imply an immediate loss of information about the firm, but it acts as a signal that the attention of 'experts' will shift from it, and that informed traders will emerge. For newly listed firms, the opposite occurs as a new investment in information is expected and as a consequence of this increased liquidity, the reaction of the market is more pronounced. This results in the additions having a significantly larger stock price reaction then the deletions.

5.6 Conclusions

In this chapter we find a significant gain (loss) to shareholders of firms added (deleted) to (from) the FTSE 100 list. This is due to the fact that when firms are added (deleted) to (from) the index the stock prices rise (fall) significantly. Furthermore we find that added (deleted) firms experience an increase (decrease) in trading volume, and an increase (decline) in the 'quantity' of available information after the FTSE 100 list change, suggesting a decrease (increase) in future trading costs. This finding does not support either the imperfect substitutes hypothesis, that postulates that the listing (de-listing) per se is informationless, or the price pressure hypothesis as an explanation of our results. Finally we provide evidence of an asymmetric price reaction, since there is clear indication of larger stock price reaction to the additions than to deletions, over a three-day event window.

The evidence in this chapter is consistent with an information cost/liquidity explanation for the empirical results. Inclusion (exclusion) in (from) the FTSE 100 list increases (decreases) the likelihood that they will be widely followed.

One implication for future research is that it may be more costly for a firm to borrow or issue capital after deletion. Another implication is that researchers should consider changes in trading and holding costs as competing explanations for price reactions associated with changes in index list.

Summary and Implications of Empirical Findings

In our research we studied the impact of transactions costs on the UK stock market from four different points of view. In this section we will briefly discuss the results and the implications of our main findings.

In the second chapter we postulated a linear functional relationship between transactions costs and the holding period of a common stock. We performed a series of econometric tests using annual data for all the FTSE All Share companies and established that the empirical evidence agrees with the theoretical predictions. Higher transactions costs were increasing the "holding period" (and vice versa) in the presence of other explanatory variables that were related to the characteristics of the stock.

In the third chapter we examined the effects of transactions costs on equilibrium asset pricing models. In the first part of the chapter we estimated the model proposed by Fisher (1994), by GMM using monthly data for the FTSE All Share. In addition we proposed and evaluated a model that assigns an independent role to transactions costs in asset pricing. We follow the Campbell and Shiller (1988a) VAR-type methodology and using the same data as previously, we confirmed the independent influence of transactions costs on equity pricing in the UK stock market. The results from both models are directly comparable despite the differences in the functional form of the final equation and the estimation procedures. Our finding adds further 'ammunition' to the idea that asset pricing models should incorporate transactions costs, as transactions costs possess an independent stochastic process.

In our fourth chapter we attempt to provide an explanation for the variability of transactions costs across securities. Our main hypothesis postulates that transactions costs are a function of information asymmetry. The information asymmetry is captured by the variance in analysts' forecasts, (Kim and Verrecchia (1994, 2001)). We discovered that this approximation is a useful mechanism for explaining transactions costs variability across stocks. For a horizon up to six months we found the inter-stock transactions costs variability was positively related to the variance of analysts' forecasts. The aim of this chapter was to assess the impact of information asymmetry on transactions costs, and not to analyse the stochastic process of transactions costs, over time.

In the fifth chapter we found that the reaction of stock prices and trading volume to changes in the status of the company as a participant in the FTSE 100, can be explained by "liquidity effects", as proxied by transactions costs.

In conclusion this thesis provides strong evidence of the hypothesis that transactions costs as proxied by the bid-ask spread are a fundamental issue in finance, both in asset pricing models and in influencing investor behaviour.

Further work could include using an alternative proxy for transactions costs, such as price impacts, opportunity costs and brokerage fees. However, as we mentioned earlier the data availability for these proxies are very difficult to obtain.

