Trading in Equity Markets

A study of Individual, Institutional and Corporate Trading Decisions

by

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To Kristin,
and my parents Inger-Anne and Arne

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Oslo, February 2004
Johannes A. Skjeltorp

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Chapter 1

Introduction

1.1 Introduction and overview

This thesis is about the trading behavior of various participants in equity markets, how they trade in various settings, their transactions costs and how their trading activity affect prices.

Vast amounts of financial assets are exchanged between various participants every day. Whether these assets are stocks, bonds, futures or options this exchange of assets reflects the trading needs of a whole range of participants. These trading needs may be related to investments, hedging, diversification, speculation/gambling or dealing, and the exchange may occur between large institutional investors, dealers, small private investors or the issuing firms themselves. The characteristics of each participant is to a great extent reflected in his trading strategy and portfolio choice. However, all participants are subject to the same question: What is the correct price of the asset? One fundamental characteristic of most financial assets is that they represent a claim on uncertain payments. Since generally a large part of these payments will occur sometime in the future, the asset price depends on the participants expectations about these future payments, and on average, the price today should equal the expected discounted payments in the future. Standard asset pricing theory assumes that information about these future payoffs and their probability of occurring is equally dispersed across all market participants, and when there are no frictions, the revision of demand and supply of rational participants occur instantaneously when new information about these payoffs arrives such that the equilibrium price of the asset is determined. This ensures that prices efficiently reflect all relevant information and that it is impossible, with the information set available to all participants, to make economic profits based on any part of this information.

Although the notion of a fully efficient market is unrealistic, and infeasible in practice, it creates a useful benchmark case. As a result of this, much of the theoretical and empirical research in finance the last few decades has addressed the importance of asymmetric information, liquidity and investor heterogeneity in the pricing of assets as well as to examine the relative efficiency of markets. For example, when information is unevenly distributed among participants and/or they interpret the information differently when forming their expectations about future payoffs, this is likely to have implications for the cost of transacting, how different participants choose to transact as well as how fast and to what degree prices reflect full information. Furthermore, when some investors have superior information, deviations from the equilibrium price may reflect a required compensation for the potential loss from trading with better informed investors. Although these issues affect observed market prices, markets may still be informationally efficient in the sense that deviations from the full information price may be due to information gathering costs such that abnormal returns relative to what would be expected in a frictionless equilibrium may merely reflect a compensation for these costs.

The general topic of this thesis is to study the trading behavior of various participants transacting in equities markets and how differential information among these affect their transaction costs, their choice of trading strategies and the implications for price discovery. Several of the essays examine how and to what degree information move prices. None of the essays are attempts to test an equilibrium model or determine whether markets are informationally efficient. Moreover, the scope of the thesis is to provide useful inputs to the literature by examining detailed datasets that may improve our understanding of how investors behave in equity markets.

I study issues related to equity trading in two main settings which constitute the two main parts of the thesis, each containing two chapters. The first part consists of two essays in which I examine transactions costs, liquidity and price volatility in a market microstructure setting. In the first chapter the trading decision and execution costs of one particular, large institutional, investor trading outside regular exchanges is examined. The second essay examines the trading activity of all participants in an electronic limit order market and how their order submission strategies affect trading volume and volatility. The second part of the thesis examines asymmetric information between the managers of the firm and the market in a corporate finance setting where the issuing company, which potentially is the ultimate informed participant, is an active trader in its own stock. The first essay in the second part examines the price effect of open market share repurchase announcements and actual repurchase executions. Since a repurchase is an event that potentially changes each shareholders ownership proportion, the second essay in the second part examines the ownership structure of firms that repurchase their own shares to obtain insights into the decision of why firms choose trade their own stock. Moreover, this last essay is a preliminary study aiming at motivating further research on the relationship between ownership structure and firms choice of repurchasing shares. To give a general overview of the different chapters of the thesis I will first briefly summarize each chapter below. In each of the subsequent sections of the introduction I will give a more detailed discussion of the separate chapters. These discussions will give the reader some background information about the markets and questions examined and try to motivate why the different questions justify a closer investigation.

Microstructure essays In the first chapter, I ask whether the costs of trading equity outside the regular exchanges (i.e. trading in crossing networks) in the US is cheaper than trading the same stocks on a regular exchange. I also examine whether the stocks that are easier to obtain outside the exchange have different characteristics than stocks that are more difficult to trade off-exchange. This is an interesting question motivated by the fact that regular exchanges, especially in the US, have experienced increased competition from so-called alternative trading systems (ATS). Regulators are concerned that these systems fragment liquidity in the same securities across several trading venues which lacks transparency. From the exchanges point of view, they are concerned that the ATS "cream-skim" their order-flow by removing large uninformed investors as well as free riding on the price discovery process in the primary exchanges. From the investors point of view this competition may constitute both benefits and costs. While investors have obtained new venues where they can execute trades at very low commissions, the costs may be related to liquidity being dispersed across several markets affecting price discovery and costs in the primary markets. In addition, their trading interest is potentially exposed to fewer participants decreasing the execution probability of their orders. The main objective of the paper is to examine to what degree the cost of trading in an ATS is lower and whether the benefit of trading in these systems is related to certain types of securities. By using information on all trades executed by a large institutional investor that implemented a large portfolio during the first half of 1998 through an ATS in the US, I try to cast light on these issues. One of the arguments for why large institutional investors may benefit from trading in these systems is that their potentially large trades do not result in adverse price movements that would increase their transaction costs. For these types of investors, the alternative trading systems is a welcomed alternative. Since there is no price discovery in crossing networks, the direct price impact costs are mitigated. However, for an investor that is pre-committed to trade, as the investor in our dataset, the cost of non-execution and delay in the crossing network may potentially be large. Thus, the implicit costs by trading in these networks is difficult to estimate without detailed data on the entire submission strategy as well as the actual executions of the different parts of the portfolio. This essay contributes to the literature by being able to estimate these costs more precisely.

In the second chapter, I examine the relationship between volume and volatility in the Norwegian stock market. More specifically, the study examines a detailed dataset containing all order submissions and trade executions that occurred on the Oslo Stock Exchange (OSE) from the beginning of 1999 through June 2001. A variety of studies document that there is a positive correlation between price volatility and trading volume. The main proposed explanation for this relationship is the *mixture of distributions hypothesis* (MDH) which states that both volume and price changes are driven by the same, unobservable, information arrival process which correlates trading volume and volatility. Thus, when new information hits the market, this increases trading volume and moves prices. However, there is also a part of the market microstructure literature that suggest that dispersion of beliefs and strategic trading behavior by economic agents affect volatility as well as trading volume above what would be expected in equilibrium. Thus, the relationship between information arrivals and volatility may not necessarily only reflect the arrival of new information, but in addition reflect uninformed traders strategically trying to extract information from the order flow (Shalen, 1993). The paper documents a similar volume-volatility relation as found in other studies that examine the MDH, where the number of trades explain a large part of the volatility. However, the main contribution of the study is that it documents several relationships between the shape of the order book, trading volume and volatility. The paper measures the order book shape by the average elasticity of the supply and demand schedules in the book. The lower the elasticity (steeper the slope), the less dispersed are the bid and ask prices in the order book.[1] To examine the effects of the order book slope on volume and volatility, the slope measure is included as an independent variable in a cross sectional time series version of the standard regression model used to examine the volume-volatility relation. A systematic negative relation between the average slope of the order book and the price volatility is documented. In addition, the results indicate that a "wider" order book (more gentle slopes) coincide with a higher trading volume. The results are also shown to be robust to the choice of time period and slope measure. One proposed interpretation of these results is that the dispersion of reservation prices in an electronic limit order market may contain information about valuation uncertainty and dispersion of beliefs about asset values (Shalen, 1993). When orders are submitted close to the inner quotes, it may be interpreted as there being more agreement about the valuation of the security compared to cases where investors submit orders across a wider range of prices.

Corporate finance essays The second part of the thesis contains two essays in corporate finance, where I examine a specific corporate event in which the issuing firm itself is an active participant in the market for its own stock (open market share repurchases). In many markets firms have not had the opportunity to repurchase their own stock. A recent trend has been that an increasing number of countries allow firms to distribute cash in this way. In the US, where repurchases has been allowed for several decades, the cash distributed through repurchases has steadily increased through the years, and today firms distribute as much cash through repurchases as through dividends. In 1999

[1] This is in the case of direct demand and supply curves (prices on the x-axis and accumulated volume on the y-axis). In the case of inverted demand and supply curves, the relationship would be opposite.

repurchases also became allowed for Norwegian firms, giving firms an additional instrument for conducting their financial policy. Both the academic literature as well as the popular press provide a vast amount of suggestions for why firms initiate repurchases. Some proposed reasons are mitigation of agency costs, takeover defense, to counter dilution effects of management and employee options, to increase the value of management options, capital structure adjustments, personal taxes, manipulating earnings-per-share (EPS) figures as well as minority shareholder expropriation, to mention a few. However, the most prevalent explanations relate to mispricing. Several studies argue that a repurchase announcement contains valuable information about current and future earnings. Assuming that the managers of firms have private information about their firms future prospects, a repurchase may be used to convey firm specific information that is not yet reflected in prices (the signalling hypothesis). Empirical evidence supporting the signalling hypothesis is accumulating across several countries and time periods. However, an emerging body of empirical literature also suggests that the market underreacts to new information related to firms current and future cash flows. Events that are a priori likely to contain cash-flow-relevant information, such as earnings surprises and dividend initiations, as well as the announcements of repurchase programs, are followed by an abnormal stock-price drift in the same direction as the price effect from the initial announcement. Given a model for expected returns, this is often referred to as underreaction. In an efficient market, the initial reaction should be complete and unbiased. However, empirical results indicate that this is not the case. Whether this is because of mispricing or misspecification of the expected returns model is still an open question. In this study I investigate whether a similar underreaction is observed in the Norwegian market. Since the repurchase announcement itself is no commitment by the firm to actually execute repurchases, I provide evidence on the market impact of actual repurchase executions and examine how this relates to the underreaction hypothesis. Previous empirical studies on open market share repurchases have been limited to examining actual repurchase activity to annual, quarterly or monthly frequencies since firms in the markets that has been studied are not required to report their transactions to the marketplace in a readily fashion. However, firms in Norway are required by law to report their transaction immediately or at least before the trading session starts the following day. This provides us with an new and interesting dataset which can be used to obtain a better understanding about how markets respond to the information inherent in the actual repurchases. Furthermore, since the initial announcement of the repurchase plan in many cases is a weak signal about undervaluation, it may be argued that the actual repurchases are stronger indications that the managers of the firm perceives the firm as being mispriced. At least, the actual repurchases informs the market that the firm follow up on their initial announcement. Further, if immediate disclosure of actual repurchases are important to pricing, strict requirements may help price discovery and improve market efficiency. In fact, one concern both in the academic literature and public press in the US is that many firms announce that they are planning on repurchasing, but that a relatively low fraction actually goes through with any repurchases. In addition, the marketplace, as well as academics, is to a large degree kept in the dark with respect to the repurchase activity and must infer this from the public press, changes in outstanding shares or changes in treasury stock from the balance sheets. Thus, due to the strict requirements for Norwegian firms to report their repurchases immediately, a detailed examination of how the repurchases affect prices and whether the repurchases provide useful information to the market.

The fourth essay is a continuation of the third essay examining the characteristics of repurchasing firms in more detail. Initially, dividends and repurchases are two alternative ways of disgorging free cash. However, there is one major issue that differentiate the two. While a dividend payment reduces the cash of the firm, a repurchase also revises each remaining shareholder's ownership proportion in the repurchasing firm. Thus, in addition to being used as a means for changing the capital structure, paying out cash or signal private information, it may also be used by the firm to strategically change the ownership structure and potentially improve corporate governance within the firm. Although there is a large empirical and theoretical literature trying to explain why firms repurchase shares, few studies examine how this relates to ownership structure and corporate governance. For example, in firms with potentially high agency costs of free cash, a repurchase may be a way to trim the cash holdings as an alternative, or in addition, to dividends. On the other hand it may also be used by managers to expropriate outside shareholders when the firm is undervalued. Thus, the essay tries to argue why ownership considerations may be an important reason for why firms choose to repurchase, and examine whether there are systematic patters in the ownership structure of repurchasing firms in Norway. The main objective of this study is to highlight some interesting ownership patterns to lay the groundwork for further research on the question of why firms repurchase shares.

Since the two main parts of the thesis concerns two different areas in financial economics, I will in the rest of this introduction divide the discussion in two parts. In the next section, I will discuss the two essays in market microstructure before I continue to discuss the two essays in corporate finance.

1.1.1 Essays in market microstructure

Market microstructure concerns how the market structure, trading rules and the interaction between various participants can explain the nature of short term price adjustments and how transaction prices relate to the long-term equilibrium values of assets. Since this is a very general definition of the area, it is useful to place the two microstructure essays in this thesis relative to the main areas of the literature. For that purpose I apply the categorizations provided by Madhavan (2000). He divides the literature on market microstructure into four main areas: (1) *price formation*, (2) *market structure and design*, (3) *transparency* and (4) *applications to other areas in finance*. Although these areas to a large degree are interrelated, my first essay concerns mainly the implications of market structure (alternative trading systems/crossing networks) on transaction costs (area 2) and the second essay relate to how price volatility and price discovery is affected by differences in beliefs among various economic agents in an electronic limit order market (area 1).

Essay 1: Equity trading by institutional investors: Evidence on order submission strategies

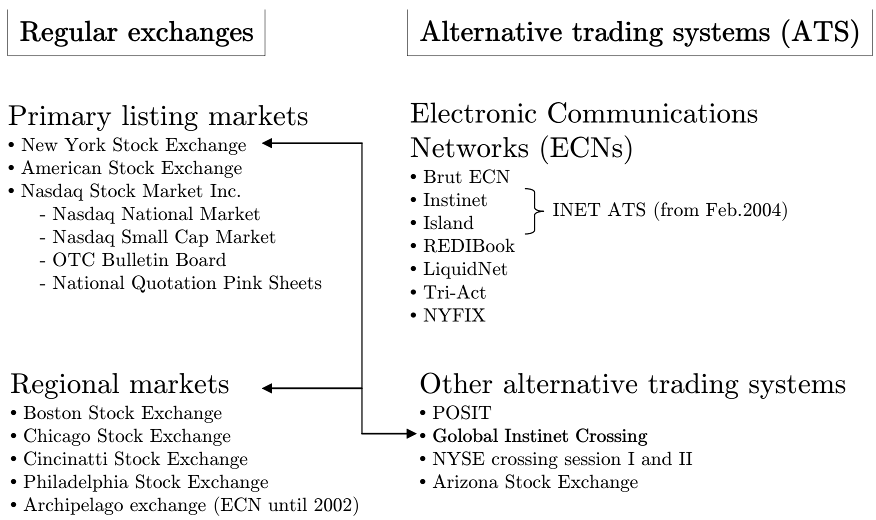
During the last decade there has been a growth in the number of venues at which equities can be traded. Generally, this has increased competition for order-flow, where new trading venues try to attract traders through lower commissions and better services. Thus, markets has moved from being consolidated to becoming more fragmented.[2] This increased competition has also raised concerns that liquidity has become more dispersed across various trading centers at the loss of execution probability and price discovery. In the US, this fragmentation has been especially strong, and today regular exchanges experience competition from a plethora of new venues. Figure 1.1 gives a non-exhaustive overview of the different types of equity trading venues in the US. At a general level it is useful to distinguish between two classes of market centers. The first group of trading venues may be characterized as *regular exchanges*. This group consists of primary listing markets and regional exchanges.[3] The primary markets are market centers where company issues are primarily listed (New York Stock Exchange, American Stock Exchange and Nasdaq). These issues are also traded at one or more of the regional exchanges. In addition, some Nasdaq stocks are traded under *unlisted trading privileges* on the regional exchanges. The Nasdaq Stock Market consists of basically four parts, where the largest and most visible is the Nasdaq National Market. A fundamental difference between NASDAQ and the other regular exchanges is that Nasdaq is a dealer market where market participants buy and sell from the dealers (market makers), while the markets for listed securities (NYSE, AMEX and the regional exchanges) are auction markets where participants trade between eachother, and the dealers (specialists) are required to ensure an orderly market as well as providing liquidity. In addition to the liquidity provided by the specialist, a large part of the orders coming into the NYSE is routed through an electronic system to the specialist. This system is called the DOT,

[2] Harris (2003) defines market fragmentation as when people can trade essentially the same thing in different market centers, while consolidation is when all traders trade in the same market center.

[3] At some point in the 19th century the US had more than 100 stock exchanges. These exchanges generally specialized in local/regional companies and facilitated the listing and trading of these (Harris, 2003).

which is an acronym for Designated Turnaround System. An additional development with respect to NASDAQ is that it also connects alternative trading systems into the market, such as Electronic Communication Networks (ECNs). Thus, the Nasdaq market is no longer a pure dealer market, as it was originally, but has become a hybrid market (a mixed dealer and auction market) where the dealers compete with the incoming orders from the ECNs.

FIGURE 1.1 Equity trading venues in the US
An overview of equity trading centers in the US. A general distinctions can be made between "Regular exchanges" and "Alternative trading systems". The arrows reflect the markets examined in the essay.



This brings us to the other main group of trading venues which falls into the category *alternative trading systems* (ATS). These markets can be split further into *Electronic Communication Networks* (ECNs) and other alternative trading systems. An ECN is essentially an electronic system into which buyers and sellers enter orders that are automatically matched by the system. Thus, ECNs provide electronic facilities that investors can use to trade directly with each other. Another characteristic of these systems is that there are generally no physical marketplaces, but rather virtual meeting places facilitated by the improvements in electronic communication and the Internet. The largest and fastest growing ECN in the US is the Island ECN[4] which is essentially an electronic limit order market in which buyers and sellers of NASDAQ securities can meet directly without using intermediaries (market makers). Additionally, they provide investors with an anonymous way to enter orders into the marketplace. Unlike market makers, ECNs operate simply as order-matching mechanisms and do not maintain inventories of their

[4]The Island ECN and Instinet was combined into INET ATS in February 2004. The remaining part of the discussion as well as chapter 3 is related to the period before these two were combined into one entity.

own. According to Island, one out of every eight trades (in 2002) in NASDAQ securities are executed through Island. Furthermore, they argue that they provide greater access to the market, increased transparency, stronger technological services, and lower transaction costs.

The other group of ATS are called crossing systems (crossing networks). These systems are also referred to as *derivative markets* because there is no direct price discovery in these systems. Instead, the price is determined in another market (the securities primary listing market). In a crossing network traders submit the quantity (number of shares) that they want to buy or sell without specifying any price. These orders are submitted electronically and are not visible to any other market participants. At fixed points in time (either intra-daily as on POSIT, or after hours as in INSTINET and the NYSE crossing sessions) the aggregate buy and sell volumes are matched at the most recent price (or VWAP) available from the stocks primary market. Thus there are no active trading session, but rather a passive matching of orders.

The large and increasing number of trading venues has spurred an growing interest both from regulators, practitioners as well as researchers, with respect to the effect of this fragmentation on inter-market competition, and how they affect transaction costs both in the primary markets as well as in the crossing networks. Most of the alternative trading systems remove the need for intermediaries, which reduces the commissions (direct transaction costs) paid in these systems. On the other hand, due to the fragmentation of liquidity across several markets, this may affect other cost components such as opportunity costs when execution is not obtained, or costs related to delay of trades while searching for liquidity. In addition, since the crossing systems derive the price from the primary market, there may be an indirect effect on the quality of the price since liquidity potentially is removed from the primary market in the same securities.

This essay relates to a the last group of market system discussed above called "crossing systems" and how trading in these systems compares with trading at the NYSE and the regional exchanges (reflected by the arrows in figure 1.1). While these system, because of their passive matching of orders without any intermediaries, reduce commissions, and reduce implicit transaction costs such as price impact costs and spread costs, they may on the other hand increase costs related to opportunity loss and execution delay. Depending on the type of investor and stocks to be traded, different investors prefer different types of systems when implementing their trading decisions, and weight these costs against the benefits when deciding how and where to trade. At a general level, whether markets will stay fragmented or consolidate over time is still debated (Madhavan, 1995). Thus, studies addressing what type of securities that are traded and which investors that prefer to trade off-exchange is an important step towards understanding why these off-exchange systems exists and if they are likely to persist into the future.

In information based models focusing on the importance of asymmetric information (e.g. Easley et al. (1996)), uninformed investors that are concerned about trading with informed investors may prefer the anonymity and the ability of crossing networks to screen out informed investors. Thus, the anonymity and batch nature of crossing networks is argued to attract uninformed order-flow ("cream skimming" the order-flow) from the primary market which may impede the price discovery in the primary market. On the other hand, as discussed in Fong et al. (1999), a batch market is also an efficient way of concentrating liquidity for illiquid securities to one point in time, increasing the execution probability for traders and reducing the potential price impact costs associated with low liquidity stocks. In addition, these systems may attract traders that would otherwise not trade, increasing overall liquidity (Hendershott and Mendelson, 2000).

Institutions account for a major part (over 70%) of the trading volume worldwide, and crossing networks are to a large degree used by institutional traders with large liquidity needs. Thus, a relatively large part of the (potentially uninformed) order-flow goes through these markets. Despite this, relatively little academic research has been done on institutional trading strategies and costs, especially related to their trading in crossing networks. This is to a large part due to the proprietary nature of these data and that the users of crossing networks generally value anonymity and are reluctant to give out transaction data. This essay asks the following two basic questions:

- Are stocks supplied in the crossing networks more/less liquid and actively traded than stocks not easily obtainable in these systems?
- What are the implicit transaction costs of executing a portfolio in a crossing network relative to implementing the same portfolio through regular exchange transactions?

Much of the current research on institutional investors' in the US equity market has aimed at answering similar questions to those stated above mainly by using data provided by the Plexus Group.[5] These studies include Keim and Madhavan (1995, 1997), Jones and Lipson (1999a,b) and Conrad et al. (2001a,b). Overall, these studies find that there seem to be quite large cost advantages to using alternative trading systems relative to trading on regular exchanges. Although, these studies examine very large datasets, with many orders from many investors, the datasets have two main weaknesses. First of all, they do not know the ex ante trading strategy of the investors they are observing the trade executions from. Thus, their sample may be biased in the sense that certain orders in certain securities are submitted to alternative trading systems. It may be that the trader has decided to send the most difficult orders to brokers and the least difficult orders to crossing networks. This relates to the first bullet point above. Secondly, they

[5] The Plexus Group is a consulting firm that monitors the costs of institutional trading.

do not know the complete history of the implementation and actual executions of the underlying portfolio. This may bias their findings towards very low transaction costs in these systems since they do not properly account for costs of non-execution which may be a significant cost component for investors that are pre-committed to trade. This relates to the second bullet point above.

Our dataset, on the other hand, includes all orders from the establishment of a US equity portfolio worth USD 1.76 billion over a 6-month period from January 1998 to June 1998. The portfolio was tracking the US part of the FTSE All World index[6], which consists of about the 500 largest stocks in the US, and has a very high correlation with the S&P 500 index. The data set is unique in that it contains information on the investors' complete order submission strategy, including the ex ante trading strategy, the dates on which the decision to trade was made, and the resulting fill rates of each order for different trading venues. Hence, the data set is close to a "controlled experiment" which is quite rare when studying institutional trading behavior.[7] Although, our dataset also has a weakness in that it is from one trader's buy orders only and covers a limited period of time, we argue that the dataset is representative for institutional traders in the US market.

The main contribution of the paper is twofold offering evidence on each of the questions in the bullet-points above. The first part of the essay, examines whether stocks that are "easily" obtained in the crossing network has a different characteristic than stocks that are difficult or impossible to obtain in the crossing network. Compared to the previously mentioned studies, we are able to do this due to the nature of the dataset. The ex-ante trading strategy of the investor for which we have data was essentially to first try to execute as much of the portfolio as possible in the crossing network. The orders that were not filled, or only partially filled, were then executed in the primary market. By observing which securities was obtained during each session we split the sample securities into groups based on the fill rate in the crossing network, and examine the liquidity characteristics of these securities in the primary market on the same dates. The results indicate that the stocks supplied in the crossing network[8] are the most liquid and actively traded securities, in a sample of the largest (and potentially most liquid) securities in the US market. Thus, this result suggests that crossing networks facilitate trading in liquid stocks, and that these markets offer cost-efficient trading possibilities for large liquidity traders.