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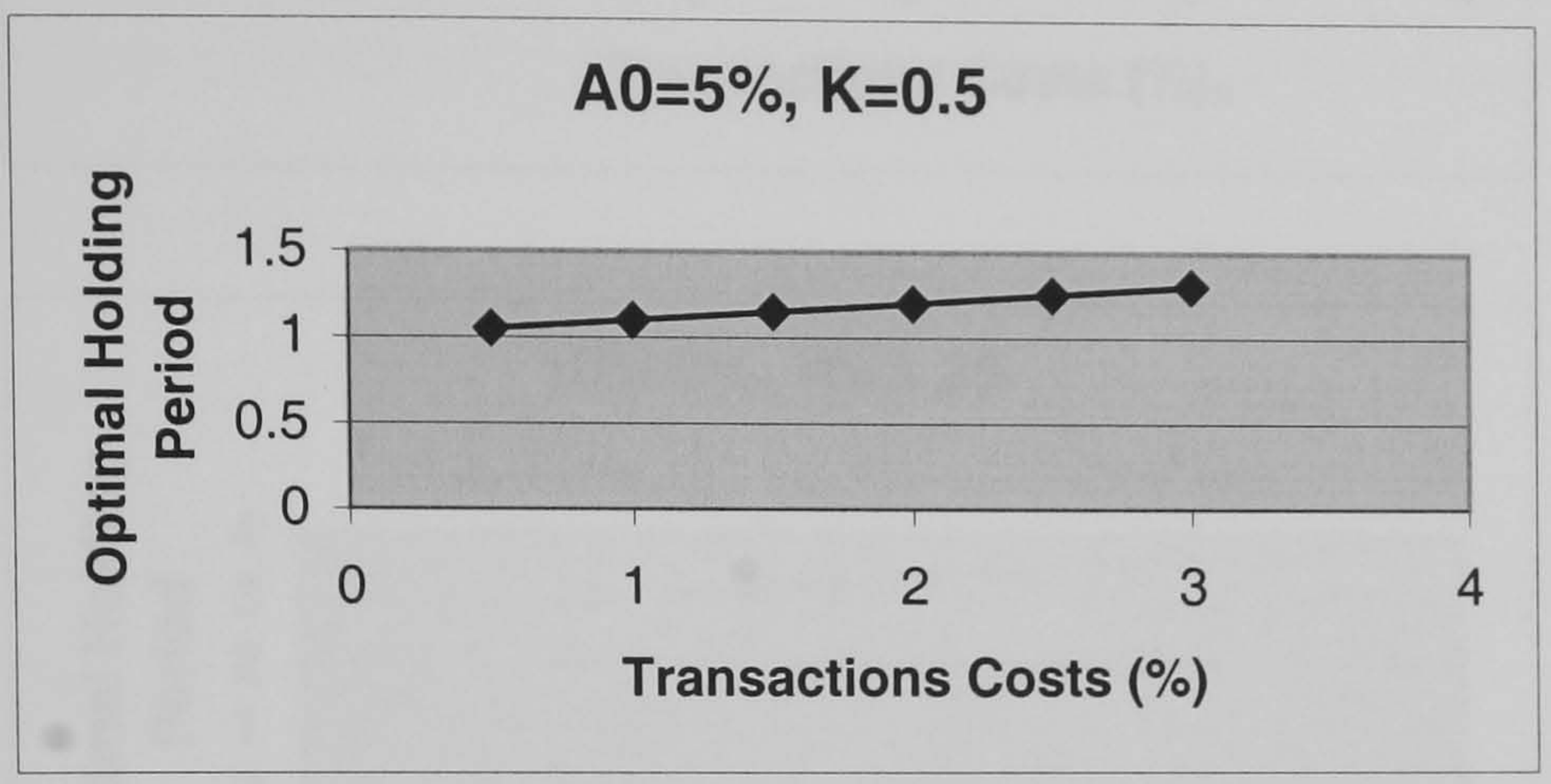