The second part of the paper provides results on the relative costs on trading in

[6]The FTSE All-World index includes 49 different countries and about 2300 stocks. The aim of the index is to capture up to 90% of the investible market capitalization of each country.

[7]In many other studies, the exact investment strategy of a trader has to be estimated from the sequence of trades. This induces a selection bias in the data. It might be that the trader has decided to send the most difficult orders to brokers and the least difficult orders to crossing networks. We are not facing a selection bias problem in our data set.

[8]Proxied by the fill rate of the order in the crossing network.

the two systems. More specifically, the paper simulates alternative trading strategies in the primary market for the same portfolio that was traded in the crossing network by the investor under study. These simulations assume that the decision to trade is the same as in the actual trading strategy, but that the orders are submitted directly to the primary market as limit orders instead of first being submitted to the crossing network. Various limit order strategies are simulated, and the results suggest that the crossing strategy was inexpensive relative to trading the stocks directly in the primary market. Even with respect to the simplest strategy where the size of the orders are ignored, the limit order strategy does not outperform the crossing strategy with respect to implicit costs. Taking into account also the much lower commissions in the crossing network the difference becomes even larger.

Essay 2: Order Book Characteristics and the Volume-Volatility Relation: Empirical Evidence from a Limit Order Market

A variety of studies document that there is a positive correlation between price volatility and trading volume for most types of financial contracts. The main theoretical explanation for this is known as the mixture of distributions hypothesis (MDH), originally proposed by Clark (1973). The main intuition behind the MDH is that new information about asset values acts as the driving force (mixing variable) for both price movements and volume. Since the mixing variable affects both trading volume and price movements (volatility) contemporaneously, these two variables are correlated. The MDH also provides an explanation for why the sample distribution of daily returns is leptokurtic. The MDH suggest that if the arrival rate of information is time varying, periods with a high amount of new information would contribute to the tails of the return distribution as well as high trading volumes, while periods with less information arrivals would contribute to the center of the returns distribution as well as low trading volumes.

Although the MDH helps explain some stylized facts about financial markets it is not necessarily the case that the arrival of new information is the only component that drives volume and volatility. As suggested by Shiller (1981), the movements in prices seem far too high relative to the movements in the fundamental values of the underlying securities. In addition, French and Roll (1986) find evidence that asset prices are much more volatile during exchange trading hours than during nontrading hours. They argue that this is evidence that trading is *self-generating* indicating that information is not necessarily the only factor driving trading volume and price volatility. In other words, trading volume and price volatility may have more than one common cause resulting in their positive correlation (Harris, 1987).

One limitation of the MDH is that it does not say anything about the type of information that drives prices, how this information is revealed to investors or the role of economic agents in determining the price. In standard asset pricing models the trading process itself does not convey information which is relevant for price determination, but rather that prices adjusts immediately when new information arrives. This is plausible for some kinds of information, but other types of information may not be easily obtainable or are costly to gather. Thus, some information may not be readily available to all investors. Although markets may still be efficient in the sense that the marginal cost of gathering information is reflected in the price (compensating information gatherers for their cost) it may have implications for relative efficiency. For example, as suggested in a noisy rational expectations equilibrium model by Shalen (1993), if uninformed investors act strategically and try to extract new information about asset values from the order-flow, they may contribute to increasing both trading volume and price volatility above what would be expected in the case when price variations and volume are only driven by the arrival of new information. In Shalen's model, uninformed investors are faced with a signal extraction problem where they are unable to distinguish informed trades from liquidity demand as well as the trades of their own type. Due to this, they react to all trades as informative and generate excess volatility and volume above what would be expected if only new information (the mixing variable) was driving these variables. This hypothesis is called the "dispersion of beliefs hypothesis" (DBH). In the MDH setting, strategic trading by uninformed investors would imply that not only the information arrival rate is important for volume and volatility, but also that the amount of uninformed traders in the trader population. As the fraction of uninformed traders increases the dispersion of beliefs about the true value of the asset increases together with excess volume and volatility, also correlating the two. Thus, "dispersion of beliefs" about fundamental value may be important for explaining the observed high volatility and trading volume in financial markets above what is expected in standard equilibrium models.

The main objective of the paper is to broaden our knowledge about the volume-volatility relation in electronic limit order markets. Since the demand and supply schedules in a limit order book represent the prices at which the liquidity suppliers are willing to trade, it is interesting to study whether the book contains information about the volume-volatility relation. The paper exploits an exceptionally rich dataset from the Norwegian equity market containing all submitted orders and trade executions for the period from February 1999 through June 2001. The Oslo Stock Exchange (OSE) operates as a fully automated limit order-driven trading system, and the data set makes it possible to rebuild the full order book at any point in time.

The first topic of the paper is to examine the traditional volume-volatility relation (MDH) in the Norwegian stock market. One motivation for this is that few studies on the MDH has been done on an electronic limit order market. Similar to other studies, the number of trades is found to be the important factor for explaining volatility, while the size of trades is less important. Thus, relative to the MDH, this suggests that the number of trades is the appropriate proxy for the mixing variable.

The second part of the the paper examines in more detail how the limit order book relates to the contemporaneous volume and volatility. This is done by rebuilding the full order book at hourly snapshots for each company every day. The rebuilt order book is used to calculate the average slope of the supply and demand schedules in the book. The main contribution of the study is that it documents several relationships between the average slope of the order book and volume and volatility. To examine the effect of the order book slope on volume and volatility, the paper first includes the slope measure as an independent variable in a cross sectional time series version of the standard regression model used to study the volume-volatility relation. A systematic negative relation between the average slope of the order book and the price volatility is documented in a daily time series cross-sectional analysis. This indicates that the a more gentle slope coincide with higher volatility. To investigate the relationship between the slope of the book and the trading volume, a similar model is estimated, with the number of trades as the dependent variable. Similarly, a significantly negative relationship between the slope measure and the daily number of trades is found, indicating that a more dispersed order book coincide with a high number of trade executions. These results are also shown to be robust to the choice of time period. Interestingly, the relationship between the slope and the number of trades seems to depend on what fraction of the order book is used when calculating the slope. When only the inner part of the order book is used, the relationship is reversed, consistent with studies that find that thick books result in trades (Biais et al., 1995).

The relationships documented in the study are interesting in several respects. First, although most of the activity occur at the inner part of the order book, the order book data shows that the liquidity provided at the inner quotes in many cases reflect only a modest part of the total liquidity supplied in the full order book. Second, the characteristics of the order book vary systematically over the trading day as well as across firms. Third, as far as I know, no previous studies have examined in detail the relationship between the characteristics of the full order book and volume and volatility in a cross-sectional time series setting.

One interesting interpretation of the findings is that the characteristics of the order book may reflect dispersion of beliefs among liquidity suppliers. More specifically, a "wide" limit order book (more gentle slope) may reflect that there is a stronger disagreement among investors about the value of the security as orders are submitted across a greater range of prices around the midpoint price. Alternatively, when orders are submitted on average closer to the midpoint price, making the limit order book more concentrated around the inner quotes, this may indicate less uncertainty about asset values. If the slope is interpreted as a proxy for dispersion of beliefs, greater dispersion is reflected in higher volume and volatility across stocks and time. Furthermore, larger stocks are found to have on average steeper slopes than smaller stocks. Initially, this may be expected in the sense that larger stocks are more liquid. On the other hand, it is not clear why large firms have a greater fraction of the order book volume closer to the inner quotes. One interpretation may be that larger stocks have a lower valuation uncertainty. This because they are more frequently followed by analysts and the public press, and have a longer track record, making these stocks potentially easier to value than smaller stocks.

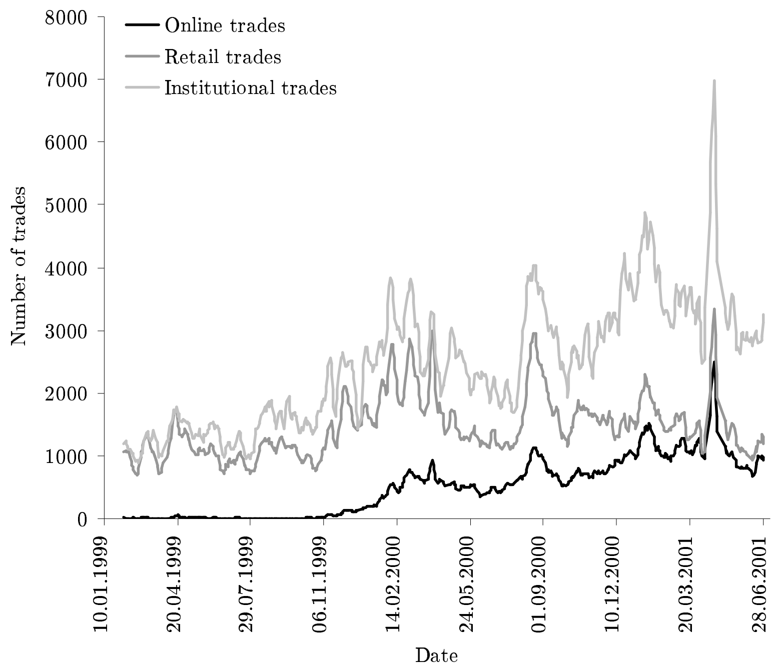
One problem is however, that there are no models that relate the full limit order book to volume and volatility. In fact, we do not know how the limit order book would look like with investors with dispersed beliefs. Although the paper does not aim at testing the dispersion of beliefs hypothesis, the empirical results may provide an interesting interpretation of how the limit order book may capture some of the aspects of dispersion.

There are several empirical studies that examine the importance of dispersion of beliefs about asset values, using various proxies for dispersion. Bessembinder and Seguin (1993) suggest that the volume-volatility relation in financial markets may depend on the type of trader. Motivated by this Daigler and Wiley (1999) perform an indirect test of the DBH where they proxy for the degree of dispersion in beliefs by the fraction of uninformed traders in futures markets. As their proxy for uninformed investors they differentiate traders by how close they are to the trading floor. Their main findings suggest that the general public, outside the trading floor, increase volatility, while floor traders decrease volatility. Ghysels and Juergens (2001) measure dispersion of beliefs directly by dispersion of analysts' earnings forecasts. Their results suggest that dispersion is significantly and positively related to both returns and volatility.

Future research on limit order markets

Relative to the mixture of distribution hypothesis as well as the dispersion of beliefs hypothesis, one interesting trend in the Norwegian market, as in many other markets, is that online trading has become more popular and available to investors. These systems generally have much lower commissions and have given small private investors direct access to the marketplace. To illustrate this development, figure 1.2 shows the total number of trades executed in the Norwegian market that was initiated by different groups of trader. The type of trader is proxied by the trading house from which the initiating order originates. "Institutional trades" reflect the number of trades in which a customer in trading houses that mainly trade for institutional traders are the initiating party in the trade, "retail trades" report the number of trades from trading houses that specialize in facilitating trading for small private investors (phone based) where the broker submit the order to the market for the customer, "online trades" reflect trades that are initiated through online brokerage houses where the investor submit orders through the internet and the order is routed directly to the limit order book.[9]

FIGURE 1.2 Trading activity by different trader types in Norway
The figure shows the total number of trades executed for different types of traders in Norway. "Institutional trades" reflect the number of trades that are initiated by customers in trading houses that specialize in facilitating trading for institutions and large investors, "retail trades" report the number of trades from trading houses that specialize in facilitating trading for small private investors (phone based) where the broker submit the order to the market for the customer, "online trades" reflect trades that are initiated through online brokerage houses where the investor submit orders through the internet and the order is routed directly to the limit order book.



As can be seen from the figure, the number of trades initiated by online traders has grown to become a significant fraction of the total number of trades at the OSE. Although the volume from online traders constitute a much smaller fraction of total number of shares, this may be an important structural change in financial markets. Especially with respect to the mixture of distributions hypothesis, the increased trading activity from potentially the most uninformed investors, may affect the volatility and transaction volume observed in equity markets. Furthermore, one interesting observation with respect to the online traders is that their trading activity is to a large degree concentrated in the most volatile stocks on the exchange. Whether their trading contributes to the volatility or they are attracted to volatile stocks (due to e.g. day trading) will be subject to future research. There is also some indications that the former retail traders, has moved to the online group. The increase in trading activity from the online

[9]These data is not examined in the essay, but motivate why trader heterogeneity may be important, and will be used in a future examination of the effect of trader type on volatility and volume.

trader group may therefore partly be because retail traders has switched to this way of trading, that online trading attract new traders to the market, or that former retail traders trade more when it is easier and cheaper for them to execute trades. Another interesting issue relating to the DBH is that the online traders may potentially be those traders that has the least precise information. If these traders react more frequently to recent order flow, they may also be the group that contributes the greatest excess volume and excess volatility in a DBH setting. More specifically, as suggested by the DBH, the more uninformed traders, the higher the excess volatility and volume is expected to be. How and whether the increase in online trading has affected the volume and volatility in the Norwegian market, and whether this can be related to the mixture of distributions hypothesis as well as the dispersion of beliefs hypothesis, will be subject to further research.

1.1.2 Essays in corporate finance

One important question in corporate finance is how firms distribute profits back to their owners. The most common way firms do this is through regular cash dividends and open market share repurchases. Although the most frequently studied, and historically most common cash distribution, is regular cash dividends, several studies on the US market show that repurchases have become increasingly important over the years. Compared to dividend distributions, an open market share repurchase is an event where the issuing firm trades its own stock. Thus, compared to a pro-rata dividend distribution, a non-proportional repurchase changes the ownership- and capital structure in the firm. In addition to being a more flexible payout method, a repurchase may also convey information to the market about the value of the firm. However, as discussed in Brav et al. (2003), the motives behind different types of payout policy as well as recent shifts in payout policy is not well understood. For example, Fama and French (2001) find evidence that dividend payments by US firms has decreased significantly over time. Also Grullon and Michaely (2002) find that there has been decrease in dividend paying firms through time, but also find evidence that many firms substitute repurchases for dividends and that US firms now distribute as much cash through repurchases as through dividends. In the study by Brav et al. (2003) they note that despite the fact that there is a lot of research available on firms payout policy, the most fundamental issues remains unanswered:

- Why do both dividends and repurchases exist?
- Why is there such a large penalty for dividend cuts, but no analogous penalty for *not* completing a repurchase program?

In addition, there are also unresolved issues with respect to how the market responds to repurchase announcements and how repurchases may be used to e.g. signal mispricing or as a mechanism for ensuring that managers don't use excess cash to engage in value destroying projects and increase their private benefits.

In this second part of the thesis, I examine detailed repurchase data from Norway which may cast some light on the questions mentioned above. A dominating part of the available empirical research on open market share repurchases is on data from the US and Canada. The main reason for this is that repurchases has been legal in these markets for several decades, while many other countries has allowed repurchases more recently, one of which is Norway. One interesting aspect of the Norwegian repurchase data is that firms in Norway are subject to a legal requirement to report their actual repurchase activity immediately. Comparably, US firms are not required to report their repurchase activity. In Canada, the requirement is stricter than in the US as firms are required to report their accumulated repurchases on a monthly basis. Thus, the Norwegian data may help us examine some questions in more detail that are difficult to study using aggregate data.

In contrast to the two first essays of the thesis, these two last essays relate to the trading decisions by corporations that trade in their own stock. In addition to being a way for firms to conduct their payout policy, a repurchase may also contain important information since the managers of the firm potentially is the ultimate informed participant in the market for its own securities. Thus, in the essays I examine how this activity relates to asymmetric information between the firm and the market and to what extent this information is reflected in prices. In addition, since a special feature of repurchases (compared to cash dividends) is that it changes the ownership composition of the firm, I examine whether there are systematic patterns in the ownership composition in these firms, and whether there are certain ownership characteristics that may constitute an underlying motivation for why firms repurchase shares.

As summarized in Allen and Michaely (2003), there are five potential imperfections relative to the Miller and Modigliani (1961) framework that may be important considerations when choosing dividend policy:

1 *Taxes* - if dividends are taxed more heavily than capital gains, minimizing dividends is optimal

2 *Asymmetric information* - if managers have private information they can use payout policy to signal this to the market

3 *Incomplete contracts* - payout policy can be used to discipline management and reduce agency costs of free cash

4 *Institutional constraints* - if various institutions prefer dividends, the firm may find it optimal to pay dividends although this imposes a tax burden on individual investors

5 *Transaction costs* - if dividends minimize transaction costs to equity holders, then dividend payout may be optimal.

The two essays in the last part of the thesis are related to several of these imperfections. In the first essay I examine whether *asymmetric information* and signalling may be an explanation for the markets reaction to the announcements of repurchase plans and the actual repurchase executions. In the last essay, the main focus is related to *incomplete contracts* and *institutional constraints* in the sense that ownership composition and corporate governance may be a motivation for why firms initiate a repurchase program.

Essay 3: The market impact and timing of open market share repurchases in Norway

An emerging body of empirical literature suggests that the market underreacts to new information about firms' cash flows. Public announcements that are likely to contain information about current and future cash-flows, such as earnings surprises and dividend initiations and omissions as well as the announcements of repurchase plans, are followed by an abnormal return drift in the same direction as the initial announcement return. This suggests that the market does not react in a complete and unbiased fashion to this information which is inconsistent with market efficiency in its weakest form. In other words, the direction of the price impact of the initial announcement (historical returns) can be used to predict future returns, using old information. Investors should not be able to earn superior returns by exploiting these systematic features without bearing additional risk since the mispricing should be mitigated through arbitrage. At a fundamental level, these findings may be related to misspecification of the benchmark model for expected returns rather than mispricing. To explain the underreaction, the literature suggests several reasons for why these patterns are observed. Fama (1999) argue that the empirical findings of over- and underreaction in various settings are sample specific and appear by chance. He also points to the fact that the long term abnormal return drifts are sensitive to the model specification, such that when taking account of size and value factors these patterns are mitigated. On the other hand, the increasing amount of studies providing new empirical evidence on these issues, applying different model specifications and samples, suggest that alternative explanations may be required. One strand of the literature propose behavioral models to explain the anomalies. One recent example is Barberis et al. (1998) who proposes that investor sentiment is important with respect to how investors form expectations about future earnings, and that investors are expected to overreact and underreact to different types of announcements due to psychological biases when interpreting new information. Other studies propose extensions to the existing paradigm, where additional risk factors may help explain the patterns.

This paper examines a detailed dataset on announcements of open market share repurchase program announcements and actual repurchases conducted by Norwegian firms during the period 1998-2001.[10] The first purpose of the paper is to study whether there is an announcement effect related to when firms announce repurchase plans in Norway. In addition, the paper examines whether this initial effect is complete and unbiased relative to the long term performance of announcing firms. Essentially, the main result from this part of the analysis is that Norwegian firms also experience a positive price impact of about 2.5% when announcing a repurchase plan, in line with models where the market interpret the announcement as positive information about future profitability. In addition, I find that these firms show a long term abnormal performance after the announcement of about 0.9% per month or 11% a year when controlling for size, book to market and momentum factors. These results line up with studies from the US and Canada suggesting that the market reaction to the initial announcement is incomplete with respect to the full signal value proxied by the post-announcement abnormal return.

These results contribute to the existing literature in the sense that the study adds an observation to the cross section of countries with additional evidence on the market reaction to repurchase announcements as well as the performance of these firms. However, the most interesting part of the Norwegian data is the detailed knowledge about the firms actual repurchases. The paper exploits this unique feature of the data to further investigate the underreaction of announcing firms and examine how the post-announcement performance relates to whether the firm actually repurchase shares or not. More specifically, by creating two portfolios conditional on whether the firms repurchase or not, an interesting pattern is observed. Those firms that do not repurchase experience a long term abnormal performance, while the portfolio of firms that actually repurchase shares (and are included in a second portfolio the month after they have conducted their first repurchase) perform as expected relative to several model specifications. In addition, when examining the excess return related to actual repurchases, the results indicate that the first repurchase executed by a firm after it has announced a repurchase plan has the strongest abnormal price effect, while subsequent repurchases has a decreasing impact.

The paper suggests several explanations for this finding. One interpretation for the difference in long-term abnormal performance between repurchasing and non-repurchasing firms may be that the market reacts in a complete fashion at the announcement of the program for firms that later repurchase shares, while there is an underreaction for non-repurchasing firms. This may be because the repurchasing firms are able to more credibly signal undervaluation at the announcement of the program. However, I do

[10]Firms where first allowed to actually execute repurchases from 1999, but were allowed to announce the repurchase plan earlier.

not find a different announcement effect for announcements that result in subsequent repurchases relative to announcements that do not result in subsequent repurchases.

Another explanation focuses on the signal conveyed to the market when the firm choose to actually execute a repurchase. One of the most prevalent explanations for why firms experience a positive price effect when announcing a repurchase plan is the signalling hypothesis. The hypothesis assumes that there is asymmetric information between the managers of the firm and the market. By announcing a repurchase plan, the manager implicitly conveys to the market that he assess the current market price to be too low relative to the true value of the firm. However, since the announcement of a repurchase plan is no commitment by the firm to actually repurchase any shares the signal may be argued to be very weak.[11] On the other hand since the actual repurchases involves real transactions, the actual repurchases may be argued to be stronger signals of undervaluation, or a confirmation of the initial announcement. Thus, one interpretation of the finding may be that when the firm executes its first repurchase, the market react to the information implicit in this action, increasing the price closer to the true value, such that subsequent returns evolve as expected. When examining the price impact of subsequent repurchases, the results suggest that the first repurchase by a firm, has the greatest abnormal price impact, while subsequent repurchases has a decreasing price effect. This may indicate that the first repurchase by a firm is the most informative in the sense that it resolves the uncertainty with respect to whether the firm will repurchase or not.

For the group of firms that do not repurchase there may be many reasons for why they do not execute any repurchases. One reason may be that these firms experience a price increase before the firm is able to execute any repurchases, such that the manager assess the firm to no longer being undervalued. An additional explanation may be that these firms are unable to execute repurchases simply because they are less liquid. When examining measures of liquidity (quick ratio and current ratio), the results indicate that non-repurchasing firms are significantly less liquid than repurchasing firms. Thus, the non-repurchasing firms may for this reason be unable to signal undervaluation through actual repurchases. If this is the case, the price of these firms remains too low and information surprises in later periods contribute to the long term abnormal drift for these companies. However, we cannot exclude the possibility that these firms are exposed to risks that are not captured by the market, book/market and momentum factors.

In a broader perspective, the findings relate to a concern that has been raised in the popular press as well as by researchers in the US. It has been argued that the

[11] For a signal to be credible, the action must incur some costs to the manager if he signals falsely. For example, if the manager in addition to announcing a repurchase plan or repurchase shares commit to retaining his shares, the signal would become much stronger because he then would reduce his wealth by repurchasing at a high price. However, such commitments are rarely observed in connection to open market share repurchases.

announcement of a repurchase plan is a way for the management to raise the stock price at little or no cost in the short run. In fact Kracher and Johnson (1997) argue that many firms in the US announce repurchase plans with no intention of repurchasing at all. One of their arguments is that since the reporting standards in the US, with respect to open market repurchases, are very loose, it is difficult for investors to actually know whether announcing firms under normal circumstances are actually going through with the repurchase plan. Their main suggestion is that US firms should be required to report the progress of the repurchase plan such that they are motivated to only announce a repurchase plan when their intentions are true.

The results in the present paper may contribute to the discussion about disclosure requirements in the US. Although the paper does not resolve the underreaction puzzle, the results may indicate that by requiring firms to report their transactions immediately to the market, this may improve price discovery.

Essay 4: The ownership structure of repurchasing firms

As expressed by Schleifer and Vishny (1997);

> *Corporate governance deals with the ways in which suppliers of finance to corporations assure themselves of getting a return on their investment. How do the suppliers of finance get managers to return some of the profits to them? How do they make sure that managers do not steal the capital they supply or invest in bad projects? How do suppliers of finance control managers?*

While a dividend payment reduces the cash of the firm, a repurchase also potentially revises each remaining shareholder's ownership proportion in the repurchasing firm. Thus, in addition to being used as e.g. signal private information, as examined in the previous essay, it may also be used by the firm to change the ownership structure of the firm or as a disciplinary mechanism when the corporate governance is weak. For example, in firms with potentially high agency costs of free cash (liquid firms with no profitable investment opportunities, low concentration and low insider ownership), a repurchase may be a way to trim the cash holdings as an alternative or in addition to dividends. Since a repurchase is more flexible than dividends[12] it may be attractive to firms with volatile cash flows. A repurchase may also be used by managers as an effective measure against takeovers which would threaten the position of the managers, by removing shareholders with the lowest valuations ((Bagwell, 1991)) as well as increasing the ownership proportion of the insiders and the most loyal owners.

In a recent study, based on interviews with corporate officials, Brav et al. (2003) find that financial executives believe that the ownership structure of their firm is important.

[12] Flexible in the sense that the market expects firms to keep their dividend payments at the new level if increased (Lintner, 1956; Brav et al., 2003), and punish firms that decrease their dividend payment.

In addition they also believe that retail investors have a strong preference for dividends (despite a tax disadvantage) while institutional investors have no strong preference between dividends and repurchases. Despite this, a large fraction of the executives (57%) stated that institutions are important with respect to establishing a repurchase program. In addition, the results from the interviews suggest that payout initiations are to a certain degree motivated by firms to avoid possible agency costs that could occur in the future if excess cash should accumulate within the firm. As suggested by Jensen (1986), payout policy may be used as a mechanism to mitigate agency costs of free cash. Interestingly, when the executives are asked whether they would initiate payouts to discipline themselves only 10% respond positively.[13] Another interesting finding, which relates to the previous essay, was that most executives answered that changes in payout policy conveyed their confidence about the firm's future prospects. About 85% of the executives believed that repurchase decisions revealed information to the market about mispricing.

Overall, the interviews conducted by Brav et al. (2003) provide a motivation for examining the ownership structure of repurchasing firms. This may provide additional evidence on the motivations for why managers initiate repurchases that are difficult to obtain through interviews such as e.g. shareholder expropriation and insider trading around repurchase events. An additional motivation is that there is a large empirical and theoretical literature aimed at explain why firms repurchase shares. However, few of these studies examine how this relates to ownership structure and corporate governance, mainly due to the lack of detailed ownership data.

Having access to detailed monthly ownership data, for all firms listed on the Oslo Stock Exchange, makes it possible to conduct a detailed examination of the ownership structure of repurchasing firms. The ownership data contains information on the number of shares owned by each owner as well as information with respect to the type of owners. In addition, we have data on the insider ownership in all listed firms. The essay provides an examination of the ownership structure of repurchasing firms, and tries to reconcile these findings with available theory.

The paper finds some interesting patterns in the data. The main results indicate that firms that announce a repurchase plan have a significantly lower ownership concentration than non-announcing firms. In addition, firms that announce repurchase plans have on average twice as many shareholders as non announcing firms, while the size of the firms in the two groups are similar. This would be in line with an agency theoretical prediction that firms with dispersed ownership may be more exposed to agency problems since there are less incentives to monitor management. Thus, if managers want to convey to the market that they are committed to not wasting cash, the initiation of a

[13] As noted by Brav et al. (2003), the managers may be reluctant to admit (even to themselves) that they may need to be monitored or impose disciplining mechanisms on themselves.

repurchase plan may be one way of sending this message. In addition, firms with many small shareholders may want to reduce the number of shareholders to concentrate the ownership and thereby reduce the probability of successful hostile takeover attempts that could result in the replacement of the managers. The results also indicate that the insider ownership is much higher in announcing firms, and that the insider ownership is the highest in firms that actually repurchase shares. With respect to the agency cost motivation, this result point in the opposite direction in the sense that agency theory predicts that high insider ownership aligns the interests of inside- and outside shareholders (Jensen and Meckling, 1976) such that additional mechanisms to mitigate agency costs are not needed. The high insider ownership in these firms may instead indicate that takeover defense, outside shareholder expropriation, or entrenchment may be reasons for why managers choose to repurchase shares.

The paper also examine how the ownership characteristics change through time when firms execute repurchases. As expected, the concentration increases, mainly due to an increased ownership by the largest owner, and the number of shareholders decreases. In addition, the ownership of institutional and personal owners decreases, while the state ownership increases. This may be because institutional and personal investors are those that trade more actively in the market, and thereby are more likely to sell shares back to the firm. On the other hand the decrease may also reflect a that these two groups of investors have a preference for dividend paying firms, and reduce their ownership if the repurchasing firms substitute repurchases for dividends. The reduction in institutional ownership is interesting since a study by Grinstein and Michaely (2001) find an opposite trend in the US. They argue that firms attract institutions through their payout policy, and find that institutions increase their holding in repurchasing firms.

The final part of the study applies a binary regression method to examine whether the ownership at the beginning of each sample year can explain the propensity for firms to initiate a repurchase program. The findings is similar to the descriptive part of the study, but some additional results appear. First, insider ownership increases the probability of announcement, while concentration is insignificant for all years. However, the existence of a large controlling shareholder reduces the propensity to announce, while the identity of the largest shareholder is unimportant. In addition, the results strongly suggest that firms that paid dividends in the previous year, are less likely to initiate a repurchase program, while larger firms are more likely to announce repurchase plans. This is probably related to dividend smoothing, and that firms are reluctant to cutting dividends as suggested in studies by Lintner (1956) and Brav et al. (2003). In addition, large firms often has a higher number of small shareholders, which may be one motivation for these firms to initiate a repurchase program.

Overall, although the findings in the paper does not strongly favor one interpretation over the other, the results are in line with an interpretation where insiders have incentives to support the initiation of a repurchase program either to maximize the future value of their wealth (Isagawa, 2000), expropriate outside shareholders or to entrench themselves. On the other hand the finding that a controlling shareholder decreases the probability of observing an announcement, may also suggest that controlling shareholders oppose the initiation of a repurchase program. Alternatively, a large shareholder may have stronger incentives to monitor, such that an additional mechanism to reduce agency costs of free cash is not needed. Interestingly, this finding is the opposite of what is the prediction in the model by Brennan and Thakor (1990) where, large shareholders prefer repurchases to dividends, while small shareholders prefer dividends. Thus, relative to their model, one would expect large shareholders to increase the firms propensity to initiate a repurchase program since they would use their voting rights to force a repurchase plan into place.

Future research on repurchases

The two essays on open market share repurchases provide some interesting results both with respect to the announcement effect, the underreaction hypothesis, the price effect of actual repurchases as well as on the ownership structure in repurchasing firms. Although, the two essays are separated in this thesis, they may be linked in several ways, which may motivate future research on this topic.

First, a critical question with respect to the signalling ability of open market repurchase announcements is whether the announcement is a credible signal. As will be discussed in chapters 4 and 5, relative to the signaling hypothesis the announcement of an open market share repurchase plan is not a commitment by the firm to actually repurchase any shares, neither does it impose any cost on the manager of the firm if it is a false signal aimed at temporarily increasing the stock price. As suggested by Isagawa (2000), the announcement of a repurchase plan may be credible if the manager has a stake in the firm through stock ownership or options, such that his future wealth depends on the value of the firm. In that case the announcement of a repurchase plan, as well as repurchase executions, signals information about the private benefits for the manager to indulge in suboptimal investments. If the private benefit from using cash on negative net present value projects is lower than his benefit from increasing the value of the firm, he will support the initiation of a repurchase program as well as execute repurchases instead of wasting cash that would lower the value of the firm and his own wealth. Thus, future research may try to examine more closely the relationship between the ownership composition in firms as well as how this relates to the signalling effect of repurchase announcements, and the future value of the firm.

A related issue which is not studied in the repurchase essays is whether the repurchase executions that are observed ex post were intended ex ante. In other words, firm specific or market wide events occurring after the announcement of the program may change the motivation for why firms in general execute repurchases. One example are large negative market movements that induce firms to repurchase to e.g. stabilize their stock prices. On recent example was the large drop in prices after the terrorist attacks in the US in 2001 which spurred a huge increase in the initiation of repurchase programs as well as actual repurchases. Although the huge increase in repurchases during this period was partly due to the Securities and Exchange Commission suspending regulations with respect to daily volume restrictions on repurchases, similar bursts in repurchase activity is found for Norway as well. In addition, findings in other studies (Stephens and Weisbach, 1998) suggest that negative price movements seem to trigger repurchases. However, more interestingly, firm specific events which were not anticipated by the managers at the announcement date may also affect whether the firm go through with repurchases or not. This is an important and interesting issue since announcing firms are likely to “self select” into being repurchasers or non-repurchasers. In the paper I find that the time between the announcement of the program and the initial repurchase executed by the firm is on average about 200 days (median 169 days). This indicates that the initiation of the program is not intended for immediate use, but rather to provide an option to the managers to execute repurchases when the circumstances are favorable or help provide liquidity to the marketplace. On the other hand, some firms execute repurchases very soon after the program announcement while about 40% of the firms do not repurchase at all. Thus, an interesting extension of the project would be to try to model the repurchase decision after the announcement of the repurchase programs to determine what are the main decision variables.

Second, several studies suggest that ownership structure may be important for economic performance and the value of the firm. Although the empirical results on this issue are ambiguous, several studies find that ownership structure matters for economic performance. In a study for the Norwegian market, Bøhren and Ødegaard (2001) find that insider ownership creates value while ownership concentration destroys value. Thus, if open market repurchases change the ownership composition in firms, or firms with certain ownership constellations are more likely to initiate repurchase programs, this may be important for the economic performance of these firms.

A final research topic with respect to repurchases relates the two last papers to microstructure issues. As suggested by Barclay and Smith (1988), the initiation of a repurchase program may increase the spread in the market since the probability of trading with an informed investor increases. Initially, this may be related to a higher probability of trading with the firm itself which increases the adverse selection component of the spread. An interesting topic for future research would be to combine the detailed intraday data used in chapter 3 with the data used in the two last essays to examine whether there is a effect on the adverse selection component of the spread after a firm announces a repurchase plan. In addition, it may be possible to track the actual repurchase executions in the intraday data to examine in more detail how the market reacts to the trading activity of an potentially informed trader, the firm.

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Chapter 2

Equity Trading by Institutional Investors: Evidence on Order Submission Strategies

Written with Randi Næs [1]

Abstract

The trading volume channelled through off-market crossing networks is growing. Passive matching of orders outside the primary market lowers several components of execution costs compared to regular trading. On the other hand, the risk of non-execution imposes opportunity costs, and the inherent "free riding" on the price discovery process raises concerns that this eventually will lead to lower liquidity in the primary market. Using a detailed data set from a large investor in the US equity markets, we find evidence that competition from crossing networks is concentrated in the most liquid stocks in a sample of the largest companies in the US. Simulations of alternative trading strategies indicate that the investor's strategy of initially trying to cross all stocks was cost effective: in spite of their high liquidity, the crossed stocks would have been unlikely to achieve at lower execution costs in the open market.

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2.1 Introduction

There is currently a plethora of venues for trading US equities. Some fit the needs of small retail investors while others are more suited for the needs of large institutional investors and portfolio managers.[2] Using a detailed data set from a large institutional investor, we investigate the nature of competition between a principal exchange and one particular type of alternative trading system, the crossing network. A crossing network is a satellite trading place: it uses prices from the primary market and merely matches quantities. Passive matching of orders implies that several components of execution costs are low compared to regular market trading: commissions are lower and there are no spread costs or direct price impact costs. On the other hand, traders are not guaranteed execution in the network, and this may lead to significant opportunity costs. In addition, the execution probability may or may not be associated with adverse selection costs, depending on the type of traders in the crossing network.[3] Finally, because crossing networks compete for order flow, crossing participants may eventually incur implicit price impact costs as a result of reduced primary market liquidity. The largest crossing markets in the US include POSIT (ITG), NYSE crossing session I and II, and Instinet Global Crossing. In addition, there are less public internal crossing networks, many of which are the exclusive domains of institutional investors.[4]

Investigating execution costs associated with different trading methods is of obvious interest to investors seeking cost effective ways to trade. However, the functioning of alternative trading systems should also be of interest to academics, regulators and policy makers responsible for the design of securities markets. The recent success of electronic

[2] The trading venues can be broadly classified into four groups: (i) the principal exchanges, (ii) the "over the counter" (OTC) markets, (iii) other exchanges and (iv) alternative trading systems (ATS). The *principal exchanges* include the NYSE and the NASDAQ/NNM. The *OTC markets* includes the OTC bulletin board and the "pink sheet" market. The OTC bulletin board is for companies too small to list on the NNM, and the "pink sheet" market is an internet quotation service for *very* small companies operated by Pink Sheets LLC. *Other exchanges* include the AMEX, the regional exchanges in Boston, Philadelphia, Pacific, and Chicago(Midwest), and the Cincinnati Stock Exchange. Finally the *ATSs* include Electronic Communication Networks (ECNs), the Arizona Stock Exchange, and external and internal crossing networks.

[3] A stated goal of many crossing networks is to keep the identities and trades of their participants anonymous, both before and after the trades. The following example is taken from the Instinet homepage: "With Instinet Global Crossing, the process is anonymous. Pre-trade or post-trade, neither your trading partner nor other market participants will know your identity, strategy, order size, or residual size."

[4] POSIT is by far the largest crossing market and facilitated the crossing of 7.8 billion shares in 2000 and 9.3 billion shares in 2001. POSIT performs eight daily matches at the price equal to the bid-ask midpoint of the stock's primary market at fixed times which are randomized within 5 minutes to avoid manipulation. The NYSE after hours crossing session I allows participants to submit orders until 5pm when the orders are matched using the NYSE closing price for each stock. The NYSE crossing session II is designed to facilitate trading of baskets of at least 15 NYSE securities valued at USD 1 million or more. Instinet Global Crossing began in 1986 as the first electronic crossing service in the US. Currently, its operations facilitate "end-of-day crossing" and "VWAP crossing". The "end-of-day crossing" crosses orders at the closing price in the primary market, while the "VWAP crossing" is settled before the opening of the primary market and the participants are guaranteed the VWAP price during the day.

trading venues has intensified the competition for order flow faced by the traditional markets. In general, the increase in competition is positive because it lowers execution costs. Several empirical studies find that transaction costs decreased over the recent past.[5] However, increased competition for order flow has also raised some concerns related to potentially negative effects from market fragmentation. Mendelson (1987) shows that market fragmentation has both costs and benefits. The costs are related to reduced liquidity and increased volatility in each "sub-market", while the benefits are related to increased quality of the market price signals. Because crossing networks do not contribute to price discovery, the potential benefits from better price signals are lost and only the potential costs from low liquidity and high volatility are left. These costs might also eventually harm participants in crossing networks through their reliance on primary market prices. A better understanding of the nature of the competition between crossing networks and primary markets is clearly called for, including under what circumstances and for which types of assets crossing networks will coexist with other markets.

Three recent empirical papers on alternative trading systems are Fong et al. (1999), Næs and Ødegaard (2000), and Conrad et al. (2001b). Fong et al. (1999) use detailed data from the Australian stock exchange (ASX) to study the competition between exchanges and different off-market trading mechanisms, including crossing networks (POSIT Australia). Off-market trading is found to be concentrated in the most liquid stocks. The cross-sectional differences in off-market trading seem to be driven by institutional trading interest (trading volume, index inclusion), primary market liquidity (spreads, market depth, introduction of closing auction market), and the existence of a derivative market. Conrad et al. (2001b) study explicit and implicit execution costs on externally crossed orders, orders sent to ECNs, and broker-filled orders based on a large data set from the US equity market provided by the Plexus Group.[6] Conrad et al. (2001b) also find that the most liquid stocks are the ones underlying the orders sent to external crossing systems. Moreover, the average total trade cost is found to be substantially lower for orders sent to external crossing systems and ECNs than for orders filled by traditional brokers.

Both papers suggest that crossing networks provide significant competition for order flow, especially in highly liquid stocks, and considerably lower execution costs than other trading methods. On the other hand, as hypothesized in Keim and Madhavan (1998) and Hendershott and Mendelson (2000), informed traders may be present in crossing networks, offsetting their explicit cost advantage. The existence of adverse selection costs is hard to detect based on the cost measures used in the empirical literature and the data typically available to researchers, such as the data from the Plexus Group

[5] For a survey on research on transaction costs, see Keim and Madhavan (1998).

[6] The sample consist of 797,068 orders submitted by 59 institutions between the first quarter of 1996 and the first quarter of 1998.

used in Conrad et al. (2001b). Using a special data set, the relation between execution probability and adverse selection is studied in Næs and Ødegaard (2000). They find that, over the month following an attempt at crossing, there is a one percent difference in risk adjusted returns between stocks that were successfully crossed and stocks that had to be purchased in the market. This finding is interpreted as evidence that the benefits of lower costs in crossing networks are mitigated by costs related to adverse selection.

In this paper, we extend the analysis of Næs and Ødegaard using the same data set. The data set includes all orders from the establishment of a US equity portfolio worth USD 1.76 billion over a 6-month period from January 1998 to June 1998. The portfolio was tracking the US part of the FTSE All World index[7], which consists of about 500 stocks, and has a very high correlation with the S&P 500 index. The data set is unique in that it contains information on the investors' complete order submission strategy, including the ex ante trading strategy, the dates on which the decision to trade was made, and the resulting fill rates of each order for different trading venues. Hence, the data set is close to a "controlled experiment" which is quite rare.[8] The weakness of the data set is that it is from one trader's buy orders only and covers a limited period of time. Both Fong et al. (1999) and Conrad et al. (2001b) have access to huge data sets on orders and trades and their results are therefore more robust than ours. However, we show that the investor in our study is quite representative for large institutional investors in the US markets.

First, we try to investigate the evidence of adverse selection more closely. On the one hand, the available empirical evidence suggest that crossing networks are competing in the most liquid stocks. If stocks that are not supplied in crossing networks are less liquid in general, then these stocks may require a higher return to induce investors to hold them, and the abnormal performance of the non-crossed stocks found in Næs and Ødegaard (2000) might be explained (or partly explained) by a liquidity premium.[9] On the other hand, a liquidity and an information story need not be mutually exclusive. First, in addition to being a proxy for differences in liquidity, a wider spread may also capture a higher adverse selection component. Furthermore, other measures of liquidity, such as depth, may also capture the effect that uninformed investors withdraw from the market if they are worried about being picked off by better informed investors. Thus, a difference in liquidity between the two groups of stocks may capture the same effect as

[7]The FTSE All-World index includes 49 different countries and about 2300 stocks. The aim of the index is to capture up to 90% of the investible market capitalization of each country.

[8]In many other studies, the exact investment strategy of a trader has to be estimated from the sequence of trades. This induces a selection bias in the data. It might be that the trader has decided to send the most difficult orders to brokers and the least difficult orders to crossing networks. We are not facing a selection bias problem in our data set.

[9]Amihud and Mendelson (1986) show that risk-adjusted returns for stocks and bonds are increasing in their illiquidity, where liquidity is proxied by the spread.

found in Næs and Ødegaard (2000), but by using different proxies for adverse selection. An interesting question in this respect, is whether the liquidity characteristics are temporary or more systematic over time. Because information asymmetries are expected to vanish relatively quickly, it would be harder to interpret a systematic liquidity difference as a sign of adverse selection, especially for the largest companies in the US market. On the other hand liquidity differences may be more permanent in nature.

We investigate these questions by calculating a whole range of liquidity and activity measures in the primary market across the groups of stocks that were supplied/not supplied in the crossing network.[10] Our results indicate that the difference in abnormal return between the two groups of stocks may be explained by both liquidity differences and private information. On the one hand, we find support for the earlier finding that crossing networks are competing in the very liquid segment of listed US equities. Stocks that are successfully crossed are significantly more liquid and more actively traded in the primary market than stocks that are not crossed. Moreover, we also show that the differences in liquidity and activity between the two groups of stocks are not date specific, but rather systematic throughout the entire period examined. On the other hand, the difference in spread between the groups of stocks is sometimes significant even though the measures of activity are equal. Following Easley et al. (1996b), this is evidence of informed trading in the stocks that could not be crossed. In addition, we show that the stocks in our sample have a very high correlation with the S&P 500 index. It is hard to believe that liquidity differences between the 500 largest and most liquid companies in the US can explain a difference in abnormal performance between the two groups of stocks of 1 percent over 20 days.

Second, we want to investigate the costs of following alternative submission strategies. This is done by simulating the set of equilibrium order submission strategies for liquidity traders in the Hendershott and Mendelson (2000) model. Our simulated strategies are based on real historical price/volume paths of the stocks traded. This is possible to do because we know the dates when the decision to trade was made in addition to the desired quantities. The simulations confirm the result that crossed and non-crossed stocks have different liquidity characteristics. The stocks that are not obtained through crossing are also the most difficult and expensive stocks to acquire in the market. More interestingly, we find that the actual crossing strategy was inexpensive. Even though the crossed stocks were among the most liquid stocks on the NYSE, it would have been very hard to achieve lower execution costs by submitting limit orders for the same stocks on the same dates that they were first tried to be crossed.

The paper is organized as follows. In section 2.2, we describe our data set. We first give a short description of the investor and the crossing strategy. Then we provide some descriptive statistics establishing that the investor is indeed representative for the

[10] We use the crossing success of the Fund as a proxy for supply in the crossing network.

group of large institutional traders in the US equity market. In section 2.3, we discuss the relationship between execution probability and several measures of primary market liquidity. Section 2.4 contains a description of the methodology and results from the simulation approach. Section 2.5 provides our conclusions.

2.2 The data

Our data set contains transactions data from an actual submission strategy carried out in the US equities market by a large institutional investor, the Government Petroleum Fund in Norway (hereafter "the Fund"). To construct liquidity measures and simulate other submission strategies, we use additional transaction data from the NYSE Trades and Quotes database (TAQ), which contains all the trades and quotes for stocks listed on the NYSE, American Stock Exchange (AMEX) and NASDAQ's National Market System. In this section, we first give a short description of the Fund and explain the opportunistic crossing strategy in some more detail. We then provide some descriptive statistics to establish that the Fund is representative for the group of large institutional traders in the US equity market.

2.2.1 The trading strategy

The Fund is a vehicle for investing the Norwegian Government's income from petroleum-related activities in international capital markets. Initially, the Fund was invested in foreign government securities only. However, new criteria, applying from January 1998, stated that between 30 and 50 percent of the Fund portfolio was to be invested in equities. The composition of the Fund portfolio was changed to include equities during the first half of 1998. We use transaction data for the part of the portfolio that was invested in US equities during this "buildup"/transition period.

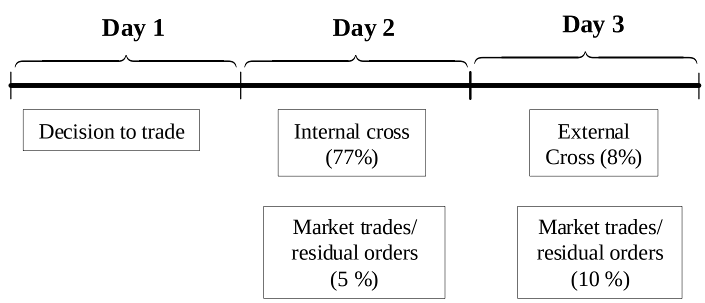
The investment universe for the equity portfolio includes at present 28 countries in Europe, America, and Asia. US stocks represent around 29 percent of the total stock portfolio. Benchmark portfolios consist of the companies in the FTSE All-World index for these countries.[11] The US part of the index currently consists of about 480 different securities. The constituents of this index are the largest companies in the US market, and the index has a very high correlation with the S&P 500 index.