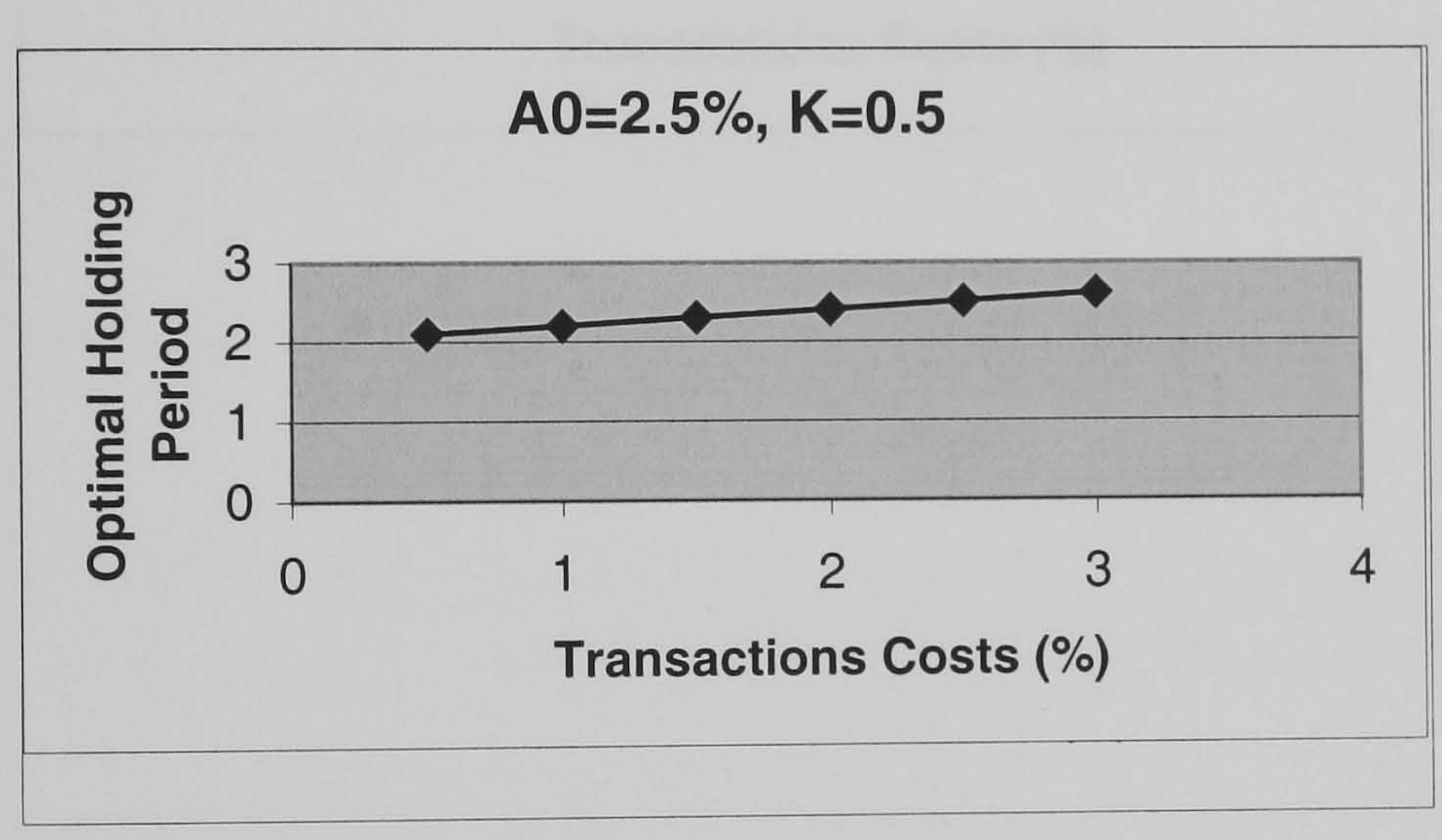
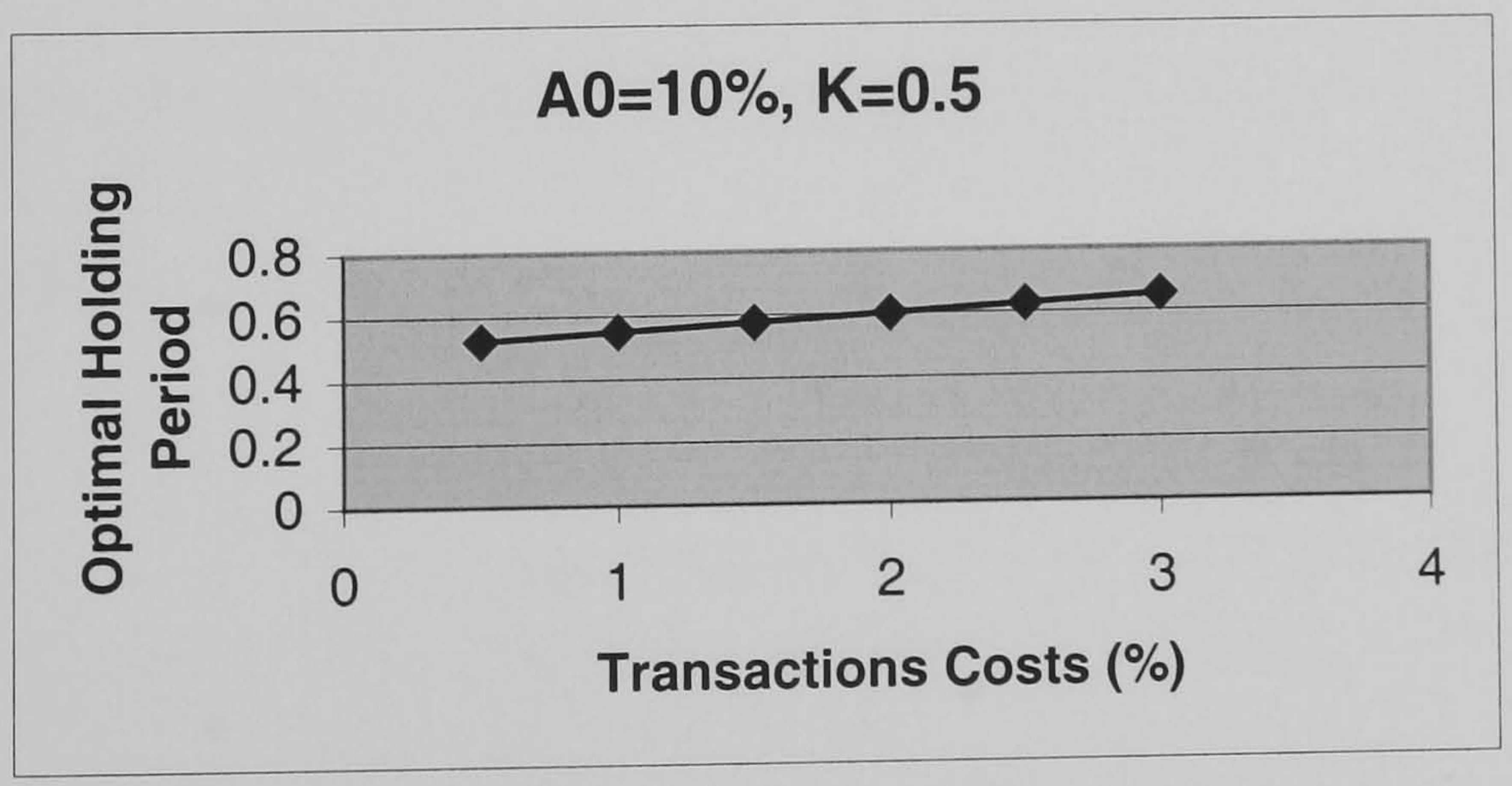
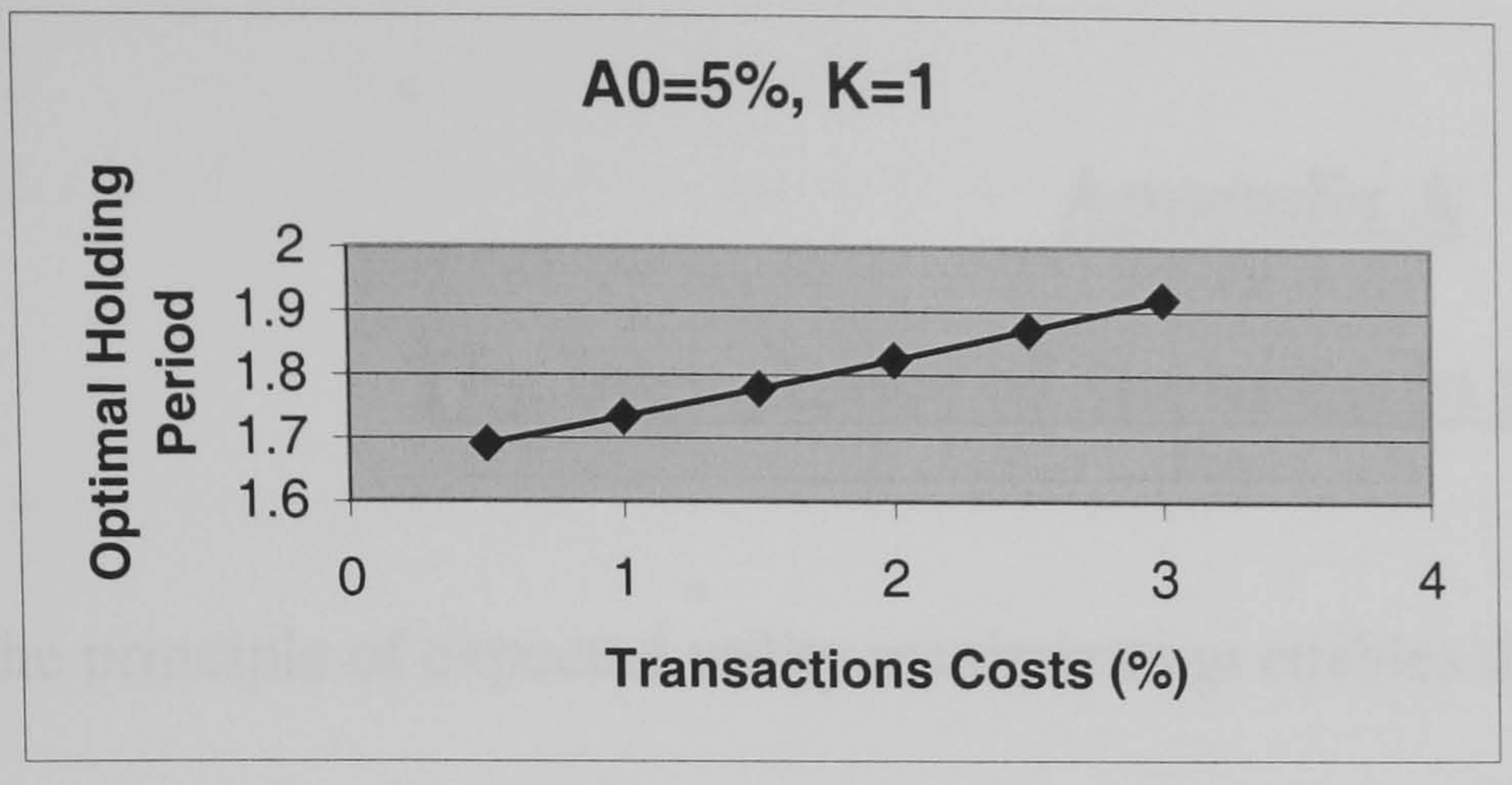
Figure A