The equity portion of the total benchmark portfolio was set to 8 percent at the end of January 1998, and was then increased by another 8 percentage points at the end of each subsequent month until it reached the benchmark weight of 40 percent in June. The maximum tracking error restriction implied that the Fund was pre-committed to buy most of the stocks in the index every month.

[11]These indices used to be called the FT/S&P's Actuaries World Index.

The Fund employed four index managers to establish the portfolio. One of the index managers was chosen as "transition manager". The order submission strategy was as follows: First, try to find sellers among the customers of the transition manager (internal crossing). If this is not possible, search for counterparties among the customers of the other three index managers or send the order to an electronic crossing network (external crossing). Finally, purchase residual orders that cannot be crossed (if any) in the primary market. According to the discussion in Ruyter (1999), this is the typical order submission strategy large index managers follow for their customers. Figure 2.1 illustrates the actual implementation of the Fund's order submission strategy.

FIGURE 2.1 Implementation of the Fund's Order Submission Strategy
The Fund's order submission strategy was as follows: First, try to find sellers among the customers of the transition manager (internal crossing). If this is not possible, search for counterparties among the customers of the other three index managers or send the order to an electronic crossing network (external crossing). Finally, purchase residual orders that cannot be crossed (if any) in the primary market. The figure illustrates the actual implementation of the order submission strategy followed by the Fund. The overall part of the orders were crossed internally. All orders were executed within two days after the decision to trade. At some occasions market trades happened on the same date as internal crosses. We do not know if these orders were sent to external crossing before they were sent to the market. Hence, it might be that the submission strategy was not strictly followed with respect to the stage with external crossing. The numbers in parentheses are percent of total portfolio investment (USD 1 751 billion).



The total portfolio investment was USD 1751 million. The Fund went to the primary market with USD 250 million, or 14 percent, of this investment. We do not know what part of the externally crossed orders that were sent to an electronic crossing network rather than being crossed with one of the Fund's index managers. The majority of the crossed orders, USD 1356 million of USD 1501 million, was executed internally. Market trades to complete the desired portfolio were needed on three of a total of sixteen trading dates. Looking at the transactions data, it turns out that at some occasions market trades happened on the same date as internal crosses. According to the order submission strategy, these orders should be sent to external crossing before they were sent to the market. We do not know if this was done. Hence, it might be that the submission strategy was not strictly followed with respect to the stage with external crossing. The highest trading volume on one date amounted to USD 300 million, or 17.1% of the total portfolio investment. Note that for the period we are considering the Fund was only buying, not selling securities. For the first two months, crossing prices were set as the primary market (NYSE/NASDAQ) closing prices that day. For the remainder of the period, prices were set as the volume weighted average price (VWAP) of trades in the primary market during the day.

2.2.2 Robustness

Our study is based on the trades of only one institution. It is therefore of crucial importance that the investor is representative for the group of institutional investors used in other studies dealing with similar issues.

The Fund used Barclay Global Investor (BGI) as a transition manager. According to Harris (2002), BGI's internal crossing network is "probably the largest in the world". Hence, both the manager and the private network, where most of the actual crossing was performed, are representative for the US market.

Most recent empirical studies of institutional investors' in the US equity market use data provided by the Plexus Group. These studies include Keim and Madhavan (1995, 1997), Jones and Lipson (1999a,b) and Conrad et al. (2001a,b). The Plexus Group is a consulting firm that monitors the costs of institutional trading. The data sets used in Jones and Lipson (1999a,b) are limited to trades executed in some specific firms. The most relevant samples of institutional investors with which to compare the Fund's trades are therefore the ones used in Keim and Madhavan (1995, 1997) and Conrad et al. (2001b).

Keim and Madhavan (1995, 1997) use data on all equity transactions of 21 institutional investors from January 1991 through March 1993. This data set contains a total of 62,333 orders. The institutions vary in size. For fundamental value managers, the mean dollar value of assets under management was USD 4.8 billion, ranging from a low of USD 0.7 billion to a high of USD 12.9 billion. For index managers and technical traders, the mean dollar value of assets under management was USD 3.2 billion and USD 5.3 billion respectively.[12] In the period we are examining, the Fund was an index tracker, and, at the end of June 1998, the US equity portfolio was worth USD 1.7 billion. Conrad et al. (2001b) have a larger data set from a more recent time period. Their sample consists of 797,068 orders submitted by 59 institutions between the first quarter of 1996 and the first quarter of 1998.

If we first look at order size, our median order is for USD 174,000. As table 2.1 shows, this is slightly larger than the median buy order of USD 138,000 in Keim and Madhavan (1995, 1997), and much larger than the crossed and ECN filled orders in Conrad et al.

[12] Fundamental value managers are defined as managers whose investment strategies are based on assessment of long-term fundamental values, technical managers are defined as managers whose strategies are based on capturing short-term price movements, and index managers are defined as managers who seek to mimic the returns of particular stock indexes (Keim and Madhavan, 1997).

Table 2.1
Descriptive statistics for traded securities

In this table, we make a comparison of the data used in this study and in Keim and Madhavan (1995, 1997) and Conrad et al. (2001b). In our study and in Keim and Madhavan (1995,1997), the numbers are for buyer-initiated trades only. "Multiple mechanism orders" in the Conrad et al. (2001b) paper are orders in which more than one of the three trading mechanisms (brokers, ECNs or external crossing systems) are used to fill the order. Market cap values are in USD billion. "Listed%" is the percentage of total orders that is in listed stocks. "n" is the total number of orders.

	Order size				Liquidity			
	Dollar value		No. of shares		Market cap		Listed	n
	mean	med.	mean	med.	mean	med.	%	
Our study								
All orders	386	174	6 898	3 800	16.9	7.5	100	4 200
- Cross	396	177	7 013	3 800	17.6	7.8	100	3 494
- Market order	339	157	6 329	3 550	13.6	6.1	100	706
KM [1995,1997]								
All orders		138		4 800		1.1	82.6	36 590
Conrad et al. (2001b)								
All orders								723 998
- External cross	187	45			12.8		>90.0	112 159
- ECN's	194	53			3.0			51 127
- Broker filled	1474	137			11.1			560 712

(2001b). One of the reasons for this may be that the orders routed through ECNs are generally much smaller than orders routed through crossing networks. The average dollar value of the Fund's orders of USD 386,000 is also higher than the average dollar value of the orders sent to external crossing and ECNs, but considerably lower than the average dollar value of the orders filled by brokers and multiple order mechanisms.

Since the Fund was tracking the US stocks included in the FTSE All-World index, the stocks in the sample are obviously the more liquid stocks in the market. The most liquid stocks in Conrad et al.'s study are the ones underlying the orders sent to external crossing systems. These securities have an average market cap of USD 12.7 billion, while the average market cap for the stocks purchased by the Fund was USD 16.9 billion. Hence, the Fund was clearly trading in the larger companies.

One more characteristic with our data set is worth noting. Unlike most other studies, there is no selection bias in our data set. The Fund did not select what orders to send to the crossing network and what orders to send to the market based on a perception of trade difficulty.

2.3 Execution probability and primary market liquidity

In this section, we analyze in detail the relation between the probability of getting a stock crossed and the liquidity and trading activity in the primary market. This is possible because we know that the Fund initially tried to cross all the stocks. The data set therefore reveals the date and identity of stocks that could not be crossed. Using a choice theoretic (probit) model on the probability of seeing a stock being crossed, Næs and Ødegaard (2000) find some evidence that the crossing network is removing trading volume from the primary market. However, in their model, market liquidity is only captured by company market values. This is not a particularly informative proxy for liquidity in our case, since all the stocks in the sample are relatively large.

We find that there are indeed significant differences in liquidity and activity between the two groups of stocks based on a wide range of liquidity and activity measures. Moreover, most of the liquidity and activity measures we calculate are significantly different across the groups of stocks, both on the days when they were first crossed and for the month prior to and after the actual trading dates. These results are confirmed in a probit model. After a proper orthogonalization of the independent variables, the probability of a successful cross is shown to be higher the lower the effective spread, the higher the liquidity ratio, and the higher the dollar trading volume in the primary market.

2.3.1 Liquidity measures

Market liquidity is a comprehensive concept that covers several transactional properties of the marketplace. Harris (1990) defines four interrelated dimensions of the concept: width, depth, immediacy and resiliency. *Width* is defined as the bid-ask spread for a given number of shares, and measures the cost per share of liquidity. *Depth* is defined as the number of shares at the bid-ask quotes, *immediacy* describes how fast a trade for a given number of shares can be executed, and *resiliency* describes how fast the price reverts to its "true" value after order flow imbalances caused by liquidity trading that has moved prices temporarily away from the "true" level. We try to capture the width, depth and resiliency dimensions by calculating several spread, volume, and volatility measures.[13]

Spread measures We consider three measures of the spread to capture the width of the market. The most commonly used spread measure is the *quoted dollar spread.* It measures the average difference between the inside quoted ask and bid for a stock over the trading day and can be thought of as the absolute "round trip" cost of trading a small amount of shares at the inner quotes. The *quoted percentage spread* is calculated as the quoted spread relative to the spread midpoint, or the "true" value, at each trade time. The *effective spread* takes into account the fact that trades are often executed inside (price improvement) or outside the spread ("walking the book"), and is often considered a more appropriate measure of trading costs than are quoted spreads, especially for large

[13]A discussion of data issues and the formulas for calculating the different liquidity and activity measures are provided in appendix A.

trades.[14] The effective spread is calculated as the average absolute dollar difference between the execution price and the bid/ask midpoint multiplied by two. The spread measures the handling of a single trade, and does not capture the ability of a market structure to absorb a series of trades without perturbing prices excessively. We therefore need to supplement the spread estimates with measures of depth and volatility.

Depth and resiliency To capture market depth and resiliency, we calculate the average quoted number of shares at the inner quotes and the daily and intraday Amivest liquidity ratio.[15] The daily liquidity ratio reflects the average trading volume that would be needed to move the price by one percent during a trading day, while the average intraday liquidity ratio measures the same relationship over 15 minute intervals. A high liquidity ratio indicates ability of the market to absorb large trades without affecting the price.[16] To get a broader picture of the volume and trading activity in the primary market across the groups of stocks, we also calculate total shares traded, the dollar value of shares traded, and the average trade size.

Volatility As an additional liquidity measure we calculate two measures of volatility. Volatility captures a dimension of liquidity in the sense that high depth at the inner quotes makes the trade prices less volatile since there is more depth to absorb the liquidity demand. The first volatility measure we calculate is the standard deviation of daily returns over the 10 days prior to the date when the Fund was trying to cross the stock. The other measure tries to capture the intraday volatility (15 minute return standard deviation) in each stock. When interpreting short term volatility, it is important to keep in mind that the sources of volatility may vary. From the viewpoint of a trader, high volatility can increase the probability of filling a limit order. This could attract liquidity suppliers to volatile stocks. However, high volatility may also be associated with news and informed trading so that the risk of an adverse price movement after a fill is higher ("pick off risk"). Furthermore, informed trading would also induce the specialist to increase his spread which would make the trading costs higher. From a liquidity perspective, high volatility may also be a sign of low liquidity in the sense that the market is unable to absorb large trades without excessive price movements.

2.3.2 Results

In order to investigate whether stocks that are easy/hard to cross have different liquidity and activity characteristics, we split the orders into three categories on each sample date: (i) *Crossed stocks*: orders in this group were fully crossed, (ii) *Cross/Market*: orders in this group could not be fully crossed, and the residual order was purchased in the open

[14] See for example Angel (1997) and Bacidore et al. (1999).
[15] Amivest Capital Management introduced this measure of liquidity.
[16] This ratio is applied in several studies (see e.g. Khan and Baker (1993), Amihud et al. (1997)).

market the next day, and (iii) *Market stocks*: orders in this group could not be crossed at all, and the whole order was therefore purchased in the open market the next day. A market trade means that the Fund was either "crowded out" by other traders who wanted to buy the stock or (the rather unlikely case) that the supply of the stock in the network was less than the size of our order.

Table 2.2 shows the different liquidity measures for the three order categories on two of the three dates when the Fund was not able to obtain all the required stocks in the crossing network.[17] In table 2.3 we have averaged the liquidity measures in table 2.2 according to the number of stocks traded by the Fund on each date. To examine whether our sample of stocks differs from the stocks in the S&P 500 index, we calculate the average liquidity measures for the S&P 500 index over the same dates as well as for the entire period when the Fund was trading (first half of 1998). For each liquidity measure, we perform tests for differences in means between the S&P 500 index stocks and the stocks purchased by the Fund. Except for the quoted percentage spread and the volatility measures, none of the liquidity measures are significantly different at the 1% level. Hence, the two samples have quite similar liquidity and activity characteristics. We also find that the S&P 500 stocks average for the entire half-year is not significantly different from the S&P 500 stocks average on the particular dates when the Fund was trading.

The numbers in both tables strongly indicate that stocks that were easy to cross had lower spread costs than stocks that were hard to cross. The average spread difference is 22%, which is both economically and statistically significant. Interpreting spreads as a proxy for liquidity, this means that stocks that could not be crossed were less liquid than the stocks supplied in the crossing network. The group of non-crossed stocks was also less liquid measured by the intraday and daily liquidity ratios. Moreover, measured by the number of trades, the trading volume, and the number of shares traded, the trading activity was lower in the non-crossed stocks over the entire sample.[18] Stocks that were hard to cross were also more volatile than stocks that were easy to cross. As we would expect, the liquidity of the stocks underlying the group of orders that were partly crossed and partly filled in the market lies in between the two other groups.

Using the result in Easley et al. (1996b) that higher spread for stocks with similar trading volume is an indication of informed trading, our results give some support to the evidence of informed trading in the crossing network found in Næs and Ødegaard (2000). On the other hand, if there are systematic differences in liquidity between the two groups of stocks also on other dates, this would be less supportive to an informed trading story. To check this, we calculate the liquidity measures on each date across

[17] We do not report the liquidity measures separately for one of the three days because the number of orders purchased in the market on this day was too small to perform reliable statistical tests of the differences between the two groups.

[18] This difference was insignificant for one of the trading dates, however.

Table 2.2
Liquidity in the primary market on the trading dates

The table shows different measures of liquidity and activity in the primary market on the dates when the Fund did not fill all orders in the crossing network. "Crossed stocks" means that the whole order of a stock was crossed. "Crossed/Market" means that part of the order was crossed and part of the order had to be purchased in the open market. "Market stocks" means that the stock could not be crossed at all. The calculation and explanation of the different measures are found in Appendix A. The t-stat and p-value are the test statistics of a two-sided t-test, where the null is that the mean for the "Crossed stocks" and "Market stocks" are equal. Similarly, for the "Crossed/Market" group, the null is that the mean for the "Crossed stocks" and "Crossed/Market" stocks are equal. The test depends on whether the population variances of the two groups are equal or not. If the variances are equal, then the t-stat is calculated as $t = (\bar{x}_c - \bar{x}_m)/\sqrt{s^2(1/n_c + 1/n_m)}$ where $\bar{x}_c$ and $\bar{x}_m$ are the means for the two groups respectively, n_c and n_m are the number of stocks in each group while s^2 is the pooled standard deviation calculated as $s^2 = [(n_c-1)s_c^2 + (n_m-1)s_m^2]/[n_c+n_m-2]$, where s_c^2 and s_m^2 are the standard deviation of measure for the cross and market stocks respectively. We use the SAS package to perform all tests. If the variances are significantly different, the standard approximation supplied in SAS is used. For the *Daily volatility* measure, we use an F-test to test for differences in variance between the two groups, where the null is that the ratio of the two sample variances is equal to 1.

DATE 1	S&P 500 stocks	Fund stocks	Crossed stocks	Market stocks	Diff. test p-value	Crossed/ Market	Diff. test p-value
Spread measures							
Effective spread	0.1112	0.1063	0.0931	0.1118**	0.0103	0.0893	0.6514
Quoted USD spread	0.1322	0.1315	0.1135	0.1395**	0.0069	0.0910	0.0969
Quoted% spread (midp.)	0.3270	0.2566[a]	0.1916	0.2852**	<.0001	0.1200*	0.0111
Volume measures							
Trades	807	861	1317	575**	0.0002	4985**	<.0001
Shares traded (1000)	1180	1274	2039	868**	0.0001	5487**	0.0007
Volume (USD mill.)	61	67	116	39**	<.0001	434**	<.0001
Trade size (USD 1000)	79	85	88	67**	0.0011	103	0.6159
Liquidity ratios and depth							
Daily LR (USD mill.)	117	148	293	76**	<.0001	785	0.1221
Intraday LR (USD mill.)	13	16	28	8**	<.0001	103	0.0576
Depth at quotes (shares)	1198	1841	2126	1692	0.0965	3351	0.1942
Volatility and return							
Daily volatility	0.0275	0.0256[a]	0.0225	0.0265**	<.0001	0.0342**	<.0001
Intraday volatility (%)	0.2601	0.2367[a]	0.2573	0.2296*	0.0307	0.2044*	0.0361
N stocks	454	368	100	261		7	

DATE 2	S&P 500 stocks	Fund stocks	Crossed stocks	Market stocks	Diff. test p-value	Crossed/ Market	Diff. test p-value
Spread measures							
Effective spread	0.1174	0.1139	0.1027	0.1327**	0.0082	0.1039	0.7636
Quoted USD spread	0.1396	0.1420	0.1299	0.1605*	0.0445	0.1326	0.5257
Quoted% spread (midp.)	0.3903	0.3375[a]	0.3255	0.3724*	0.0380	0.3136	0.5391
Volume measures							
Trades	737	678	515	692	0.1830	763*	0.0447
Shares traded (1000)	1015	929	847	875	0.8390	1025	0.2390
Volume (USD mill.)	53	48	40	46	0.5469	54	0.1914
Trade size (USD 1000)	68	67	78	66**	0.0065	67	0.0917
Liquidity ratios and depth							
Daily LR (USD mill.)	100	101	81	92	0.5182	120	0.0598
Intraday LR (USD mill.)	10	9	8	8	0.9397	11	0.2481
Depth at quotes (shares)	1572	1506	1524	1464	0.7546	1532	0.9676
Volatility and return							
Daily volatility	0.0220	0.0263[a]	0.0250	0.0271**	0.0025	0.0263*	0.0449
Intraday volatility (%)	0.3494	0.3217[a]	0.3298	0.3220	0.6551	0.3167	0.4233
N stocks	454	478	114	171		193	

[a] Equality of the measure between the S&P 500 and Fund stocks is rejected at the 5% level.
* Equality of the measure between the Crossed and Non-crossed stocks (Market stocks) is rejected at the 5% level.
** Equality of the measure between the Crossed and Non-crossed stocks (Market stocks) is rejected at the 1% level.

TABLE 2.3

Average liquidity over all stocks

The first and second columns in the table show the cross-sectional average measures for the S&P 500 constituent stocks during the first half of 1998 (S&P 500 June-July) and on the same dates as for the Fund trades (S&P 500). The third column (Fund) is the cross-sectional average for all the stocks that the Fund traded on the two dates. The t-stat and p-value are the test statistics of a two-sided t-test, where the null is that the mean for the "Crossed stocks" and "Market stocks" are equal. Similarly, for the "Crossed/Market" group, the null is that the mean for the "Crossed stocks" and "Crossed/Market" stocks are equal. The test depends on whether the population variances of the two groups are equal or not. If the variances are equal, then the t-stat is calculated as, $t = (\bar{x}_c - \bar{x}_m)/\sqrt{s^2(1/n_c + 1/n_m)}$ where $\bar{x}_c$ and $\bar{x}_m$ are the means for the two groups respectively, n_c and n_m are the number of stocks in each group while s^2 is the pooled standard deviation calculated as $s^2 = [(n_c - 1)s_c^2 + (n_m - 1)s_m^2]/[n_c + n_m - 2]$, where s_c^2 and s_m^2 are the standard deviation of measure for the cross and market stocks respectively. We use the SAS package to perform all tests. If the variances are significantly different, the standard approximation supplied in SAS is used. For the *Daily volatility* measure, we use an F-test to test for differences in variance between the two groups, where the null is that the ratio of the two sample variances is equal to 1.

ALL TRADES	S&P 500 Jan-July	S&P 500 stocks	Fund stocks	Crossed stocks	Market stocks	Diff. test p-value	Crossed/ Market	Diff. test p-value
Spread measures								
Effective spread	0.1151	0.1143	0.1106	0.0982	0.1201**	0.0006	0.1034	0.1157
Quoted $ spread	0.1360	0.1359	0.1374	0.1222	0.1478**	0.0021	0.1312*	0.0204
Quoted% spread (midp.)	0.3414	0.3586	0.3023[a]	0.2629	0.3197**	<.0001	0.3068**	0.0037
Volume measures								
Trades	758	772	758	890	621*	0.0255	911	0.8897
Shares traded (1000)	1073	1097	1079	1404	871**	0.0015	1181	0.2454
Volume (mill. USD)	58	57	56	76	42**	<.0001	68	0.5154
Trade size (1000 USD)	77	74	74	83	67**	0.0004	68**	<.0001
Liquidity ratios and depth								
Daily LR (mill.USD)	116.62	108.23	121.45	179.70	82.28**	<.0001	143.74	0.2189
Intraday LR (mill.USD)	12.69	11.81	12.02	17.68	8.34**	<.0001	13.92	0.1771
Depth at quotes (shares)	1851	1385	1652	1805	1601	0.2018	1596	0.2369
Volatility and return								
Daily volatility	0.0238	0.0250	0.0261[a]	0.0241	0.0269**	<.0001	0.0266**	<.0001
Intraday volatility (%)	0.2785	0.3048	0.2847[a]	0.2960	0.2662**	0.0078	0.3128	0.2163
Average stocks per date	452	454	423	107	216		100	

[a] Equality of the measure between the S&P 500 and Fund stocks is rejected at the 5% level.

* Equality of the measure between the Crossed and Non-crossed stocks (Market stocks) is rejected at the 5% level.

** Equality of the measure between the Crossed and Non-crossed stocks (Market stocks) is rejected at the 1% level.

a window stretching from 20 business days before to 20 business days after the actual trading date. The results are shown in figure 2.2 with the values and tests in table 2.4. As can be seen from the figure and table there are systematic differences in most of the liquidity and activity measures. A notable exception is the intraday volatility measure which is quite similar between the two groups, except on the actual trade date when it is significantly higher for the crossed stocks. If a market cannot absorb trades without large price movements, the intraday volatility increases. If this is the reason for the change in intraday volatility on the trade dates, the stocks that were supplied in the crossing network did experience a decline in primary market liquidity. Note also that the quoted depth is significantly higher for the crossed stocks than for the non-crossed stocks during the days prior to the crossing date, but not significantly different on the actual crossing dates. These findings are in line with a story where crossing networks remove order-flow from the primary market.

To investigate the relationship between primary market liquidity and the outcome of the attempt at crossing the stocks more formally, we estimate a probit model of the probability of getting a stock crossed as a function of various liquidity measures. More specifically, we assume that the probability of observing a cross is given by the model

$$y = \Pr(\text{cross}) = F\left(\beta_0 + \beta_1 \text{eff\_spread}_i + \beta_2 \text{depth}_i + \beta_3 \text{LR}_i + \beta_4 \text{volume}_i + \beta_5 \text{vola}_i + \epsilon_i\right) \tag{2.1}$$

where $F(\cdot)$ is the cumulative normal distribution function, and the β's are coefficients of the explanatory variables. Explanatory variables include the effective spread ("eff_spread"), the average depth at the inner quotes ("depth"), the intraday liquidity ratio ("LR"), the trading volume measured in USD ("volume"), and the standard deviation of daily returns measured over the last 10 days ("vola"). The total data set contains 646 transactions, of which 214 were crosses.[19]

The model is estimated on all orders that were either fully crossed or fully filled in the primary market. The explanatory variables capture many dimensions of primary market liquidity and trading activity. The effective spread is considered the most appropriate measure of trading costs or market width. Average depth at the inner quotes is a frequently used depth measure, see for example Chordia et al. (2001). The intraday liquidity ratio captures part of the market resiliency dimension, and dollar trading volume and return volatility capture different aspects of the trading activity.[20] The estimation results are presented in table 2.5.