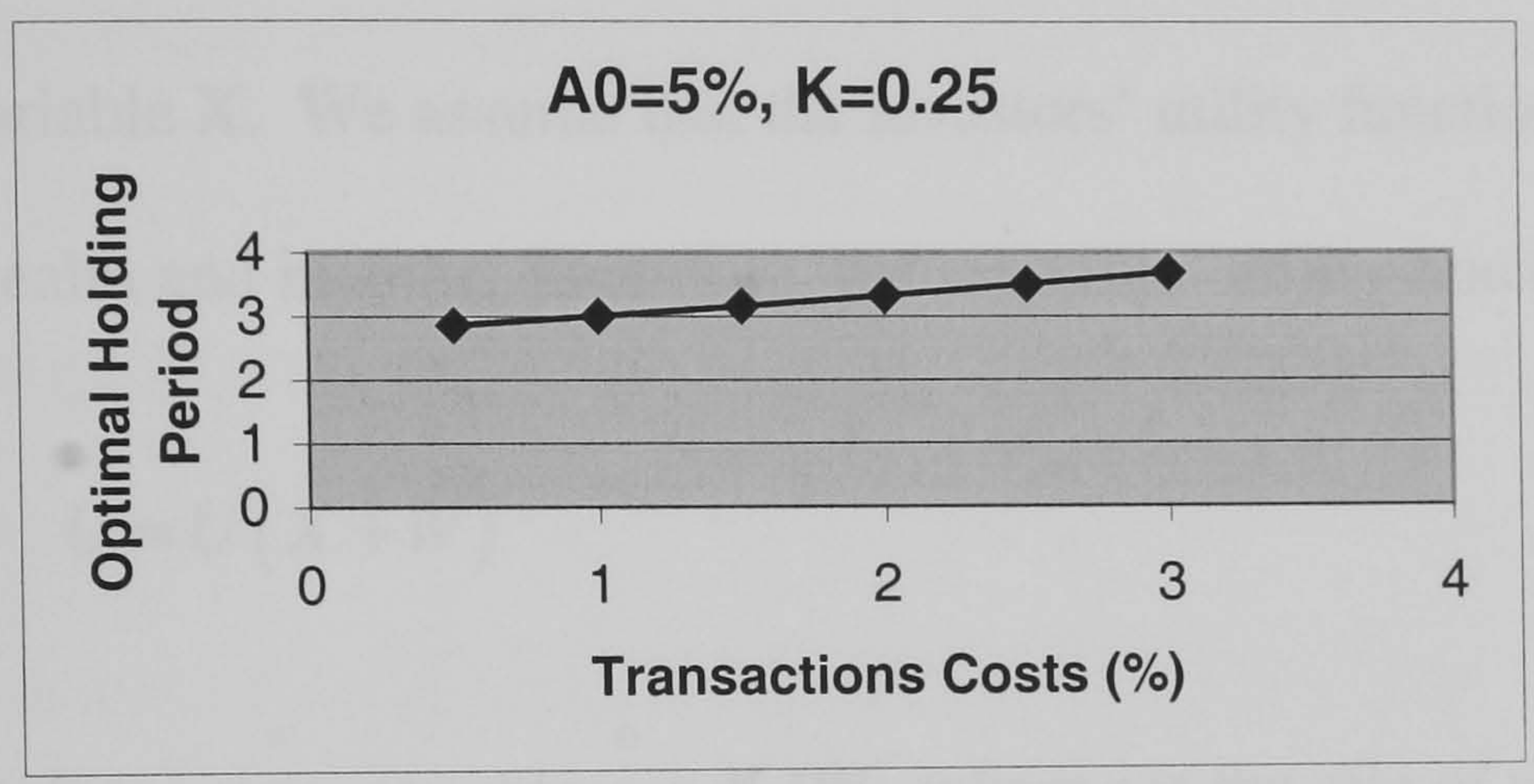
Graphical Relationship between the Optimal Holding Period and Transactions Costs








A0=5%, K=1
Optimal Holding Period
2
1.9
1.8
1.7
1.6
0
1
2
3
4
Transactions Costs (%)


A0=5%, K=0.25
Optimal Holding Period
4
3
2
1
0
0
1
2
3
4
Transactions Costs (%)

Appendix A

The Importance of Skewness in the Risk Premium

The principle of expected utility maximization enables the specification of certain types of investor risks. Let the investors' wealth be denoted by W and his income by the random variable X. We assume that the investors' utility function, U, is made up of the sum of his wealth and income. Therefore, the investors' utility function is

$$U = U\left(X + W\right) \tag{A.1}$$

Define a new variable $r = X / W$, where r is the rate of return on an investment W. If this is the case then (A.1) may be written as

$$U = U\left(rW + W\right) \tag{A.1a}$$

Expanding U in a Taylor series about $w + E\left(rW\right)$, where $E\left(rW\right)$ represents the expected value of income, taking the expectation of both sides, and assuming that W and $E\left(rW\right)$ are constant gives

$$E\left(U\right) = U\left[W + E\left(rW\right)\right] + \frac{W^2}{2!}U^{\prime\prime}\left(W + W\mu_1\right)\mu_2 \tag{A.2}$$

$$+ \frac{W^3}{3!}U^{\prime\prime\prime}\left(W + W\mu_1\right)\mu_3 + \text{terms involving higher order moments}$$

Where μ_1, μ_2, and μ_3 denote the first, second, and third moments of r's probability distribution. Equation (A.2) states that the expected utility is a function of those risks associated with the higher moments of a probability distribution. Note that attention has been concentrated on the second and third moments of r's distribution. This has been done due to the fact that, the higher moments of r add little, if any, information about the distribution's physical features.[72]

The above relationship has been derived without making any assumptions about the investors' attitude to risk. This must now be done to arrive at a testable hypothesis concerning the variability and skewness of returns as risk measures and the relation of such measures to the expected return. Assume that the typical investor is risk averse. Economic theory describes the risk averter as the one whose marginal utility decreases with increasing wealth. That is,

$$U^{"} \prec 0 \qquad \text{(A.3)}$$

Condition (A.3) states that the coefficient of μ_2 must be negative. The economic implication of this negative sign is direct – the greater the variability of return on an investment, the lower the expected utility of the investment. Consequently for the investment to retain its appeal under an increase in the variability of returns and no change in the other moments, its expected return must increase.

One implication of the diminishing marginal utility assumption is that the cash equivalent of the expected utility is less than the expected utility of the venture. This proposition is true of any concave utility function. The amount by which the expected value exceeds the cash equivalent of the expected utility is called the risk premium. It can be thought of as the amount the investor must be given in order for him to risk a sum equal to his cash equivalent.

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[72] For evidence of this see Arditti (1967) page 20.

According to Pratt (1964), it is possible to define the risk premium mathematically. Let σ^2 be the variance of income and π a measure of the local risk premium. Then

$$\pi \approx \frac{\sigma^2}{2}\frac{U''(W)}{U'(W)} \quad \text{(A.4)}$$

It can be argued that the investor attaches a smaller risk premium to any given risk the greater his wealth. For example, consider the situation where two individuals, one poor and the other extremely wealthy, each find themselves in possession of a ticket which entitles the holder to partake in the following gamble:

" If on one toss of a coin a head appears the ticket holder receives £20,000. On the other hand, if a tail appears, the holder must pay £10,000 ". Who would demand a higher price for the sale of the ticket?

It seems reasonable to assume that the wealthy man would since a loss of £10,000 to him would be trivial while a similar loss to the poor man would render him assetless. But the price the seller is willing to accept is the cash equivalent of his expected utility, and the difference between the cash equivalent and the expected value of the ticket is by definition the risk premium. Since the asking price of the wealthy man is higher than the poor man and each ticket has the same expected value, the wealthy individual's risk premium is less than that of the poor man's. Therefore one can infer that the risk premium decreases with wealth.

Mathematically the risk premium can be stated as,

$$\frac{d}{dw}\left[-\frac{\sigma^2}{2}\frac{U''(W)}{U'(W)}\right]=\frac{\sigma^2}{2}\bullet\frac{-U'(W)\,U'''(W)\,+\left[U''(W)\right]^2}{\left[U'(W)\right]^2}\prec 0 \tag{A.5}$$

Since $U'(W)\succ 0$, for the above inequality to hold.[73]

Making use of this result, $U'''(W)\succ 0$, and equation (A.2), it must be stated that the coefficient of the third moment μ_3 must be positive. This analysis suggests that skewness may be an important factor in determining the risk premium of an investor. This could imply that the skewness could be an important determinant of the holding period of an investor, since it may capture any non-linearity in the specification.[74]

[73] For proof of this result see Pratt (1964).