When interpreting the model, we calculate slope estimates (marginal effects) at the

[19] We use STATA 7 to estimate the model. The intraday liquidity variable is highly correlated with the dollar volume of trading. We therefore use orthogonal versions of these two variables in the regression model.

[20] We also estimate a multinomial logistic regression model using the same set of explanatory variables, but with an additional category consisting of the partly crossed orders. Because the results from this model do not provide any additional insight, we only report the results from the probit model.

TABLE 2.4

Time series of liquidity and activity measures over all sample stocks

The time series of liquidity and activity measures of 40 trading days surrounding the actual trade dates for the crossed stocks (C) and non-crossed stocks (M) that were bought in the market in the portfolio. A t-test for differences in means between the two groups is performed for each date for each measure. Numbers in bold indicate a significant difference at the 5% level. The test applied is a two-sided t-test, where the null is that the mean for the "Crossed stocks" and "Market stocks" are equal. The test depends on whether the population variances of the the two groups are equal or not. If the variances are equal, then the t-stat is calculated as $t = (\bar{x}_c - \bar{x}_m)/\sqrt{s^2(1/n_c + 1/n_m)}$ where $\bar{x}_c$ and $\bar{x}_m$ are the means for the two groups respectively, n_c and n_m are the number of stocks in each group while s^2 is the pooled standard deviation calculated as $s^2 = [(n_c - 1)s_c^2 + (n_m - 1)s_m^2]/[n_c + n_m - 2]$, where s_c^2 and s_m^2 are the standard deviation of measure for the cross and market stocks respectively. We use the SAS package to perform all tests. If the variances are significantly different, the standard approximation supplied in SAS is used.

	Effective spread		Quoted spread (USD)		Quoted % spread		Shares traded		Volume USD		Trades		Trade size (Shares)		LR (daily)		LR Intraday		Depth (shares)		Intraday Volatility	
Date	C	M	C	M	C	M	C	M	C	M	C	M	C	M	C	M	C	M	C	M	C	M
-20	**0.094**	**0.114**	**0.121**	**0.142**	**0.239**	**0.309**	**1388**	**832**	**76**	**43**	**879**	**560**	**91**	**77**	**168**	**86**	**17**	**9**	1864	1724	0.250	0.233
-19	**0.097**	**0.114**	**0.122**	**0.140**	**0.241**	**0.310**	**1346**	**798**	**71**	**41**	**916**	**610**	**79**	**67**	**161**	**85**	**16**	**8**	1820	1660	0.278	0.272
-18	**0.093**	**0.115**	**0.121**	**0.143**	**0.241**	**0.312**	**1122**	**771**	**59**	**40**	781	559	78	73	**161**	**86**	**15**	**9**	1931	1634	0.233	0.238
-17	**0.095**	**0.115**	**0.119**	**0.141**	**0.239**	**0.309**	**1308**	**804**	**69**	**42**	**905**	**570**	**77**	**74**	**168**	**83**	**17**	**9**	1962	1745	0.261	0.243
-16	**0.096**	**0.116**	**0.120**	**0.143**	**0.237**	**0.309**	**1235**	**762**	**68**	**40**	**841**	**561**	**80**	**73**	**167**	**82**	**16**	**8**	1974	1654	0.244	0.246
-15	**0.095**	**0.110**	**0.119**	**0.136**	**0.236**	**0.299**	**1295**	**763**	**71**	**40**	**899**	**583**	**75**	**70**	**171**	**80**	**17**	**8**	2154	1860	0.241	0.231
-14	**0.095**	**0.116**	**0.119**	**0.142**	**0.238**	**0.309**	**1309**	**822**	**72**	**43**	853	626	**81**	**69**	**175**	**81**	**17**	**9**	**1939**	**1620**	0.244	0.244
-13	**0.095**	**0.117**	**0.120**	**0.145**	**0.242**	**0.321**	**1356**	**835**	**73**	**43**	**955**	**669**	**79**	**65**	**176**	**81**	**18**	**9**	1799	1562	0.292	0.282
-12	**0.097**	**0.117**	**0.123**	**0.145**	**0.244**	**0.320**	**1400**	**727**	**75**	**37**	**950**	**556**	**82**	**67**	**180**	**82**	**17**	**8**	1773	1567	0.270	0.264
-11	**0.096**	**0.110**	**0.120**	**0.137**	**0.237**	**0.305**	**1375**	**759**	**72**	**38**	**910**	**521**	**82**	**73**	**176**	**88**	**17**	**8**	**2094**	**1572**	0.257	0.242
-10	**0.093**	**0.114**	**0.117**	**0.145**	**0.237**	**0.317**	**1380**	**861**	**70**	**43**	886	631	**80**	**69**	**184**	**86**	**17**	**8**	**1836**	**1541**	0.283	0.262
-9	**0.096**	**0.120**	**0.121**	**0.149**	**0.242**	**0.319**	**1441**	**855**	**74**	**46**	**1002**	**641**	**78**	**71**	**189**	**86**	**17**	**9**	1771	1539	**0.275**	**0.249**
-8	**0.093**	**0.118**	**0.118**	**0.147**	**0.239**	**0.319**	**1285**	**876**	**67**	**46**	880	649	**81**	**70**	**188**	**87**	**16**	**10**	**1941**	**1545**	0.259	0.254
-7	**0.093**	**0.118**	**0.119**	**0.145**	**0.237**	**0.316**	**1324**	**862**	**68**	**43**	844	632	**83**	**68**	**191**	**84**	**17**	**8**	1950	1684	0.256	0.249
-6	**0.093**	**0.118**	**0.117**	**0.148**	**0.233**	**0.315**	**1375**	**819**	**70**	**42**	**849**	**582**	**83**	**74**	**184**	**85**	**17**	**9**	**2267**	**1756**	0.246	0.236
-5	**0.094**	**0.129**	**0.119**	**0.154**	**0.228**	**0.318**	1374	965	75	50	944	732	**76**	**68**	**204**	**98**	**20**	**10**	1879	1636	0.241	0.245
-4	**0.095**	**0.117**	**0.121**	**0.148**	**0.236**	**0.316**	**1291**	**846**	**67**	**41**	860	617	**76**	**65**	**185**	**89**	**16**	**8**	**1953**	**1618**	0.248	0.243
-3	**0.095**	**0.116**	**0.118**	**0.144**	**0.234**	**0.307**	**1239**	**874**	**66**	**42**	819	627	**81**	**68**	**182**	**90**	**15**	**8**	1858	1594	0.272	0.255
-2	**0.096**	**0.115**	**0.120**	**0.142**	**0.237**	**0.309**	**1499**	**806**	**76**	**39**	**948**	**562**	**81**	**69**	**176**	**88**	**17**	**7**	**2074**	**1668**	0.283	0.267
-1	**0.096**	**0.122**	**0.120**	**0.145**	**0.237**	**0.315**	**1231**	**779**	**66**	**38**	**854**	**570**	**77**	**67**	**173**	**86**	**16**	**8**	**1955**	**1629**	0.281	0.272
0	**0.098**	**0.120**	**0.122**	**0.148**	**0.263**	**0.320**	**1404**	**871**	**76**	**42**	**890**	**621**	**83**	**67**	**180**	**82**	**18**	**8**	1805	1601	**0.296**	**0.266**
1	**0.095**	**0.117**	**0.122**	**0.146**	**0.244**	**0.316**	**1405**	**824**	**76**	**41**	**877**	**602**	**84**	**68**	**177**	**84**	**19**	**8**	1866	1563	0.276	0.255
2	**0.091**	**0.113**	**0.114**	**0.139**	**0.227**	**0.304**	**1291**	**858**	**71**	**43**	**837**	**613**	**83**	**70**	**179**	**84**	**17**	**9**	**2115**	**1647**	0.275	0.256
3	**0.092**	**0.111**	**0.117**	**0.139**	**0.232**	**0.303**	**1443**	**917**	**83**	**44**	**828**	**606**	**93**	**74**	**183**	**84**	**20**	**9**	**2078**	**1597**	0.259	0.255
4	**0.095**	**0.113**	**0.118**	**0.139**	**0.237**	**0.304**	**1441**	**842**	**80**	**41**	**898**	**554**	**94**	**73**	**186**	**87**	**18**	**8**	**1983**	**1596**	**0.272**	**0.247**
5	**0.090**	**0.112**	**0.116**	**0.139**	**0.232**	**0.304**	**1258**	**795**	**69**	**39**	**871**	**596**	**78**	**65**	**188**	**88**	**18**	**8**	1883	1582	0.237	0.245
6	**0.094**	**0.112**	**0.119**	**0.140**	**0.236**	**0.302**	**1511**	**946**	**84**	**48**	**971**	**671**	**87**	**72**	**189**	**87**	**21**	**10**	1799	1545	0.265	0.266
7	**0.095**	**0.113**	**0.120**	**0.141**	**0.236**	**0.307**	**1310**	**874**	**72**	**45**	842	626	**83**	**70**	**190**	**88**	**17**	**9**	**1938**	**1541**	0.273	0.260
8	**0.097**	**0.117**	**0.122**	**0.146**	**0.240**	**0.313**	**1311**	**869**	**75**	**44**	**848**	**629**	**86**	**69**	**189**	**85**	**17**	**9**	1741	1576	0.286	0.280
9	**0.094**	**0.115**	**0.121**	**0.148**	**0.238**	**0.320**	**1047**	**641**	**58**	**32**	**745**	**455**	**76**	**69**	**188**	**88**	**16**	**7**	1747	1514	0.246	0.235
10	**0.094**	**0.118**	**0.115**	**0.142**	**0.229**	**0.303**	**1299**	**804**	**74**	**40**	**853**	**559**	**82**	**72**	**191**	**89**	**18**	**8**	**1987**	**1557**	0.266	0.264
11	**0.097**	**0.118**	**0.121**	**0.145**	**0.239**	**0.308**	**1547**	**920**	**84**	**46**	**905**	**587**	**94**	**77**	**185**	**89**	**19**	**9**	1839	1588	0.278	0.273
12	**0.095**	**0.116**	**0.118**	**0.144**	**0.235**	**0.305**	**1521**	**889**	**84**	**44**	**987**	**636**	**85**	**71**	**183**	**92**	**20**	**8**	**1975**	**1592**	0.262	0.268
13	**0.092**	**0.116**	**0.119**	**0.142**	**0.242**	**0.309**	**1416**	**730**	**80**	**38**	**978**	**532**	**80**	**72**	**182**	**103**	**20**	**9**	**1718**	**1479**	0.253	0.263
14	**0.095**	**0.117**	**0.119**	**0.147**	**0.236**	**0.311**	**1395**	**852**	**80**	**44**	**968**	**625**	**80**	**70**	**172**	**92**	**18**	**10**	**1932**	**1523**	0.253	0.263
15	**0.096**	**0.119**	**0.120**	**0.146**	**0.241**	**0.308**	**1665**	**974**	**89**	**49**	**1084**	**696**	**81**	**71**	**166**	**95**	**20**	**10**	**1877**	**1550**	0.298	0.276
16	**0.095**	**0.117**	**0.120**	**0.146**	**0.243**	**0.314**	**1429**	**920**	**79**	**48**	**963**	**666**	**79**	**71**	**171**	**96**	**18**	**9**	**1870**	**1541**	0.297	0.279
17	**0.093**	**0.120**	**0.120**	**0.150**	**0.243**	**0.321**	**1232**	**806**	**68**	**43**	**844**	**592**	**79**	**72**	**171**	**94**	**16**	**10**	1853	1549	0.232	0.238
18	**0.095**	**0.122**	**0.119**	**0.152**	**0.242**	**0.318**	**1252**	**790**	**72**	**44**	**896**	**652**	**76**	**67**	**168**	**93**	**17**	**10**	1967	1656	0.275	0.266
19	**0.092**	**0.118**	**0.117**	**0.145**	**0.237**	**0.308**	**1387**	**925**	**81**	**53**	920	723	**87**	**73**	**166**	**93**	**20**	**12**	1987	1623	0.276	0.275
20	**0.095**	**0.120**	**0.120**	**0.150**	**0.242**	**0.314**	1466	1130	**84**	**59**	953	839	**86**	**71**	**178**	**100**	**19**	**11**	**1880**	**1528**	0.301	0.305
All dates	**0.095**	**0.116**	**0.119**	**0.144**	**0.238**	**0.311**	**1356**	**844**	**74**	**43**	**896**	**613**	**82**	**70**	**179**	**88**	**18**	**9**	**1918**	**1604**	0.266	0.258

FIGURE 2.2 Time series average of liquidity and activity measures

The figures show average time series plots of the different liquidity and activity measures. The actual trading days are aligned at t=0. From the figures there seem to be a systematic difference in both liquidity and activity over time between the group of stocks that were fully crossed and those that were not crossed at all. Similar plots of the measures around the separate dates show the same systematic patterns.

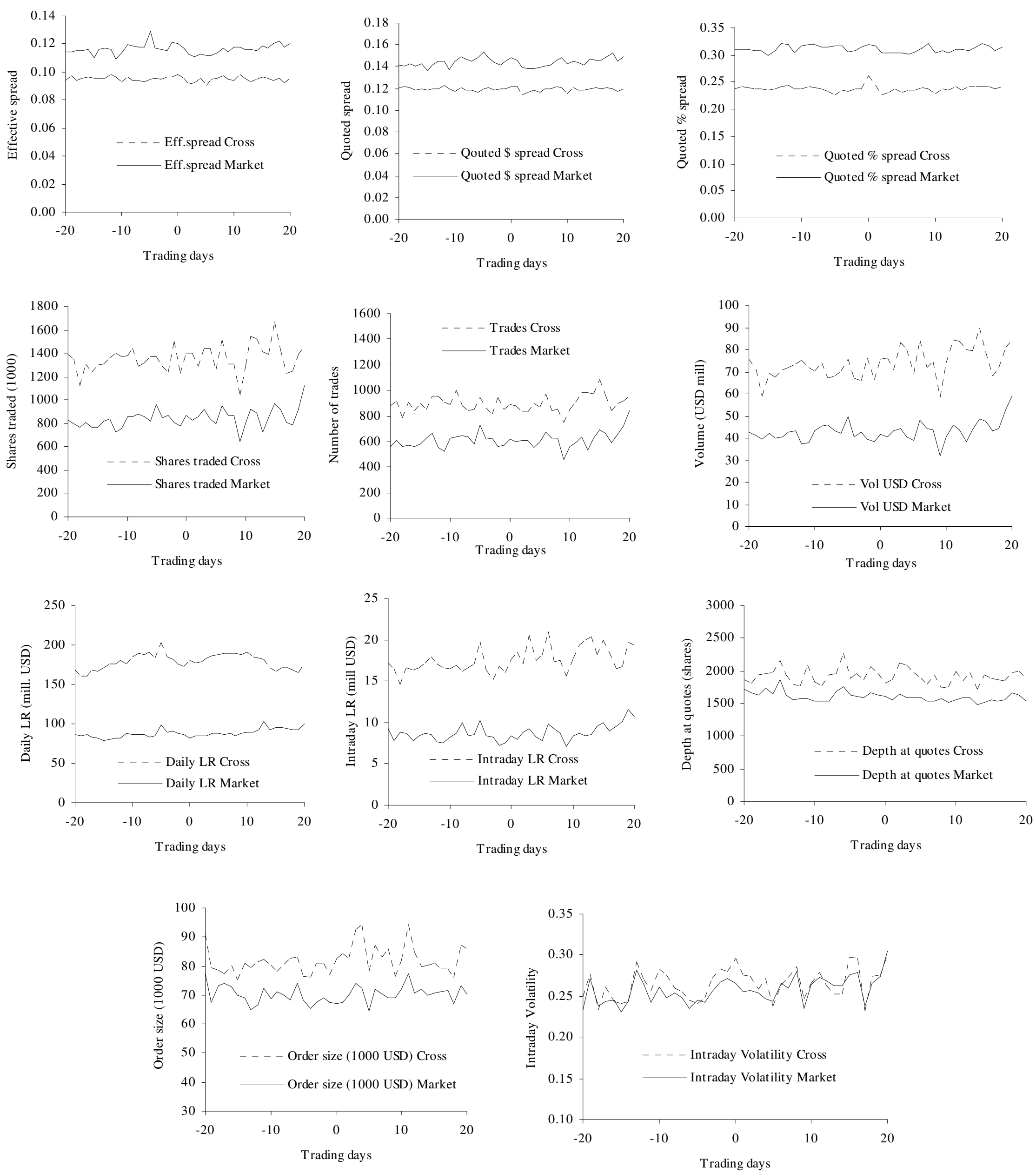


TABLE 2.5
Probit model estimating determinants of probability of a cross

We estimate a probit model of the probability that a given order is successfully crossed. The probability of observing a cross is assumed to be given by the model

$$y = \Pr(\text{cross}) = F(\beta_0 + \beta_1 \text{eff\_spread}_i + \beta_2 \text{depth}_i + \beta_3 \text{LR}_i + \beta_4 \text{volume}_i + \beta_5 \text{vola}_i + \epsilon_i)$$

where $F(\cdot)$ is the cumulative normal distribution function, and the β's are coefficients of the explanatory variables. Explanatory variables include the effective spread ("eff_spread"), the average depth at the inner quotes ("depth"), the intraday liquidity ratio ("LR"), the trading volume measured in USD ("volume"), and the standard deviation of daily returns measured over the last 10 days ("' vola"). The total data set contains 646 transactions, of which 214 were crosses. The intraday liquidity variable is highly correlated with the dollar volume of trading. We therefore use orthogonal versions of these two variables in the regression model. $\frac{dy}{dx}$ is the slope estimates (marginal effects) at the means of the regressors. These estimates predict the effects of changes in one of the explanatory variables on the probability of belonging to a certain trade category.

	coefficient	std deviation	pvalue	dy/dx
β_0: constant	0.0888	0.1887	0.6380	-
β_1: eff_spread	-4.8483	1.4834	0.0010	-1.7173
β_2: depth	-0.0002	0.0314	0.9940	-0.0001
β_3: LR	0.1926	0.0528	0.0000	0.0682
β_4: volume	0.2424	0.5630	0.0000	0.0858
β_5: vola	-1.4638	3.3163	0.6590	-0.5185
n	646			
Wald $\chi^2(5)$	27.94			
Prob $> \chi^2$	0.00			
Log likelihood	-389.08			
pseudo R^2	0.05			
Observed P	0.33			
Predicted P (at means)	0.31			

means of the regressors ($\frac{dy}{dx}$ in table 2.5).[21] These estimates predict the effects of changes in one of the explanatory variables on the probability of belonging to a certain trade category. Note also that our estimation is simplified by the fact that our data only contains buy orders; we need not adjust for the direction of trade.

The estimated probit model in table 2.5 confirms the result in 2.3 that the probability of finding a counterparty in the crossing network is positively related to the liquidity of the stock in the primary market. The probability of a cross is higher the lower the effective spread, the higher the intraday liquidity ratio, and the higher the dollar trading volume in the primary market. This implies that stocks that are easy to cross are also highly traded in the market and have low costs measured by the effective spread.[22]

To sum up, our results indicate that the most liquid and actively traded stocks in the primary market also have the highest probability of being crossed. Our results indicate that both liquidity differences and private information may explain the difference in ex post abnormal return between the crossed and non-crossed stocks found in Næs and Ødegaard (2000). A significant difference in liquidity between the two groups of stocks, also on other dates than the trading dates, may indicate that investors need a higher return to hold the non-crossed stocks. On the other hand, it is hard to believe that liquidity differences between the 500 largest and most liquid companies in the US can explain a difference in abnormal performance between the two group of stocks of 1 percent over 20 days as found in Næs and Ødegaard (2000).

2.4 Limit order simulation

To judge whether trading in the primary market is more expensive than crossing, we need additional information on the costs of obtaining the stocks directly in the market. Since the Fund was trading in the 500 largest and most liquid companies in the US market, it could well be that a strategy of buying them directly in the market would have been less expensive than the crossing strategy followed by the Fund.

In this section, we examine the cost of the opportunistic crossing strategy relative to alternative submission strategies. In addition to a cost comparison, the simulations allow us to obtain a measure of immediacy. This is an important dimension of liquidity which is crucial for transaction costs, and which is not directly captured by the measures used in the previous section.

[21] For non-linear probability models such as the probit and the logit model, we have that the effects of changes in one of the explanatory variables will vary with the value of the regressors.

[22] Market depth and return volatility do not have significant effects on the probability of getting a stock in the crossing network.

2.4.1 Literature

Crossing networks There are two theoretical papers on crossing networks; Hendershott and Mendelson (2000) and Dönges and Heinemann (2001). There is also closely related literature on the ability of multiple competing trading venues to coexist, see for example Chowdhry and Nanda (1991), Easley et al. (1996a) and Seppi (1990).[23]

Hendershott and Mendelson (2000) develop a complex model where different types of heterogenous liquidity traders and informed traders choose between a competitive dealer market and a crossing network. There are two types of informed traders: one type with short-lived information and one type with long-lived information. Short-lived information cannot be exploited in the crossing network, but traders with long-lived information can first try trading in the crossing network and then go to the dealer market if they are not able to cross. Trader strategies are modeled as Nash strategies: each trader chooses his or her best response given her expectation of all other traders' strategies.[24] The model solution consists of multiple equilibria. All equilibria are characterized by three cutoff values that segment liquidity traders into the following four (some possible empty) sets of strategies:

- do not trade,
- trade exclusively on the crossing network,
- trade opportunistically in the crossing network, i.e. attempt to trade in the crossing network, and then go to the dealer market if you cannot get an execution in the crossing network, and
- trade only in the dealer market.

The implications on dealers' spread from the introduction of a crossing network are shown to depend on the types of traders in the market. With *no informed trading*, the negative "cream-skimming" effect dominates the positive effect of attracting new order flow. This is because the crossing network has a negative impact on the dealers' inventory and fixed costs, and because orders going first to the crossing network impose higher costs on the dealer market than those going directly to the dealer market.[25] With *short-lived* information, the low order-submission costs ensure that the introduction of a crossing network will always raise the dealers' spread. This is because the crossing network reduces the order flow from liquidity traders without affecting the order flow

[23] There is an extensive literature on related subjects such as (i) the costs of using electronic communication networks (ECNs) (see Barclay et al. (2001), Barclay and Hendershott (2002), Coppejeans and Domowitz (1999), Domowitz and Steil (1998)), and Hasbrouck and Saar (2001) and (ii) why some traders may want to trade outside the primary market (see Easley et al. (1996a) and Seppi (1990)).

[24] Trading decisions are based on the trader's reservation value, the spread cost, a crossing commission, the probability of getting a cross executed, and an impatience factor.

[25] Order flow sent to the crossing network leaves the dealers with fewer orders to cover the inventory and fixed costs, leading to higher average costs per order.

from informed traders. Under most circumstances, the crossing network will also increase dealer spreads when information is *long-lived*. However, this can be offset if the crossing network manages to attract sufficient new liquidity traders.

The Dönges and Heinemann (2001) model is considerably simpler than the Hendershott and Mendelson (2000) model. Competition for order flow is modeled as a coordination game. The central variable is the value of trading, or, equivalently, the disutility from non-executed orders in the crossing network. Three different settings are analyzed. In the first setting all traders face an identical and certain cost of not getting an order executed in the crossing network. In this case, there are multiple equilibria as in the Hendershott and Mendelson model. In the second setting, all traders face an identical, but unknown cost of non-execution. By introducing private signals on the value of this cost, a unique equilibrium with market consolidation is shown to exist. According to Dønges and Heinemann, assets with low price volatility and large turnovers will be traded at a crossing network, while assets with high volatility or small volumes will be traded at dealer markets. In the third setting, the cost of non-execution is no longer assumed to be common among the traders. In this case, and provided that the disutility from non-execution differs sufficiently, there exists a unique equilibrium with market fragmentation. The two models provide few unambiguous implications. Rather, they form a framework for discussing important questions.

Limit order simulations The probability of non-execution is a central variable for both limit orders and orders submitted to a crossing network, especially for investors who are precommited to trade. Much cited papers on the modeling of execution probability and execution time of limit orders are Angel (1994), Lo et al. (2002), and Hollifield et al. (1999).[26] Angel (1994) derives closed form solutions for the probability of limit order execution when orders arrive according to a Poisson process and prices are discrete. Lo et al. (2002) develop an econometric model of limit order execution times using survival analysis and estimate it using actual limit order data. Hollifield et al. (1999) also develop, estimate, and test an econometric model of a pure limit order market. Their model describes the tradeoff between the limit order price and the probability of execution.

There are also several interesting empirical papers on the use of limit orders. Cho and Nelling (2000) investigate the probability of limit order executions for a selection of stocks at the NYSE. They find that the probability of execution is higher for sell orders than for buy orders, lower when the limit price is farther away from the prevailing quote, lower for larger trades, higher when spreads are wide and higher in periods of

[26]There is also an extensive theoretical literature on the effect of limit orders on the price discovery process as well as the relative profitability of limit orders compared to market orders. Important contributions include Foucault (1999), Glosten (1994), Easley and O'Hara (1992), Parlour (1996), Chakrevarty and Holden (1995), Seppi (1997).

higher volatility. In addition, they find that the longer a limit order is outstanding, the less likely it is to execute, and that limit orders tends to be submitted at the bid-ask midpoint. Examining order flow and limit order submission strategies in a pure limit order market (the Paris Bourse), Biais et al. (1995) find that traders' limit order strategies depend on the market conditions: traders submit more market orders when spreads are narrow and submit more limit orders when spreads are wide, as shown by Angel (1994). Harris and Hasbrouck (1996) compare the performance of limit orders relative to market orders using the TORQ database. They find that limit orders placed at the quotes or further into the market outperform market orders when the spread is larger than the tick size. They therefore argue that limit orders in some cases can reduce execution costs compared to market orders. Handa and Schwartz (1996) approach the problem from a different angle by examining the performance of limit orders versus market orders by "submitting" hypothetical limit orders on the actual price paths of the thirty Dow Jones Industrial firms traded on the NYSE. Since they are using simulations, they can also evaluate the cost of non-executed limit orders. Their main finding is that non-execution costs are positive, but not always significant.

2.4.2 Simulation design

We base our simulations on the strategies followed by the liquidity traders in the Hendershott and Mendelson (2000) model, ignoring the "no trade" category. The first strategy, *opportunistic crossing*, is the actual strategy followed by the Fund. The second strategy, *pure cross*, is the case where the trader only submit orders to the crossing network. In this case, the trader has a low demand for immediacy/liquidity.

The third strategy is the case where the orders are only submitted to the market. Orders submitted to the market can be market orders or limit orders. An uninformed investor such as the Fund would generally prefer the lower costs and lower execution probability associated with limit orders to the immediacy provided by market orders. On the other hand, orders that are worked into the market may help reducing transactions costs. Domowitz (2001) shows that when the trader is "monitoring the book", and thus strategically searching for liquidity and favorable execution possibilities, a market order strategy (working the order) may reduce transaction costs considerably and reduce the price impact cost for large orders. Angel (1997) shows that about 30 percent of the market orders submitted through the SuperDot system experienced a price improvement of about USD 0.04 per share.

The best way to simulate a market order strategy would probably be to set up and estimate a dynamic model that minimizes transaction costs given the stock and market characteristics at the time of submission, such as the order flow, the depth of the limit order book, the volatility etc. The realism of such an ex post optimized strategy would be very hard to judge, however. Moreover, an "in sample" optimized strategy based on data from a limited period of time have restricted interest "out of sample". Due to the obvious difficulties in constructing a market order simulation taking into account the plethora of strategic decisions involved, we restrict our analysis to simulating different limit order strategies. In this way, we get an interesting additional liquidity statistic and a realistic "lower bound" on the implicit execution costs of alternative submission strategies in the primary market.[27]

The closest proxy to a market order strategy in our simulations is a marketable limit order strategy (MLO). A MLO strategy is a limit order strategy that is more aggressive ("in to the market") than an "at the quote" (ATQ) limit order strategy. The main difference between an ATQ and MLO strategy is that the limit price is set at the bid and ask prices respectively. The higher limit price of the MLO strategy increases the execution probability and speed relative to an ATQ strategy. However, this increased immediacy may come at a cost.[28]

Note that both limit orders and crossing orders have a potentially costly adverse selection component. From the buyer's perspective, a limit order is filled when there is adverse price movement and not filled when the stock value increases. Both cases may or may not be due to new information. Similarly, the probability of being a successful buyer in a crossing network increases with the number of investors on the selling side of the market. As for limit orders, if there are informed investors (with long-lived information) in the crossing network, the execution probability of a buy order decreases if the information is positive.[29]

Limit order simulations All limit order submissions are simulated using the same stocks and dates that applied when the Fund first tried to cross the orders. The first limit order simulation (LO1) is identical to the simple simulation strategy in Handa and Schwartz (1996), i.e. we do not take into account the actual order sizes traded by the Fund. In other words, we assume that only one share is traded in each stock. At the beginning of each crossing date, a limit order is submitted with a limit price equal to the opening bid-quote ("at the quote" limit order strategy) for each stock that the Fund tried to cross. If a trade with a price lower than the limit order price is observed during the day, the order is assumed to be filled. If an order is not filled, we assume that it is executed at the opening price the next day. Thus, we implicitly assume an investor

[27] As noted by Lo et al. (2002), there will be a general bias in favor of early execution of simulated limit orders compared to actual limit orders. Moreover, the simulation does not track where in the limit order queue our order is at any point in time, only the price priority. This probably affects the fill rate and execution time of the orders in favor of the simulated orders compared to actual limit order execution.

[28] The cost differential between the two types of strategies may vary over time depending on market conditions. The execution probability of a marketable limit order is likely to be lower in a bear market relative to a bull market.

[29] Næs and Ødegaard (2000) find evidence that the Fund was "crowded out" by informed investors on the same side of the market.

who is pre-committed to trade the stocks. During the transition period, the Fund was tracking an index with a limit on the relative volatility between the transition portfolio and the benchmark. Thus, even though the trades probably could have been worked more carefully into the market the next day, the penalty for unexecuted orders which follow from our assumptions is not completely unrealistic. Because we are ignoring order size, the first limit order simulation constitutes a lower bound on transaction costs.

In the second simulation (LO2), we split the actual order size into suborders. The number and size of the suborders are determined by the average order size traded in the stock at $t-1$. In addition, we have one residual suborder of a smaller size (if necessary). All the suborders are assumed to be submitted sequentially. Thus, at the beginning of the trading day, the first suborder is submitted as an "at the quote" limit order. A suborder is assumed filled if the observed execution price is less than the limit-price without taking into account the size of the suborder. When a suborder is filled, the next suborder is submitted at the bid quote following the fill ("chasing the market"). Unfilled orders are assumed to be executed at the opening price the next day.[30]

The third limit order simulation (LO3) is the most realistic because here we also take into account the size of the suborders. The strategy is similar to LO2 except that we also examine whether the size of the suborder is less than or equal to the size of the actual order executed in the market. A suborder is only assumed filled if the observed execution price is less than the limit price *and* the size is equal to or larger than the size of our order. Due to price priority, our hypothetical order would under most circumstances execute before the observed trade since our order would be the last in the queue at our limit price.

A problem with this type of simulation is that the hypothetical orders most likely would have changed the structure of the market in the stocks if they had actually been submitted. Furthermore, Lo et al. (2002) note than the results from simulations with actual limit-order data underestimate the execution times in a real world trading situation. The execution time for a real limit order is a function of the order size, the limit price and the current market conditions, and a trader would generally vary the order submission strategy based on current and expected market conditions. Such factors are obviously very hard to capture in a simulation approach like ours. On the other hand, we do know the order sizes of the actual strategy and we do take these into account in the LO2 and LO3 simulations, which probably reduces the bias.

Pure crossing simulation A pure crossing strategy is defined as a strategy where the trader only trades in the crossing network. According to Hendershott and Mendelson (2000), the low liquidity preference traders who would follow this type of strategy are most likely to benefit from the existence of a crossing network. To simulate this strategy

[30] The unexecuted orders are assumed submitted to the pre-trade auction without affecting the opening price.

we use the actual price data for the stocks that the Fund was able to cross. For the stocks that the Fund was not able to cross, we assume crossing over the next 10 days. Hence, the opportunity costs are simulated, but the identity of stocks that could not be crossed are not. The choice of a 10-day trading window for calculating the opportunity costs is based on the statistics on order fills in Conrad et al. (2001b): the 95th percent confidence interval for getting an order filled in an external crossing system is reported to be 10 days. Thus, on each crossing date we take the stocks that did not cross and assume that they were crossed over the next 10-day period to the equally weighted close price over the 10-day period.

2.4.3 Measuring trading costs

In order to compare the performance of different submission strategies we must apply a measure of transaction costs. Current empirical academic literature on transaction costs are to a large degree based on versions of a theoretical measure which was first proposed by Treynor (1981) and which Perold (1988) later called the implementation shortfall. The implementation shortfall is defined as the difference in performance between the portfolio of actual trades and a matching paper portfolio in which the stock returns are computed assuming that the trades were executed at the prices prevailing on the date of the decision to trade. In this way, both explicit cost components such as brokers fees, and implicit components such as spread costs, price impact costs, and costs related to delayed or uncompleted trading (opportunity costs) are captured. The approach also overcomes the problem of measuring costs on an individual trade basis when the order consists of a package of sub-trades [31]. Keim and Madhavan (1998) and Conrad et al. (2001b) suggest an empirical version of the implementation shortfall approach:

$$\begin{aligned}\text{total cost} &= \text{explicit cost} + \text{implicit cost} \\ &= \left\{\frac{\text{commission per share}}{P_d}\right\} + \left\{[\alpha\frac{P_a}{P_d} + (1-\alpha)\frac{P_{d+x}}{P_d}] - 1\right\}\end{aligned} \tag{2.2}$$

where P_d is the closing price for the stock on the day before the decision to trade, P_a is the average price for all the executed trades in the order, α is the fill rate, and P_{d+x} is the closing price x number of days after the decision date, i.e. the unfilled portion of an order is assumed settled x days after the decision date.

We use the same measure as in Conrad et al. (2001b), except that we assume that the non-crossed orders in the pure crossing strategy are settled at the average of the closing prices over the x days after the decision date. In addition, since we cannot easily get good estimates for the explicit costs related to the trades that we simulate, the cost

[31] Much of the relevant research on the measurement of transaction costs is summarized in Keim and Madhavan (1998)

comparison is made on the basis of implicit costs only. Thus, our cost comparison is *not* based on total execution costs. A more serious problem is related to the limited number of trading days in our data set. The implicit cost estimate is intended to account for the price impact of orders. However, the price difference between $\mathsf{P_a}$ and $\mathsf{P_d}$ will also be affected by general market movements between the two observation times. Essentially, the measure assumes that the main source of price impact is our order. When we look at averages for trades on many different dates, this is not a big problem, because the market movement will tend to wash out in the average[32]. However, if we look at trades concentrated on a few dates, the general market movements at these dates will affect the measured costs. As we shall see, this is a particular problem for the market orders in our data set because they are concentrated on only three days.

Empirical studies document that the magnitude of different cost components vary with factors such as order size, intraday timing of the trade, stock liquidity, market design and investment style. Hence, to measure costs properly, detailed data on the entire order submission process is required. For the actual submission strategy followed by the Fund, we have access to such data. For the simulated strategies, however, the results will necessarily be driven to some extent by our own assumptions.

2.4.4 Results

For the orders that were executed on the day following the initial attempt at internal crossing, the total cost should be decomposed into one component associated with the delay of the order in the internal crossing network, and one component associated with the final execution in an external crossing network or in the primary market. Table 2.6 decompose the implicit costs for the Fund's order submission strategy into these two components.

Including the delay costs, the average implicit cost for all crossed orders was 0.11 percent, and the average implicit cost for all market orders was -0.74 percent. This implies an average implicit cost for all orders of -0.03. Some care should be taken when interpreting the negative implicit costs for the market orders. Because the orders purchased in the primary market are concentrated on three trading days only, the cost estimates are quite sensitive to the market movements on these days. Ignoring the delay component, the average implicit cost for all market orders was about 0.25 percent. The Fund incurred delay costs for market orders on one occasion. The market went markedly down on this day, leaving the Fund with an implicit delay cost for the non-crossed orders of -1.79 percent. Because the non-crossed orders had to be bought in the market on the following day, an average additional cost of 0.48 percent was incurred, giving a total implementation shortfall cost of -1.31 percent.

[32] Keim and Madhavan (1997) show that the average daily return on stocks is small compared to the price impact from a trade.

Measured over some time, the daily market movements are small compared to the price impact costs, as shown in Keim and Madhavan (1997). Hence, for large samples, adjusting for daily market returns does not make much difference. However, in our case, the cost measure is likely to be largely driven by the market movement. Keim and Madhavan (1997) argue that one should *not* try to adjust for market movements because they are a part of the timing cost for the order submission strategy. If so, the average implicit cost associated with the delay of orders in the private internal crossing network of -0.121 percent should be interpreted as a negative timing cost. On the other hand, the fact that the drop in market values on one of the trading days was large enough to have a significant effect on the total implementation shortfall cost of the actual strategy, suggests that the true costs of opportunistic crossing may be underestimated.

What the discussion above highlights most of all is that cost measures based on the implementation shortfall over a few days should be interpreted with great caution. Due to the non-synchronous nature of the Fund's market trades relative to the close-to-close returns on the SP 500 index, a correct adjustment for the market movement would involve the actual timing of the trades during the day as well as the intraday SP 500 returns. None of which are easily obtainable. What we want is to set up a horse race between the opportunistic crossing strategy and certain alternative order submission strategies. If the alternative strategies cannot beat the strategy when the negative delay costs are excluded, they surely cannot beat the strategy when these costs are included. In Table 2.7, we have therefore compared the estimated execution costs for the simulated strategies with the actual average execution costs *excluding* the delay costs.[33] That is, all cost estimates in the table are in percent of the closing price on the day before the trade.[34]

Examining the execution costs for the simulated strategies in table 2.7, we find that neither the pure crossing strategy nor the two first limit order strategies (LO1 and LO2) have significantly different execution costs from the opportunistic crossing strategy. Thus, not even the most simplistic and unrealistic limit order simulation (LO1), which constitute our "lower bound" on primary market execution costs, is able to significantly beat the opportunistic crossing strategy. The most realistic limit order strategy (LO3) is significantly more expensive than the opportunistic crossing strategy, with costs of about 0.24 percent. In addition, we have not taken into account that the explicit costs in crossing networks are lower than in the primary market. Hence, the total execution costs would overwhelmingly favor the opportunistic crossing strategy, or potentially the pure crossing strategy.

[33] What we ignore, however, is that the high volatility in the market at this particular day may have affected the outcome with respect to what stocks we were able to achieve in the crossing networks, as suggested in Domowitz (2001).

[34] Næs and Ødegaard (2000) also estimate the explicit costs for the Fund's strategy. The equally weighted average explicit costs for all orders were 3 percent. For the crossed orders and the non-crossed orders, the explicit costs were 3 percent and 5 percent respectively.

Table 2.6

Decomposition of the implicit costs for the opportunistic crossing strategy

Estimates of the average implicit costs for the opportunistic crossing strategy are decomposed into (i) the average implicit cost *excluding* the costs associated with the delay of orders, (ii) the average delay cost, and (iii) the average implicit cost *including* the delay cost, i.e. the average implicit implementation shortfall cost. The two last columns show respectively the number of trading days and the number of stocks traded for each type of orders.

Average implicit costs	Costs ex delay	Delay costs	Impl. shortfall	Days	Stocks
All orders	0.088	-0.121	-0.033	16	4 517
Crossed orders	0.055	0.056	0.111	15	3 767
Non-crossed orders	0.254	-0.998	-0.744	3	750
Delayed orders:					
All delayed orders	0.018	-0.620	-0.603	3	865
Delayed crossed orders	-0.415	0.465	0.049	2	447
Delayed non-crossed orders	0.483	-1.787	-1.304	1	418

Table 2.7

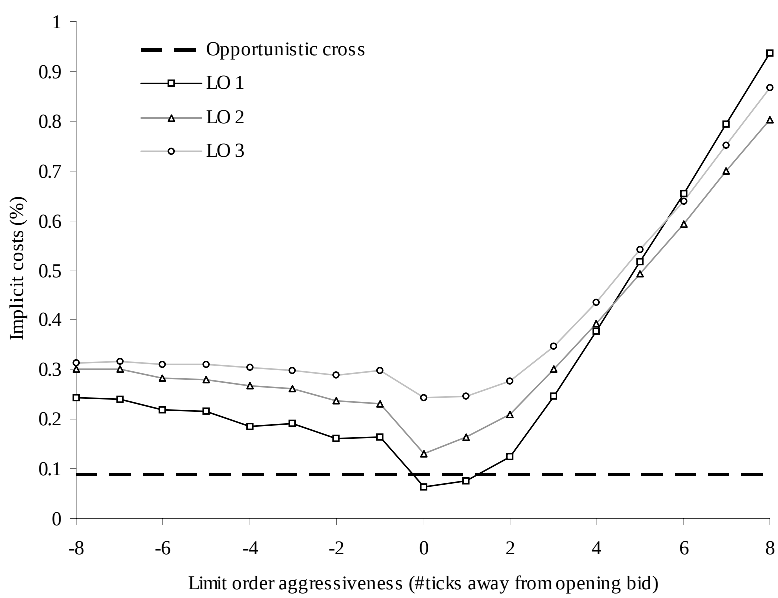
Estimates of implicit costs for different trading strategies - pre-trade benchmark

The table shows the execution cost estimates for four alternative submission strategies in addition to the original strategy (*Opportunistic Cross*). The estimates are based on the implementation shortfall methodology. The second strategy in the table, *Pure cross*, is the result of a hypothetical strategy where we assume that the entire residual order would have been crossed in equal amounts over the 10 days after the decision to trade. We split the non-crossed part of the order into 10 equal orders, each one of which is assumed crossed at the closing price each of the 10 days. The three last strategies in the table show the implicit cost estimates for the three submission strategies in the primary market. The first limit order strategy (LO1) is the most passive strategy which assumes that limit orders are submitted at the opening bid ("At-the-quote" limit order strategy), ignoring order sizes (no sub orders) as in Handa and Schwartz (1996). Whenever we observe a trade at our limit price or better, we assume the entire order is filled at that price. The second limit order strategy (LO2) assumes that limit orders are submitted sequentially at the prevailing bid following the filling of a suborder ("chasing the market"). However, in this case we ignore the size of each suborder. The third limit order strategy (LO3) is the most realistic strategy where all limit orders (also suborders) are submitted sequentially at the prevailing bid following the filling of a suborder as for LO2, but this simulation also takes the size of each suborder into account when evaluating the fill. If we observe a trade that is larger or equal in size to our order, we assume that our order would have been filled at that price. If there is a fill, the next suborder is submitted at the following bid. For all strategies, we assume that the remaining/unfilled part of an order is bought at the opening price the next day. Numbers in bold are estimates that are significantly different from zero at the 1% level. For each strategy and original group of stocks, tests of difference in means between the original submission strategy and the respective strategies are performed where ** indicates a significant difference in implicit costs at the 1% level.

Implicit costs	Opport. Cross	Pure Cross	LO 1	LO 2	LO 3
EW					
All orders	**0.0879**	**0.1443**	**0.0626**	**0.1303**	**0.2435****
Crossed orders	0.0553	0.0553	-0.0147**	**0.0520**	**0.1729****
Non-crossed orders	**0.2536**	**0.5867**	**0.4317****	**0.5048****	**0.6143****
VW					
All orders	0.2028	0.2534	0.0836	0.2849	0.3885
Crossed orders	0.1837	0.1837	0.0141	0.2007	0.3025
Non-crossed orders	0.3101	0.5867	0.4298	0.6615	0.7892

An additional choice variable for an investor is the aggressiveness of the limit order. In figure 2.3, we have plotted the implicit costs for the three limit order strategies LO1, LO2 and LO3 assuming more or less aggressive limit prices. In addition, the figure includes the implicit cost (ex delay costs) of the opportunistic crossing strategy (straight line across all aggressiveness levels). The ATQ limit order strategy is at 0 on the x-axis (indicating that the limit price is 0 ticks away from the opening bid). The MLO strategy is located between 1 to 3 ticks away from the bid, depending on the spread and tick sizes of the different stocks at the time of submission. An interesting observation in figure 2.3 is that the LO1 line forms a lower bound on execution costs. In addition, we see that the implicit costs across all strategies and aggressiveness levels reaches a minimum around 0 and 1 ticks away from the opening bid. This is in line with the results in Harris and Hasbrouck (1996), that limit orders generally are cheaper than market orders. More specifically, they find that when the spread is larger than one tick, limit orders placed in the market (improving the best bid or ask) perform better with respect to costs. Furthermore, Cho and Nelling (2000) show that the majority of limit orders are in fact submitted at the bid-ask midpoint.

FIGURE 2.3 Limit order simulation for varying aggressiveness levels.
The figure shows the implicit costs of the three types of limit order simulations we perform (LO1, LO2 and LO3) for varying aggressiveness levels, where aggressiveness is measured in ticks relative to the "at the quote" limit order strategy. A limit order aggressiveness of 0 indicates that the limit order price is set at the opening bid price. An aggressiveness larger (lower) than 0 means that the limit order price is set x number of ticks higher (lower) than the opening bid price. The horizontal line shows the implicit cost of the opportunistic crossing strategy excluding delay costs.



By looking more carefully at the crossed/non-crossed groups, we find that the non-crossed stocks have the highest execution costs regardless of submission strategy. In the previous section, we found that stocks that are not supplied in the crossing network are less liquid than stocks that are easily crossed. The higher execution costs for these stocks support this finding: these stocks are also the most difficult to fill in the primary market. Note also that the opportunity costs constitute a large part of the execution costs for orders in these less liquid stocks. Since unfilled limit orders generally are for stocks that rise in value, these orders are penalized by the execution at the opening price the next day. This result, together with the high costs found for the pure crossing strategy, supports the finding in Næs and Ødegaard (2000) that the stocks bought in the market had a high ex post return.

Overall, our results strongly favor the opportunistic crossing strategy as a cost-effective submission strategy, especially when the difference in explicit costs between the crossing network and primary market is taken into account. Furthermore, it is important to recognize that the orders examined here are for the most liquid and largest companies in the US. Thus, even the stocks with the potentially lowest execution costs in the primary market would have been cheaper to obtain in the crossing network.

In table 2.8, we have calculated the fill rates for all orders in panel (a), and the fill rates across groups of orders in panel (b). The execution times (in minutes since open) for the simulated strategies are shown in panel (c). As expected, the fill rate decreases and the execution time increases as we impose more restrictions on the limit order strategy. It is interesting to note that the fill rates across groups of stocks in panel (b) are higher for the non-crossed orders than for the crossed orders. Thus, even though the fill rate is higher for the non-crossed stocks, the execution costs are higher. This indicates that the stocks in the non-crossed group that were not filled in the limit order simulation had a very high opportunity cost. This result provides further support to the information hypothesis in Næs and Ødegaard (2000).

2.5 Conclusion

In this paper, we use data from an actual order submission strategy using crossing networks to investigate execution costs and primary market liquidity. The data includes all orders from the establishment of a US equity portfolio worth USD 1.76 billion in the period from January 1998 to June 1998. The investor in our study was following an "opportunistic" crossing strategy, meaning that an attempt was made to cross all stock orders initially, and residual orders were purchased in the open market. Because we know the identity of stocks and timing of stock orders that failed to be executed in the crossed network, we can investigate whether stocks that are supplied in crossing networks and stocks that can only be traded in the market have systematically different characteristics.