[74] We cannot say that investors prefer positively skewed stocks. This is because for this to be the case there must be ceteris paribus analysis of preferences and moments. Brockett and Garven (1998) found that this was impossible since equality of higher order central moments implies the total equality of the distributions involved.

Appendix B

The Derivation of the Utility Adjusted Return

Consider the return to holding an asset over the time period t to $t+1$, say a share. We have

$$R_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t} - 1 \qquad \text{(A.6)}$$

where D_{t+1} is any dividend or payment in the period and P_t, P_{t+1} is the price of the asset at time t and $t+1$.

We assume for simplicity that investors are risk neutral so that via arbitrage expected returns are equal to those on a riskless asset with a real interest rate, $\overline{R}$, assumed constant, so that $E_t R_{t+1} = \overline{R}$.

Since P_t is part of the current information set, the expectation of (A.6) when rearranged is given by

$$P_t = \frac{1}{\left(1+\overline{R}\right)} E_t P_{t+1} + \frac{1}{\left(1+\overline{R}\right)} E_t D_{t+1} \qquad \text{(A.7)}$$

Assuming rational expectations and solving this model forwards N periods we obtain

$$P_t = E_t \sum_{i=1}^{N} \frac{D_{t+i}}{\left(1+\overline{R}\right)^i} + \frac{E_t P_{t+N}}{\left(1+\overline{R}\right)^N} \qquad \text{(A.8)}$$

In the absence of speculative bubbles we assume that the last term goes to zero as we let N go to infinity. In this case the current asset price is equal to the expected value of the stream of dividends into the indefinite future. This term is the fundamental of the process which we can call F_t.

Under these assumptions we have that:

$$P_t = E_t \left[\sum_{i=1}^{\infty} \frac{D_{t+i}}{\left(1+\bar{R}\right)^i} \right] \tag{A.9}$$

We can write (A.9) in the equivalent form

$$P_t = E_t \left[\sum_{i=1}^{\infty} \frac{D_{t+i}}{\left(1+\bar{R}\right)^i} \right] + \frac{D_t}{1+\bar{R}} - \frac{D_t}{1+\bar{R}} + \frac{E_t D_{t+1}}{\left(1+\bar{R}\right)^2} - \frac{E_t D_{t+1}}{\left(1+\bar{R}\right)^2} + \frac{E_t D_{t+2}}{\left(1+\bar{R}\right)^3} - \frac{E_t D_{t+2}}{\left(1+\bar{R}\right)^3} + \ldots \tag{A.10}$$

Rearranging (A.10) we have that

$$P_t = E_t \left[\sum_{i=1}^{\infty} \frac{\Delta D_{t+i}}{\left(1+\bar{R}\right)^i} \right] + \frac{D_t}{1+\bar{R}} + \frac{E_t D_{t+1}}{\left(1+\bar{R}\right)^2} + \frac{E_t D_{t+2}}{\left(1+\bar{R}\right)^3} \ldots \tag{A.11}$$

So by using (A.9) we can rewrite (A.11) as

$$P_t = E_t \left[\sum_{i=1}^{\infty} \frac{\Delta D_{t+i}}{\left(1+\bar{R}\right)^i} \right] + \frac{D_t}{1+\bar{R}} + \frac{P_t}{1+\bar{R}} \tag{A.12}$$

Multiplying through by $1+\bar{R}$ and re-arranging we obtain the alternative form

$$P_t = \frac{D_t}{\bar{R}} + \frac{1}{\bar{R}} E_t \left[\sum_{i=1}^{\infty} \frac{\Delta D_{t+i}}{\left(1+\bar{R}\right)^{i-1}} \right] \tag{A.13}$$

Equation (A.8) shows that the current price of the stock is equal to the dividend divided by $\bar{R}$ plus a term in the discounted stream of expected future changes in dividends. In this form the model is amenable to empirical testing in the form of cointegration analysis. If dividends are a non stationary process but the changes in dividends are stationary then the stock price is cointegrated with coefficient $\frac{1}{R}$.

An insightful special case of the above model arises when dividends are expected to grow at a constant rate g.

For this case

$$E_t D_{t+i} = (1+g) E_t D_{t+i-1} = (1+g)^i D_t \tag{A.14}$$

Substituting (A.14) in (A.9) we obtain

$$P_t = \frac{(1+g) D_t}{(1+\bar{R})} + \frac{(1+g)^2 D_t}{(1+\bar{R})^2} + \frac{(1+g)^3 D_t}{(1+\bar{R})^3} + \frac{(1+g)^4 D_t}{(1+\bar{R})^4} + \ldots \tag{A.15}$$

We can rewrite (A.15) as

$$P_t = \frac{(1+g) D_t}{(1+\bar{R})} \quad 1 + \frac{(1+g)}{(1+\bar{R})} + \frac{(1+g)^2}{(1+\bar{R})^2} + \frac{(1+g)^3}{(1+\bar{R})^3} + \ldots \tag{A.16}$$

Recalling that $\frac{1}{1-x} = 1 + x + x^2 + x^3 + \ldots$ for $|x| \prec 1$ and assuming that $g \prec \bar{R}$ (as it must be since the stock price is not infinite) we can rewrite (A.16) as

$$P_t = \frac{(1+g)D_t}{(1+\bar{R})}\left\{\frac{1}{1-\frac{(1+g)}{(1+R)}}\right\} = \frac{(1+g)D_t}{\bar{R}-g}. \tag{A.17}$$

This form is the Gordon growth model. It demonstrates the important point that if $\bar{R}$ is close to g then small permanent changes in $\bar{R}$ can have a major impact on the stock price.

The assumption made in the derivation of the asset price (A.9) is that expected stock returns are equal to a constant risk-free real rate of interest (in the context of CAPM say a constant real rate plus a constant risk premium). Relaxing this assumption in the above framework results in the loss of analytic tractability since expectations would be of a non-linear form.

It is interesting to note an approximation for the case of a variable return that preserves tractability, which was initially employed by Campbell and Shiller (1988a).

Take logarithms of (A.6) we have that

$$\log(1+R_{t+1}) = \log(P_{t+1}+D_{t+1}) - \log(P_t) = \log(P_{t+1}) - \log(P_t) + \log\left(1+\frac{D_{t+1}}{P_{t+1}}\right) \tag{A.18}$$

If we define h_{1t} as the logarithm of the utility adjusted return, we can re-write (A.18) as

$$h_{1t} = \log\left(\frac{P_{t+1}+D_{t+1}}{Pt}\right) \tag{A.19}$$

If we include in the utility adjusted return, the effect of consumption (A.19) becomes

$$h_{1t} = \log\left(\frac{P_{t+1} + D_{t+1}}{Pt}\right) + \alpha \log\left(\frac{C_{t+1}}{C_t}\right) \tag{A.20}$$

If we adjust the utility adjusted return displayed in (A.20) to include the effect of transactions costs (i.e. the effect of changes in the bid-ask spread), then we obtain the following utility adjusted return.[75]

$$h_{1t} = \log\left(\left(\frac{P_{t+1} + D_{t+1}}{P_t}\right) - \left(\frac{S_{t+1}}{S_t}\right)\right) + \alpha\left(\frac{C_{t+1}}{C_t}\right) \tag{A.21}$$

[75] The Derivation of the Utility Adjusted Return was obtained from Minford and Peel (2002).

Appendix C

The Estimation of Equation (3.35)

TABLE 3.3. Present value Tests of the CCAPM including Transactions Costs, estimated for the UK stock market for the period 1980-2000.

Lag	N	Δd_t	ΔS_t	Δc_t	$\bar{R}^2$
1	239	0.423 (2.21)*	-0.029 (-2.89)*	0.343 (2.45)*	0.372
2	238	0.315 (2.54)*	-0.026 (-2.72)*	0.294 (2.36)*	0.351

Notes:

The t statistics are shown in brackets and * indicates significance at the 5% level.

All the variables in the above equation are expressed as natural logarithms.

Diagnostic Results

Period	Serial Correlation Test	Heteroscedasticity Test	Normality Test	Functional Form Test
1980-2000	0.48	0.27	0.35	0.75

Notes:

All the diagnostic statistics that are reported are based on the F statistic.

The heteroscedasticity test is based on the test proposed by White (1980).

The serial correlation test is based on the test proposed by Godfrey (1978a, 1978b).

The normality test is based on the test proposed by Jacque and Bera (1987).

The functional form test is based on the Ramsey (1969) test.

Appendix D

The sample of companies used in the Information Asymmetry Chapter

The 26 companies and the years for which data are available are:

Company Name	Year
ABBEY NATIONAL	90-98
ALLIED DOMECQ	90-98
PRUDENTIAL	96-98
SCHRODERS	91-98
ARM HOLDINGS	90-98
POWERGEN	90-98
BAA	90-99
SAFEWAY (UK)	91-98
BOOTS	90-99
BP	90-99
BRITISH AIRWAYS	90-99
TESCO	91-98
BRITISH TELECOM	97-98
CAPITA GROUP	90-98
SAINSBURY (J)	91-98
CENTRICA	90-98
COMPASS GROUP	90-99
DAILY MAIL 'A'	90-99
HSBC HOLDINGS	90-99
DIXONS GP.	90-98
ELECTROCOMP.	97-98
EMI GROUP	90-98
VODAFONE GROUP	90-98
SAGE GROUP	94
HANSON	94-95
GRANADA	90-98

No. of companies	Year
17	90
22	91
21	92
21	93
22	94
22	95
23	96
24	97
24	98
7	99

203	

Appendix E

Dates of Changes in the FTSE 100 List over the time period 1984-2001

Date of Change	Firms Added	Firms Deleted	Sample Total
19/01/84	1	1	2
02/04/84	1	1	2
02/07/84	2	2	4
19/07/84	1	1	2
01/10/84	3	3	6
04/12/84	1	1	2
02/01/85	4	4	8
01/02/85	1	1	2
01/04/85	3	3	6
01/07/85	2	2	4
06/08/85	1	1	2
01/10/85	1	1	2
02/01/86	1	1	2
08/01/86	2	2	4
01/04/86	4	4	8
21/04/86	1	1	2
22/04/86	1	1	2
01/07/86	3	3	6
01/10/86	3	3	6
09/12/86	1	1	2
02/01/87	3	3	6
01/04/87	3	3	6
27/04/87	1	1	2
01/07/87	2	2	4
01/10/87	3	3	6
04/01/88	2	2	4
25/02/88	1	1	2
05/04/88	4	4	8
01/07/88	1	1	2
07/07/88	1	1	2
03/10/88	1	1	2
21/12/88	1	1	2
03/01/89	2	2	4
03/04/89	4	4	8
17/07/89	1	1	2
27/07/89	1	1	2
08/08/89	1	1	2
11/09/89	1	1	2
02/11/89	1	1	2
02/01/90	2	2	4
02/04/90	1	1	2
02/07/90	1	1	2
13/07/90	1	1	2
01/10/90	3	3	6