TABLE 2.8

Fill rates and order execution time for different trading strategies

Panel (a) shows the fill rates for the different strategies with respect to the total number of shares and the number of orders filled. Panel (b) shows the fill rates across the groups of crossed/non-crossed stocks. Panel (c) shows the average execution time (in minutes) for the entire strategy with respect to the opening time of the market (minutes since open). The numbers in parenthesis are the average execution time of the orders (minutes since submission). For the opportunistic and pure crossing strategies these numbers are ignored since they are over several days. For LO1, the measure of "minutes since open" and "minutes since submission" is equal because only one order is submitted for each stock.

(a) Fill rates for submission strategies

	Opport. Cross	Pure Cross	LO1	LO2	LO3
Orders					
Filled (%)	83.2%	100.0%	85.6%	71.9%	65.1%
Not filled (%)	16.8%	0.0%	14.4%	28.1%	34.9%
Submitted orders	3909	3909	3909	11864	11289
Filled orders	3316	3909	3346	8528	7347
Unfilled orders	594	0	563	3336	3942
Shares					
Filled (%)	84.8%	100.0%	88.5%	49.7%	42.5%
Not filled (%)	15.2%	0.0%	11.5%	50.3%	57.5%
Shares in submitted orders	26776710	26776710	26776710	26776710	26776710
Shares in filled orders	22714683	26776710	23693158	13303893	11372729
Shares in unfilled orders	4070060	0	3083552	13472817	15403981

(b) Fill rates across groups

	Opport. Cross	Pure Cross	LO1	LO2	LO3
Orders					
Cross group:					
Filled (%)	83.2%	100.0%	84.8%	70.9%	64.0%
Not filled (%)	16.8%	0.0%	15.2%	29.1%	36.0%
Non-crossed group:					
Filled (%)	100%	-	89.7%	76.3%	70.2%
Not filled (%)	0	-	10.3%	23.7%	29.9%
Shares					
Cross group:					
Filled (%)	84.8%	100.0%	88.1%	48.9%	41.5%
Not filled (%)	15.2%	0.0%	11.9%	51.1%	58.5%
Non-crossed group:					
Filled (%)	100%	-	90.5%	53.6%	47.7%
Not-filled (%)	0	-	9.6%	46.4%	52.3%

(c) Execution time (minutes)

	Opport. Cross	Pure Cross	LO1	LO2	LO3
Mean	-	-	30 (30)	42 (22)	71 (38)
Median	-	-	7 (7)	9 (5)	24 (10)
Minimum	-	-	0 (0)	0 (0)	0 (0)
Maximum	-	-	389 (389)	390 (390)	390 (390)
First quartile	-	-	3 (3)	4 (1)	7 (1)
Third quartile	-	-	19 (19)	31 (14)	80 (34)
Standard deviation	-	-	67 (67)	80 (56)	102 (73)

In addition, the costs of alternative, more traditional, submission strategies can be estimated and compared.

By calculating several measures of liquidity for the different groups of stocks in the data set, we show that there are significant differences in liquidity between stocks that are crossed and stocks that have to be bought in the market. For one trading date, spreads were significantly different even though the trading volume in the two groups of stocks was similar. According to the market microstructure literature, this might be an indication of informed trading in the stocks that could not be executed in the crossing network, a result which is also suggested in Næs and Ødegaard (2000). We also find, however, that there are systematic differences in liquidity between the two groups of stocks on other dates than the trading dates of the actual crossing strategy. This result suggests that there are systematic differences in the characteristics of the two groups of stocks that are not related to private information.

To evaluate the performance of the actual crossing strategy against other submission strategies, we perform limit order simulations on transactions data from the NYSE. The simulations can also be viewed as an additional measure of trading difficulty. The non-crossed orders turn out to be significantly more expensive than the crossed orders across all simulations. Hence, the stocks that the Fund could not get in the crossing network would also have been the most difficult to buy in the market. We also show that it would have been very hard to beat the actual opportunistic crossing strategy. The only simulation which gives us a lower implicit cost estimate is when we completely ignore the size of our orders. However, the explicit cost differential between the crossing network and regular market would probably even this difference out. Finally, it should be stressed that the significant differences found in crossing probability, liquidity and primary market execution costs are for the 500 largest and most liquid stocks in the US market.

2.A Data issues and variable description

Calculation of liquidity and activity measures

To calculate the liquidity statistics in the primary market for all securities traded by the fund we use the TAQ database (NYSE Trades and Quotes database). However, before we perform the calculations, the data has to be filtered to remove erroneous records both in the quotes file and the trades file.

Data issues and filtering

Quotes data
All the spread measures are calculated with respect to the inside quotes (best bid and ask) reported in the TAQ database between 9:30 and 16:00. There are several filters applied to "clean" the data. We mainly use the quote conditions (MODES) in the TAQ data[35] to do this. An observation is removed if one of the following conditions applies;

- **Closing quote** The last quote from a participant during the trading day (Mode=3)
- **News dissemination** A regulatory halt when price sensitive news arrives (Mode=4)
- **Fast trading** Indicating that there is extreme activity (quotes are entered on a "best efforts" basis) making the time stamps unreliable (Mode=5)
- **Order imbalance** A non-regulatory trading halt due to large order imbalances (Mode=7)
- **Non-firm quote** A regulatory halt when the Exchange is unable to collect, process and disseminate quotes that accurately reflect market conditions (Mode=9)
- **News pending** A regulatory trading halt or delayed opening due to an expected news announcement (Mode=11)
- **Trading halt due to related security** A non-regulatory halt used when there is news related to one security which will affect the trading and price in another security (Mode=13)

In addition we remove quotes where the bid price is larger than the ask price, quotes are negative, or the average quoted spread is zero over the trading day. Also quotes with a price higher than USD 10,000 are removed both due to possible errors as well as to remove securities with extreme prices which could affect our statistics. Lastly, when quotes from several different exchanges are reported at the same time (down to

[35] A more detailed description can be found in the TAQ User Guide which can be downloaded from the NYSE homepage at http://www.nyse.com/marketinfo/marketinfo.html

the second), we use the lowest ask or highest bid among these as a proxy for the NBBO (National Best Bid and Offer).

Trades data

The trades reported in TAQ may contain corrections and errors. If so, the record has a *Correction Indicator* (Corr) attached to it. The requirement is that a trade must have a correction value less than 2 (Corr < 2). If Corr=0, then the trade record is a regular trade that was not corrected, changed, cancelled or was erroneous. If Corr=1, then the observation was later corrected, but the record contains the original time and the corrected data for the trade. If Corr > 2, then the record is either out of time sequence, cancelled due to error or cancelled due to wrong timestamp. Thus, we remove all records with Corr ≥ 2.

There are also *Sale Conditions* (Corr) connected to each trade. We apply a filter removing records with conditions that make the timing and reliability of the records questionable. A record is removed if one of the following conditions applies;

- **Bunched sold** A bunched trade not reported within 90 seconds of execution (Cond=G)
- **Sold last** A trade reported later than the actual transaction time (Cond=L)
- **Opened last** An opening trade with delayed reporting (Cond=O)
- **Sellers option** Delivery date is between 2 and 60 days after the trade (Cond=R)
- **Pre- and Post-Market Close Trades** A trade that occurred within the current trading day, but is executed outside of the current market hours (Cond=T)
- **Sold sale** A transaction that is reported to the tape at a time later than it occurred and when other trades occurred between the time of the transaction and its report time (Cond=Z)
- **Crossing session** NYSE Crossing Session matches (Cond=8 and 9)

After the filtering is performed, we use the remaining quotes and trades to calculate the following liquidity and activity measures.

Spread measures

Effective spread

The effective spread takes into account the transaction prices (and accounts for the fact that many trades are executed within the quoted spread due to price improvement). The number of trades in the security, i, on date, t, is denoted by $N_{i,t}$. The index τ

defines the time of the day when a trade is observed, $P_{i,\tau}$ is the trade price, and $bid_{i,\tau}$ and $ask_{i,\tau}$ is the bid and ask, respectively, at the time of the trade. The first valid trade is normalized to $\tau = 1$. Then, for security i on date t, the average effective spread is calculated as,

$$ES_{i,t} = \frac{1}{N_{i,t}} \sum_{\tau=1}^{N_{i,t}} \left\{ 2 \mid P_{i,\tau} - \frac{ask_{i,\tau} + bid_{i,\tau}}{2} \mid \right\}$$

The effective spread takes into account the relationship between execution price and quoted spread, and is often considered a more appropriate measure of trading costs than quoted spreads, especially for large trades.

Quoted dollar spread

The average quoted dollar spread is defined as the average difference between the inside quoted ask and bid for a firm over the trading day. The quoted dollar spread is calculated with respect to each trade observed at time τ. The inner ask and bid is defined as $ask_{i,\tau}$ and $bid_{i,\tau}$ respectively, and $N_{i,t}$ is the total number of trades in security i during the trading day t. Thus, the quoted dollar spread is calculated as,

$$QS_{i,t} = \frac{1}{N_{i,t}} \sum_{\tau=1}^{N_{i,t}} (ask_{i,\tau} - bid_{i,\tau})$$

Quoted percentage spread

The quoted percentage spread calculates the absolute spread relative to the spread midpoint at each valid trade record τ. Thus,

$$RS_{i,t} = \frac{1}{N_{i,t}} \sum_{\tau}^{N_{i,t}} \left\{ \frac{ask_{i,\tau} - bid_{i,\tau}}{(ask_{i,\tau} + bid_{i,\tau})/2} \right\}$$

Volume and depth measures

It is widely argued that spreads should not be examined in isolation when using it as a liquidity measure. This is because liquidity shocks both widen spreads as well as reduce depths. Furthermore, spreads may also widen as a response to adverse selection without liquidity necessarily decreasing. Therefore, we also look at volume and depth measures.

Trading Volume (Shares)

The total number of shares traded in security i during day t.

$$\mathsf{VOL\_shares}_{i,t} = \sum_{\tau=1}^{N_{i,t}} Q_{i,\tau}$$

Trading volume (USD)
The total dollar value of trades during day t in security i.

$$\mathsf{VOL\_USD}_{i,t} = \sum_{\tau=1}^{N_{i,t}} Q_{i,\tau} \cdot P_{i,\tau}$$

Trades
The total number of trades during day t in security i.

$$\mathsf{Trades}_{i,t} = \sum_{\tau=1}^{N_{i,t}} \tau_i$$

Trade size
The average trade size in USD 1000 on day t in security i.

$$\mathsf{Trade\_size}_{i,t} = \frac{\mathsf{VOL\_USD}_{i,t}}{\mathsf{Trades}_{i,t} \cdot 1000}$$

Quoted depth
The quoted depth is calculated as average of the quoted bid and ask depths during the day t in security i,

$$\mathsf{QD}_{i,t} = (\bar{q}_{i,t}^{bid} + \bar{q}_{i,t}^{ask})/2$$

where $\bar{q}_{i,t}^{bid}$ and $\bar{q}_{i,t}^{ask}$ is the average depth on the bid- and the ask-side respectively in security i on day t.

Liquidity ratios and volatility measures

Daily Liquidity Ratio
The Amivest Liquidity Ratio is one type of liquidity measurement which represents the dollar value of trading associated with a one percent change in the share price. The liquidity ratio measures the average trading volume necessary to move the price by one percent during a trading day. We calculate the average daily liquidity ratio over the 10-day period prior to the Fund's trading date, t_0. The daily liquidity ratio for security

i on date t is thus calculated as,

$$LR(D)_{i,t} = \frac{1}{10} \sum_{t=t_0-11}^{t_0-1} \frac{VOL\_USD_{i,t}}{|\%r_{i,t}|}/1000$$

where $|\%r_{i,t}|$ is the absolute "midpoint return" over day t calculated using the bid-ask midpoints at opening and closing to avoid biases with respect to the bid-ask bounce. $VOL\_USD_{i,t}$ is the total USD trading volume in security i on date t.

Intraday Liquidity Ratio

To measure liquidity on one date, we also calculate the liquidity ratio using intraday data. To do this, we first discretisize the data to get a common time frame. Consistent with several other studies we use 15-minute windows, starting from 9:30am until 16:00pm. Thus, we have 26 15-minute intervals during each trading day. During each interval, denoted by ω, we calculate the midpoint returns using the bid-ask midpoint price at the beginning (or closest to the beginning) of each window. Thus, $\omega \in [1, 26]$, and the average ratio for security i on date t is calculated as,

$$LR(I)_{i,t} = \frac{1}{26} \sum_{\omega=1}^{26} \frac{VOL\_USD_{i,\omega}}{|\%r_{i,\omega}|}/1000$$

where $VOL\_USD_{i,\omega}$ is the total USD volume traded in security i in window ω, and $|\%r_{i,\omega}|$ is the 15-minute absolute midpoint return over window ω. Generally, the liquidity ratio measure assumes that there is a linear relationship between the trade size and price change which is not necessarily the case. In addition, the ratio is positively correlated with the general price trend in the market and negatively correlated with volatility.

Average 10-day volatility

Calculates the 10-day average volatility prior to the actual trading date (t_0) as,

$$V(D)_{i,t} = \sqrt{\frac{1}{10} \sum_{t=t_0-11}^{t_0-1} (r_{i,t} - \bar{r}_i)^2}$$

where $r_{i,t}$ is the return on day t and $\bar{r}_i$ is the average return over the 10-day period prior to the actual crossing date.

Intraday volatility

When calculating intraday volatility, we use the same discretization as for the intraday liquidity ratio calculations described above. Thus, we calculate the volatility of 15-minute returns over the trading day, using the bid-ask midpoint price at the beginning of each window, such that,

$$V(ID)_{i,t} = \sqrt{\frac{1}{26}\sum_{\omega=1}^{26}(r_{i,\omega} - \bar{r}_{i,t})^2}$$

where $r_{i,\omega}$ is the midpoint return over 15-minute window ω, and $\bar{r}_{i,t}$ is the average return over all windows during trading day t in security i.

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Chapter 3

Order Book Characteristics and the Volume-Volatility Relation: Empirical Evidence from a Limit Order Market

Written with Randi Næs

Abstract

We examine empirically the relationship between the demand and supply schedules in a limit order book and the volume volatility relation. Several empirical studies find support for the hypothesis that the volume-volatility relation is driven by the arrival rate of new information, proxied by the number of transactions. Our results show that the number of trades and the price volatility are also related to the slope of the order book. One possible interpretation for this finding is that the slope of the book is proxying for dispersed beliefs among investors. If so, this would support models where investor heterogeneity intensifies the volume-volatility relation.

3.1 Introduction

In this paper, we examine empirically the relationship between the demand and supply schedules in a limit order book and the volume volatility relation.

A variety of studies document that there is a positive correlation between price volatility and trading volume for most types of financial contracts including stocks, Treasury bills, currencies and various futures contracts. The main theoretical explanation for this phenomenon is that new information about asset values acts as the driving force (or mixing variable) for both market prices and trading volume. Harris (1986) links this "mixture of distributions hypothesis" to asset pricing theory, and suggests that the mixing variable is the process that directs the rate of flow of information from systematic risk factors into prices and trading volume. However, for many types of financial contracts, movements in prices seem much "too large" to be attributed to movements in the fundamental values of the underlying securities.[1] A suggested explanation for this puzzle is that prices do not change merely because of changes in systematic risk factors and asset payoffs but also because investors have dispersed beliefs about asset values. This dispersion may be due to asymmetric information or to differences of opinion about symmetric information. In any case, theoretical models by Shalen (1993) (asymmetric information) and Harris and Raviv (1993) (symmetric information) show that dispersion of beliefs will intensify the volume-volatility relation, by increasing both trading volume and volatility.

The theoretical explanations for the volume-volatility relation are hard to test. The essence of the mixture of distributions hypothesis is that prices adjust to new equilibria over time as new information is being reflected through trades. Since the arrival rate of information is unobservable, it is difficult to set up an alternative hypothesis. Several empirical studies find support for the explanation under the assumption that the arrival rate of information can be proxied by the daily number of transactions.[2] Since the daily number of transactions may be driven by factors other than new information, these studies do not rule out the other explanations for the volume-volatility relation. Specifying data implications from the models with dispersed beliefs is also very challenging. Daigler and Wiley (1999) perform an indirect test of Shalen (1993)'s model and find evidence that uninformed traders contribute to price volatility. Ghysels and Juergens (2001) measure dispersion of beliefs directly by dispersion of analysts' earnings forecasts. They also find that dispersion is positively related to volatility.

The objective of this paper is to broaden our knowledge about the volume-volatility relation in an electronic limit order market. Since the demand and supply schedules in a limit order book represent the reservation prices of the liquidity suppliers in the market, it is interesting to study whether the book contains additional information about the

[1] A standard reference for the stock market is Shiller (1981).

[2] See Harris (1987) and Jones et al. (1994)

volume-volatility relation. We have access to exceptionally rich transactions data from the Norwegian equity market in the period from February 1999 through June 2001. The market operates as a fully automated limit order-driven trading system, and our data sample enables us to rebuild the full order book at any point in time. We are not aware of anyone who has investigated this issue with a data set as rich as ours.

Several papers investigating order book data are relevant for our work. Biais et al. (1995) analyze in detail the interaction between the order book and order flow on the Paris Bourse. One relevant finding is that the status of the order book is important for order flows and trading volume. Biais et al. (1995) only have data on the cumulative trading interest near the inner quotes. We show that the whole order book contains additional, interesting information. Goldstein and Kavajecz (2000) provide evidence of a negative relation between the shape of the order book and volatility during a case of an extreme market movement. However, they do not attempt to investigate this relation over a longer time period with varying trading conditions. Our data set spans a relatively long period which included the boom and burst of the internet bubble. Kalay et al. (2003) estimate the demand and supply elasticities for stocks on the Tel Aviv Stock Exchange. Their main findings are that the order book is more elastic at the beginning of the day, and that the demand side is more elastic than the bid side.[3] Kalay et al. (2003) only have data for order placements at the opening of the market. Our estimates of supply and demand schedules are also based on the continuous trading session.

We first establish that the standard volume-volatility relation exists in a limit order market, and investigate in detail the composition of the order book at the intra-day level. This exercise documents that the trading structure on the Norwegian Stock Exchange exhibits the same features as are found in empirical studies of other countries' stock markets. The features suggest that: informational asymmetries are more pronounced at the beginning of the trading day, there is competition among informed traders, and uninformed traders require a compensation for the higher pick-off risk at the beginning of the day.[4] These results are systematic across sub-periods, firm sizes, and tick-sizes.

The main contribution of our study is that we are able to document several relationships between the volume-volatility relation and the shape of the order book. We measure the order book shape by the average elasticity of the supply and demand schedules in the book. The lower the elasticity (steeper the slope), the less dispersed are the bid and ask prices in the order book.[5] To examine the effects of the order book slope on

[3]The first result is interpreted as supportive to sequential trading models with asymmetric information which predict higher adverse selection at the opening (Glosten and Milgrom, 1985). The second result is interpreted as supportive to the empirical finding that buy orders have larger price impacts than sell orders.

[4]Our results are in accordance with the results in Kalay et al. (2003) as well as with the results in several studies of time-of-day effects in spreads and price impacts, for example French and Roll (1986), Harris (1986), and Niemeyer and Sandas (1995).

[5]This is in the case of direct demand and supply curves (prices on the x-axis and accumulated volume

volume and volatility, we first include the slope measure as an independent variable in a cross sectional time series version of the standard regression model used to document the volume-volatility relation. To investigate the relationship between the slope of the book and the trading activity, we estimate a cross-sectional time series regression with the number of trades as the dependent variable. A systematic negative relation between the average slope of the order book and the price volatility is documented in a daily time series cross-sectional analysis. These results are also shown to be robust to the choice of time period. Similarly, we find a significant and robust negative relationship between our slope measure and the daily number of trades.

If the slope of the book is essentially a liquidity measure, most of the information contained in the slope should be reflected by the volume close to the inner quotes. To check this, we calculate the slope measure based on different fractions of the order book and re-estimate all the regression models. When we investigate the relation between different slope measures and trading activity, an interesting pattern emerges. In line with the findings in Biais et al. (1995) that thick books at the inner quotes result in trades, we find a significant *positive* relationship between the slope of the book and the number of trades when the slope is calculated based on the volume at the inner quotes. This result is the opposite of what we get when we use a slope measure based on the full order book. Thus, the slope of the book provides different information depending on what fraction of the book we use in the calculation.

A possible interesting interpretation of the full order book slope is related to the dispersion of beliefs hypothesis. Harris (1987) notes that, if trades are self generating, the number of daily transactions will be the true mixing variable rather than a proxy for the arrival rate of new information. It could be that the slope of the limit order book capture dispersion of beliefs about asset values, i.e. steep slopes of the supply and demand schedules indicate that there is a high degree of agreement among investors about the fair value of the security, while gentle slopes indicate that there is greater disagreement among investors about the value of the security. If so, our finding that there is increased trading activity when slopes are more gentle (greater disagreement about valuation) could reflect a situation of self generating trades, i.e. that the volume-volatility relation is not merely driven by new information. This interpretation would be in line with models where heterogeneity among investors contributes to the volume-volatility relation.

On the other hand, our results can also be explained within a Glosten (1994) type of model where all liquidity suppliers are homogeneous: for a given level of liquidity motivated trading and a given probability of informed trading, the slopes will be more gentle the more volatile assets are, while a positive relation between the slope at the

on the y-axis). In the case of inverted demand and supply curves, the relationship would be opposite.

inner quotes and trading activity could be explained by price sensitive liquidity traders.[6] However, the results from the test of the Glosten model in Sandås (2001) do not provide empirical support for a model with homogeneous liquidity suppliers.

The paper is organized in the following way. Section 3.2 surveys the relevant literature. Section 3.3 describes our data sample. Section 3.4 examines in detail the order flow and order book on an intra-daily basis. Section 3.5 provides the results from our analysis of the volume-volatility relation in the Norwegian equity market. Section 3.6 concludes the paper.

3.2 Literature

The mixture of distributions hypothesis The early research into the volume-volatility relation is reviewed in Karpoff (1987). The main theoretical explanation from this period is known as the "mixture of distributions hypothesis" (hereafter the MDH). According to the MDH, there is a positive correlation between daily price changes and trading volume because both variables are mixtures of independent normals with the same mixing variable. Originally, the MDH was suggested by Clark (1973) as an alternative explanation for the observed leptokurtosis in the distribution of log price changes.[7] The basic idea underlying the hypothesis is that prices and trading volume are driven by a time-varying arrival rate of information.[8] Let $\Delta p_{i,t}$ and $v_{i,t}$ be respectively the intraday price change and volume of trade resulting from information event number i on date t, and let n_t be the total number of information events during day t. Assume that (i) the number of events each day, n_t, varies across days, and that (ii) the intraday price changes, Δp, and trading volumes, v, are jointly independently and identically distributed with finite variances. Our explanation of the MDH is largely based on Harris (1987). The daily price change and trading volume are equal to the sum of respectively the intraday price changes and trading volumes, i.e.

$$\Delta P_t = \sum_{i=1}^{n_t} \Delta p_{i,t} \quad \text{and} \quad V_t = \sum_{i=1}^{n_t} v_{i,t} \tag{3.1}$$

[6] We are grateful to an anonymous referee for pointing this out to us.

[7] Mandelbrot (1963) and Fama (1963) showed that the return distributions of commodity and stock prices were leptokurtic, and well approximated by symmetric stable distributions with characteristic exponents between 1 and 2 (the normal distribution has a characteristic exponent equal to 2). An examination of the stable distributions hypothesis for the Norwegian market is provided in Skjeltorp (2000) who shows that a characteristic exponent between 1.6 and 1.7 best characterizes the Norwegian data.