02/11/90	1	1	2
02/01/91	2	2	4
23/01/91	1	1	2
02/04/91	3	3	6
01/07/91	3	3	6
16/09/91	1	1	2
01/10/91	1	1	2
26/11/91	1	1	2
04/12/91	1	1	2
02/01/92	3	3	6
01/04/92	4	4	8
22/06/92	3	3	6
13/07/92	1	1	2
21/09/92	6	6	12
21/12/92	2	2	4
22/03/93	1	1	2
01/06/93	1	1	2
21/06/93	4	4	8
20/09/93	3	3	6
25/10/93	1	1	2
05/11/93	1	1	2
20/12/93	2	2	4
21/03/94	3	3	6
20/06/94	1	1	2
19/09/94	2	2	4
17/03/95	1	1	2
26/07/95	1	1	2
18/09/95	3	3	6
19/09/95	1	1	2
23/10/95	1	1	2
11/12/95	1	1	2
18/12/95	5	5	10
28/12/95	2	2	4
31/01/96	1	1	2
24/06/96	3	3	6
19/07/96	1	1	2
17/08/96	1	1	2
23/09/96	1	1	2
30/09/96	1	1	2
23/12/96	2	2	4
14/02/97	1	1	2
24/02/97	1	1	2
24/03/97	1	1	2
23/06/97	2	2	4
22/09/97	5	5	10
17/12/97	2	2	4
22/12/97	4	4	8
24/12/97	1	1	2
23/03/98	1	1	2
21/05/98	1	1	2
02/06/98	1	1	2

22/06/98	2	2	4
08/09/98	1	1	2
21/09/98	5	5	10
16/12/98	1	1	2
21/12/98	4	4	8
04/02/99	2	2	4
22/03/99	4	4	8
29/03/99	1	1	2
10/05/99	1	1	2
21/06/99	2	2	4
28/07/99	1	1	2
20/09/99	3	3	6
11/11/99	1	1	2
24/11/99	1	1	2
20/12/99	2	2	4
07/03/00	1	1	2
20/03/00	9	9	18
12/05/00	1	1	2
30/05/00	1	1	2
19/06/00	4	4	8
27/07/00	1	1	2
18/09/00	5	5	10
17/10/00	1	1	2
18/12/00	5	5	10
27/12/00	2	2	4
02/02/01	2	2	4
19/03/01	2	2	4
10/04/01	1	1	2
18/06/01	1	1	2
12/07/01	1	1	2
07/08/01	1	1	2
10/09/01	2	2	4
24/09/01	8	8	16
19/11/01	2	2	4
12/12/01	1	1	2
Total	**258**	**258**	**516**

Appendix F

Portfolio Estimations of Stock Price Reactions to FTSE 100 Changes

TABLE 5.1A Portfolio Estimations of Stock Price Reaction to Announcement of Changes in the FTSE 100 List, between the time period of 1984-2001. Cumulative Average Prediction Errors (CAPE) and t-statistics are reported

Panel A. Additions			Panel B. Deletions		
Days Relative to Event	CAPE (%)	t-statistic	Days Relative to Event	CAPE (%)	t-statistic
-60, -2	1.34	0.37	-60, -2	-3.49	-0.71
-60, -41	1.43	0.34	-60, -41	-2.69	-0.45
-40, -21	-2.26	-0.69	-40, -21	-1.84	-0.98
-20, -11	1.94	0.46	-20, -11	-2.62	-1.26
-10	-0.71	-0.97	-10	-0.76	-0.62
-9	0.52	0.34	-9	1.34	1.09
-8	2.18	1.20	-8	0.93	0.98
-7	0.17	0.50	-7	1.35	0.83
-6	-1.36	-1.34	-6	0.98	0.93
-5	1.05	0.24	-5	0.65	0.59
-4	2.72	1.18	-4	-0.43	-1.28
-3	2.59	1.08	-3	-1.64	1.09
-2	3.49	2.27*	-2	-1.21	-2.11*
-1	2.87	2.41*	-1	-1.84	-2.79*
0	1.29	2.58*	0	-2.55	-3.58*
1	2.43	2.94*	1	-1.32	-2.35*
2	1.12	2.26*	2	-1.38	-2.47*
3	-0.54	-0.72	3	-0.76	-1.26
4	2.14	1.46	4	-1.38	-1.12
5	1.46	0.56	5	-1.21	-1.39
6	-0.99	-0.17	6	-0.13	-1.55
7	0.63	0.51	7	1.39	1.41
8	-0.89	-1.24	8	-0.86	-1.23
9	-0.32	-1.38	9	-.1.08	-1.31
10	-1.99	-1.27	10	-0.35	-1.37
+11, +20	-2.34	-1.21	+11, +20	-1.78	-0.83
+21, +40	-3.84	-1.42	+21, +40	1.53	1.39
+41, +60	-3.97	-1.64	+41, +60	-3.92	-1.48
+2, +60	-4.56	-1.67	+2, +60	-4.49	-1.64
CAPE(-1, +1)	6.59	2.63*	CAPE(-1, +1)	-5.71	-2.87*

Notes:

Day 0 is the day on which the changes in the FTSE 100 list are announced on the London Stock Exchange.

* Significant at the 5% level (two-tailed test).