[8] Copeland (1976, 1977)'s "sequential arrival of information" model which is later extended by Jennings et al. (1981) and Jennings and Barry (1983) also predicts a positive relationship between volume and absolute price changes. The main feature of the model is that information is disseminated to only one trader at a time, and the main criticism of the models is that traders cannot learn from the market prices as other traders become informed.

where ΔP_t is the daily price change and V_t is the daily trading volume. Given equation (3.1), and provided that n_t is large, the joint distribution of the daily price change and volume of trade will be approximately bivariate normal conditional on n_t.[9] The volume-volatility relation arises because both price changes and trading volume are likely to be large when the number of information events is large and small when the number of information events is small.[10]

Harris (1986) finds empirical support for the MDH based on cross-sectional tests of common stocks continuously traded on the NYSE or one of the regional exchanges in the period 1976-1977. The critical assumption behind the tests is that the distribution of the mixing variable is not identical for all securities. Assuming that transactions take place at a uniform rate in event time, Harris (1987) finds both theoretical motivation and empirical support for the use of the daily number of transactions as a proxy for the time-varying unobserved information evolution rate.[11] However, since the arrival rate of new information is unobservable, we do not know whether a part of the volume-volatility relation may be a result of the actions of heterogeneous traders. As suggested by Harris (1987), if trading is self-generating, the daily number of transactions would be the *true* mixing variable rather than a proxy for the unobserved information evolution rate.

Using a simple regression approach for daily data on Nasdaq-NMS securities over the 1986-1991 period, Jones et al. (1994) find that both volatility and trading volume are positively correlated with the number of daily transactions. However, the average size of trades contains no additional information about volatility beyond that contained in the number of transactions. If the number of transactions is a good proxy for the mixing variable, this result is supportive of a pure MDH; "..volatility and volume are positively correlated only because both are positively related to the number of daily information arrivals (the mixing variable)." The problem caused by a lack of ability to interpret the mixing variable can be further illustrated by this study. If informed traders camouflage their information, for example by splitting their orders into medium sized trades as suggested by the "stealth trading hypothesis" of Barclay and Warner (1993), the number of daily transactions would be the true mixing variable and the results in Jones et al. (1994) would also support explanations of the volume-volatility relation based on heterogeneous traders.[12]

[9] See Harris (1987), page 129.

[10] The variation in the daily number of information events implies that the expectation of the unconditional distribution is a weighted average (or "a mixture") of the conditional distributions.

[11] Harris (1987) derives and tests several implications of the MDH for transactions data on a sample of 50 NYSE stocks that traded between December 1, 1981 and January 31, 1983. The results from the tests are supportive of the MDH.

[12] In addition, in order-driven markets, a large order is often automatically executed against many smaller orders by the automatic matching system. Thus, even though the original order is large, it may show up as many small trades as it is matched against several smaller orders rendering the average daily trade size unimportant in explaining volatility.

Dispersion of belief The MDH simply states that price changes and trading volume are directed by the flow of new information. It does not say anything about what type of information or how this information is revealed to investors. Hence, an important limitation of the hypothesis is that it does not address the role of economic agents or market structure for prices and trading volume. Later theoretical work on the volume-volatility relation centers around these issues. Harris (1986) links the MDH to asset pricing theory by suggesting that the mixing variable directs the rate of flow of information from systematic risk factors. A problem with this interpretation is that the movements in prices for many types of financial contracts seem much "too large" to be attributed to movements in the fundamental values of the underlying securities only. This fact suggests that prices are not merely driven by changes in systematic risk factors and asset payoffs, but also by changes in the expectations of heterogeneous agents. Figure 3.1 illustrates the information structure in a standard asset market for the two main types of such models. Panel (a) in the figure describes a "differences in opinion" model, while panel (b) describes a market microstructure model with asymmetric information.

Figure 3.1 (a) illustrates a "differences of opinion" model. In this model, investors are assumed to act differently on the same news, i.e. trading is induced by differences of opinion about publicly available information. Beliefs are updated using Bayes rule. All traders are rational, but they view others as having irrational models. Harris and Raviv (1993) explain the volume-volatility relation by a model of this kind. Two groups of risk-neutral speculators receive the same information but disagree on the extent to which it is important (but agree to disagree). As long as one of the groups remains more optimistic than the other, there is no trading. Trading occurs only and whenever the cumulative information for one of the trader groups switches from favorable to unfavorable, or vice versa.[13]

In the standard asset pricing models, the trading process itself does not convey information which is relevant to price determination. Prices adjust immediately as a result of new information. This is a plausible assumption for some kind of news. Other types of news are likely to be dispersed and not immediately available to all investors in aggregated form.[14] Modelling dispersed information is the essential feature in the market microstructure models illustrated in figure 3.1 (b). In these models, there is a group of investors who trade on the basis of private information. The market maker and the uninformed investors can only infer this information from trades and order flows. The room for strategic behavior among agents differs in different models.[15] Shalen

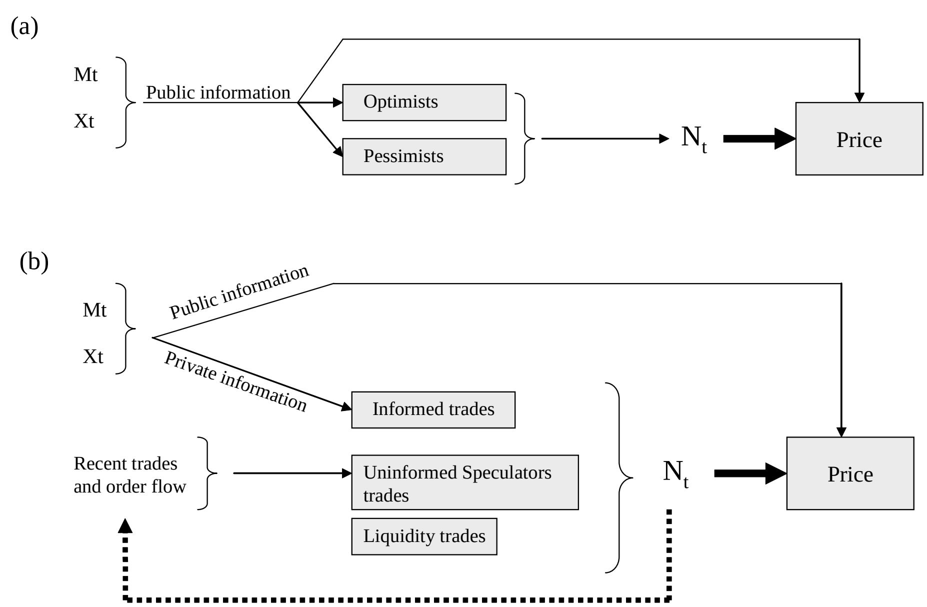
[13] Prices change every period whether or not trading occurs. The volume-volatility relation arises because the price changes are larger on average when trading occurs.

[14] Evidence of the existence of dispersed news is given in French and Roll (1986) who document empirically that asset prices are much more volatile during exchange trading hours than during non-trading hours. This phenomenon cannot be reconciled with a standard asset pricing model unless there is a systematic tendency for price-relevant information to arrive during normal business hours only.

[15] In Kyle (1985), informed investors attempt to camouflage their trades by spreading them over time.

FIGURE 3.1 The Information Structure

The figure illustrates the assumed information structure in a "differences in opinion" model (panel a) and a market microstructure model (panel b). From the fundamental asset pricing equation, $P_{i,t} = E_t[\sum_{j=0}^{\infty} M_{t+j} X_{i,t+j}]$, we know that relevant information about the price, P, of an asset, i, may come from either news about the stochastic discount factor, M_i, or news about the payoff, X_i. In the "differences in opinion" model in panel a, all news arrives as public information. Some types of information are immediately incorporated into the asset price. For other types of information, traders disagree on the effects on the valuation of the underlying assets. Trading occurs whenever the cumulative information for a particular type of trader switches from favorable to unfavorable. In the market microstructure model in panel b, new information arrives as either public or private information. Public information is immediately incorporated into the asset price. Informed traders trade on the basis of private information. Uninformed investors are either liquidity traders or speculators. The uninformed investors are trying to infer the private information from the trades, N_t. However, they are not able to separate informed and uninformed trades.



(1993) uses a market microstructure model to study the volume-volatility relation. In her model, both trading volume and price volatility increase with the dispersion of traders' expectations about fundamental values. This is called the "dispersion of beliefs hypothesis"(hereafter the DBH). In this version, dispersion of beliefs about the value of a security is assumed to be wider the larger the share of the traders in the security that consists of uninformed investors. Uninformed traders cannot distinguish informed trades from liquidity trades. Instead they react as if all trades were informative, and thus they increases both volatility and volume relative to equilibrium values.

Daigler and Wiley (1999) perform an indirect test of the DBH. Facilitating the possi-

Kyle's model implies that larger volumes support more informed traders. In Admati and Pfleiderer (1988), a certain amount of the uninformed investors are allowed to act strategically by having the discretion to time their trading. This is shown to imply that within-day trading becomes concentrated. Hence, price changes and transactions are bunched in time, and the effect of volume on price movements will depend on recent volume levels.

bility of distinguishing traders with different types of information in the futures markets, they test whether uninformed traders contribute to volatility. The results of their study support Shalen (1993): "..uninformed traders who cannot differentiate liquidity demand from fundamental value increase volatility." In a similar study, Bessembinder and Seguin (1993) examine the relation between the volume-volatility relation and market depth, proxied by open interest, in eight physical and financial futures markets. Unexpected volume is found to have a larger effect on volatility than expected volume, and large open interest is found to mitigate volatility.

Limit order markets In this paper, we investigate the information about trading volume and price volatility contained in the slope of a limit order book. In an electronic limit order market, liquidity is not supplied by designated specialists or market makers, but rather by the traders themselves. The majority of trades are first submitted to the market as limit orders, which accumulate into the limit order book. Hence, at any point in time, the limit order book reflects an aggregate of buying and selling interests at various prices. Each ask (bid) price reflects the lowest (highest) price at which different investors are willing to sell (buy) the security.[16]

Theoretical models of limit order markets differ in their assumptions about investor heterogeneity. In Glosten (1994), privately informed investors are assumed to submit market orders while homogeneous uninformed investors provide the limit order book. Hence, the shape of the limit order book reflects the information characteristics of the incoming market flow. In the dynamic model proposed by Parlour (1998), all traders are assumed to have different valuations for the traded asset. Parlour shows that, when the choice between a limit order or a market order depends both on the past (through the state of the order book) and the future (through expected subsequent order flow), then systematic patterns in order placement strategies will be generated even in the absence of asymmetric information. Moreover, both sides of the book will matter for optimal order placement strategies. Foucault et al. (2003) model a limit order market where liquidity suppliers have asymmetric information on the risk of being picked off by traders with superior information. This feature is shown to affect the shape of the order book. When the book is thin, uninformed liquidity traders are reluctant to add depth because it may be an indication of high pick-off risk. The informed liquidity traders exploit this by bidding less aggressively than in the case where the liquidity traders have symmetric information. Sandås (2001) tests a version of Glosten (1994) empirically.[17]

[16] Biais et al. (1995) note that the shape of the order book may reflect the competition among buyers/sellers as well as the correlation in their valuations. If the supply and demand curves are inelastic and volume is concentrated around the inner quotes, this may reflect that the valuations among various investors are correlated on each side of the market relative to the case where the valuations are more dispersed and the order book is more elastic.

[17] The tests are based on updating restrictions that link the market order flow to the order book dynamics and break-even conditions for the marginal bid and offer prices that define the price schedule.

The results do not lend support to the model. Relative to the theoretical predictions, the empirical price schedules of the limit order book offer insufficient depth.

3.3 The Data

3.3.1 The Norwegian Stock Market

Our data set is from the the Oslo Stock Exchange (OSE) in Norway.[18] Norway is a member of the European Economic Area, and its equity market is among the 30 largest world equity markets by market capitalization.[19] Table 3.1 reports some general statistics for all the companies listed on the OSE. At the end of 2001, 212 firms were listed on the exchange with a total market value of about NOK 657 bill. The OSE is the only regulated marketplace for securities trading in Norway. Since January 1999, it has operated as a fully computerized centralized limit order book system similar to the public limit order book systems in e.g. Paris, Toronto, Stockholm and Hong Kong.

The OSE allows the use of limit orders, market orders, and various customary order specifications. Participants can also submit hidden orders. When an order is submitted as a hidden order, only a specified fraction of the underlying order is visible to the market. As is normal in most electronic order-driven markets, the order handling rule follows a strict price-time priority.[20] All orders are submitted at prices constrained by the minimum tick size for the respective stocks which is determined by the price level of the stock. For prices lower than NOK 9.99 (Norwegian kroner) the tick size is NOK 0.01, between NOK 10 and NOK 49.9 the tick size is NOK 0.1, between NOK 50 and NOK 999.5 the tick size is NOK 0.5 and for prices above NOK 1000 the tick size is NOK 1.

The trading day of the OSE comprises two sessions: the "pre-trade" session starting at 9:30 and ending with an opening auction at 10:00, and the "continuous trading" session from 10:00 until the trading closes at 16:00. During the pre-trade session, brokers can register trades that were executed after the close on the previous day as well as new orders. At the opening auction at the end of the pre-trade session, all orders registered in the order book are automatically matched if the prices are crossing or equal. The quoted opening price is thus the price that clears the market. During the continuous trading session, electronic matching of orders with crossing or equal price generates transactions. Orders without a limit price (market orders) have automatic price priority and are immediately executed at the best available prices. At the OSE, market orders

[18] We obtained the data directly from the exchange's surveillance system. The SMARTS© system is the core of the exchange's surveillance operations. Through access to the SMARTS© database, we obtained all the information on orders and trades in the market

[19] Source is FIBV (International Federation of Stock exchanges). Notable Norwegian listings include Norsk Hydro, Telenor, and Statoil.

[20] In the case of hidden orders, when the visible part of the order is executed, it loses time priority.

TABLE 3.1
Oslo Stock Exchange (OSE) - General statistics

Descriptive statistics for the Oslo Stock Exchange for the period 1999 to 2001. All numbers in the table are official statistics obtained from the OSE annual reports (available at www.ose.no).

	1999	2000	2001
Number of listed firms	215	214	212
Market capitalization (bill. NOK)	582.94	637.86	677.03
NOK/USD exchange rate[a]	7.81	8.81	8.99
Turnover velocity[b]	88.6	96.7	86.4
Total dividends (mill. NOK)	14443	12194	13767
Market development			
Market index level (TOTX)	1153.74	1366.05	933.22
OSE benchmark index	189.76	195.79	167.18
OSE benchmark index return (%)	48.45	3.18	-14.61

[a] Average midpoint rate for the respective year. [b] Turnover velocity: Average of annualized turnover per month divided by market value at the end of each month. Only capital registered in the VPS.

are allowed to "walk the book" until they are fully executed. Any remaining part left of the market order is removed from the order book. This is different from the treatment of market orders on e.g. the Paris Bourse, where any remaining part of an unfilled order is automatically converted to a limit order at the current quote. The difference implies that market orders on OSE are more aggressive than market orders at the Paris Bourse. On the Paris Bourse, market orders are essentially marketable limit orders.

3.3.2 The data sample

The dataset consists of every order and trade that occurred on the OSE in the period from February 1999 through June 2001.

The trade data contains, quantity transacted, a time stamp, brokerage house ID on each side, and an ID for the house that initiated the trade as well as whether the house was the buyer or a seller in the transaction. Every trade is linked to the underlying orders through an order ID. Thus, if a large order is executed against many smaller orders resulting in several smaller trades, we can trace each executed part back to the initial order. There are also additional flags attached to each trade that identify special features of the trade such as whether it was an odd-lot trade, an off-exchange trade, a cross (within the same or different brokerage houses), and whether a trade results from a market order or a limit order. The order data contain all order entries as well as all deletions and amendments of orders already in the order book.

In table 3.2 we provide some descriptive statistics of the trade data throughout our sample period. A large part of the listed firms are traded quite infrequently. Since we examine intraday data, including infrequently traded firms would introduce a large amount of noise into our analysis. We therefore filter the firms based on their trading activity through the sample period. The first filtering criterion is that the firm must have been traded in at least 400 out of 597 days, or about 70 percent of the trading days, and the second criterion is that the firm must have an average of 5 trades per day to be included in our sample. Once the first criterion is applied, the second criterion only removes a few companies from our sample. After the filtering we are left with 108 firms, which constitute our sample throughout the paper. Note that there were 215, 214 and 212 listed firms at the end of 1999, 2000 and 2001 respectively. Table 3.2 shows that there has been increasing trading activity during the sample period with the total number of trades having tripled and the volume in Norwegian kroner (NOK) having doubled. Further, the average number of daily trades across firms has more than doubled from 32 in the first half of 1999 to 79 in the first half of 2001.[21] The increase in activity has also been accompanied by a decrease in the average percentage spread. As found in most markets, the average effective spreads are lower than the average quoted spreads. To give a better picture of the diversity of the sample, we divide the sample into four portfolios based on their market capitalization value. The firms are assigned to a market capitalization group based on their market capitalization value at the beginning of each year. The general picture is that the number of trades, the trading volume (both in shares and NOK), the prices and the quoted spread increase across firm size portfolios, while the average daily volatility, the average trade size and the quoted percentage spread decrease.

We also report the average correlations between the trading volume, the trade size and the number of transactions. The correlation structure in our sample is quite similar to the one documented for the US market in Jones et al. (1994). The correlation between the average trade size and the number of trades is low, and both the average trade size and the number of trades have high positive correlations with share volume. Hence, the two components of share volume seem to contain different information about volume. The same structure is evident when we calculate correlations over sub-periods of half a year.

3.3.3 Composition of orders

Our order data are quite rich. For each order, we have a time stamp, a unique order ID, the disclosed/hidden orders as well as flags indicating whether the order was a buy or sell order, whether the order is a new order, a deletion of an order or an amendment to an existing order (price change and/or volume change). In addition, a unique brokerage house ID is attached to each order. Moreover, compared to the Paris Bourse data in Biais et al. (1995), our data are not restricted to include placements, amendments and

[21] At the same time, the average trade size has gone down from 3429 shares to 2648 shares. This decline is most likely related to the introduction and growth of online trading in the sample period, since these traders generate a lot of trades of small sizes. During our period, the fraction of total trades coming from pure online brokerage houses has increased from 0% to almost 10%.

TABLE 3.2
Descriptive statistics of trades

The table provides some descriptive statistics of trades for the whole sample, the five half-year sub-periods, and the four market capitalization groups. Group 1 consists of the 25% smallest firms while group 4 consists of the 25% largest firms. Some firms have experienced large changes in capitalization value during the sample period. To take account of this, we re-sort the market capitalization groups at the beginning of each year. At the bottom of the table we report the Pearson correlation coefficients between the trading activity variables. The number of trades (N) is the average number of daily trades across all firms. The share volume (V) is the average daily share volume (in 1000 shares) across all firms. The average trade size (AV) is the average number of shares in each trade averaged across all firms for the sample period. The quoted spread is calculated as a percent of the spread midpoint. The effective spread is calculated as the difference between the execution price and the spread midpoint (in percent of the spread midpoint) multiplied by two.

	Whole	Sub-periods (half-years)					Market Capitalization groups			
	sample	1999.1	1999.2	2000.1	2000.2	2001.1	1	2	3	4
Aggregate statistics:										
Number of firms	108	107	108	108	108	104	27	27	27	27
Trades (in thousands)	3724	328	545	946	953	953	390	522	504	2309
Shares traded (mill.)	9585	1339	2300	2027	2072	1847	1707	1922	919	5037
NOK volume (bill.NOK)	648	67	131	152	153	146	21	44	68	516
Cross-sectional averages:										
Market cap (mill.NOK)	5259	4120	4714	5507	6127	5836	354	938	2339	13978
Price	88.4	71.8	82.7	102.7	102.3	81.9	23.34	62.43	105.66	150.73
Daily volatility (%)	2.71%	2.64%	2.89%	2.98%	2.48%	2.57%	3.49%	2.98%	2.30%	2.29%
Shares traded (thousands)	151	130	167	155	151	153	116	171	78	288
Trades	58	32	40	72	69	79	28	41	41	148
Trade size (AV) in shares	2890	3429	3365	2453	2551	2648	4859	2684	1549	1912
Quoted spread (NOK)	1.65	1.55	1.62	1.79	1.78	1.50	0.94	1.63	2.11	1.57
Effective spread (NOK)	1.22	1.12	1.14	1.34	1.36	1.13	0.68	1.20	1.59	1.16
Quoted% spread (midpt.)	3.04%	3.66%	3.49%	2.62%	2.55%	2.89%	4.74%	2.77%	2.40%	1.34%
Effective% spread (midpt.)	2.22%	2.67%	2.48%	1.92%	1.89%	2.15%	3.38%	2.03%	1.85%	0.99%
Correlations:										
Corr(AV,N)	-0.061	0.045	0.051	-0.091	-0.085	-0.084	-0.116	0.280	0.172	-0.066
Corr(V,N)	0.525	0.660	0.591	0.724	0.568	0.442	0.690	0.480	0.847	0.365
Corr(V,AV)	0.330	0.358	0.438	0.290	0.288	0.201	0.393	0.932	0.504	0.759

deletions of orders within the 5 best quotes. We have access to all orders, which makes it possible to reconstruct the full order book at any point of time. The descriptive statistics discussed in this section are based on 6 hourly spaced snapshots of the entire order book during each trading day for each listed company during our sample period. The order book is rebuilt at 10:30, 11:30, 12:30, 13:30, 14:30 and 15:30 each trading day for each firm. We exclude order volume above/below 100 ticks away from the inner quotes. For a stock trading at NOK 100 with a minimum tick size of NOK 0.5 this would mean that orders above NOK 150 and below NOK 50 are excluded from our calculations. The limit on 100 +/- ticks means that we disregard less than 5 percent of our sample.

To get a general view of the composition of the order-flow, we group the orders into four types based on their trading aggressiveness. "Market orders" are orders with no limit price. "Aggressive limit orders" are orders that are placed at the opposite quote (marketable limit order) or at a price further away from the best quote on the opposite side. "Quote improving orders" are orders that are placed in between the inner quotes, and "Passive orders" are orders that are placed at the best (same side) quote or further away from the market. Panel A in table 3.3 shows the composition of orders and the order book activity for our data sample. The numbers in the table are daily cross-sectional time series averages of order volumes (in shares), and the number of orders submitted. The numbers are averaged over each of the three years in the sample as well as over market capitalization quartiles. Each firm is assigned to a market capitalization quartile at the beginning of each year.

The table shows the distribution of order placements in the market. The use of market orders is modest. However, market orders and aggressive limit orders together constitute around 40 percent of the average daily number of submitted orders. Measured in number of shares, there is considerable variation in the size of the submitted orders across order groups. A part of this variation can probably be explained by differences in the price level of the stocks, both over time and over firm size. Quote improving orders are the largest order group, while market orders are the smallest order group. This holds for the entire sample as well as for each market capitalization group, and is also a systematic pattern across sub-periods (not shown in the table). Measured over the whole sample, on average 94 orders are submitted during a trading day for one firm. The activity is considerably higher for the largest firms than for firms in the other three groups. The average daily number of orders submitted for the largest firms was 224, while the similar average for the three other groups ranged from 45 to 53. For comparison, Biais et al. (1995) report an average of 160 orders for the Paris Bourse in 1995.

In Panel B in table 3.3, we show the distribution of volume in the order book averaged across all firms and dates. At each tick level, the fraction of total shares in the order

TABLE 3.3
Descriptive statistics of the order book

Panel A shows the daily average number of submitted orders and the daily average order size for different types of orders. The numbers are averaged over companies and time. We also report averages over the four market capitalization groups. Group 1 consists of the 25% smallest firms while group 4 consists of the 25% largest firms. Some firms have experienced large changes in capitalization value during the sample period. To take account of this, we re-sort the market capitalization groups at the beginning of each year. Limit orders are classified into three different types based on their aggressiveness. Passive orders are orders that are submitted at the best (same side) quote or further away from the market. Quote improving orders are orders that are submitted in between the inner quotes prevailing at order submission, and aggressive orders (Aggr.) are orders that are submitted at the opposite quote (marketable limit order) or at a price further away from the market on the opposite side. Market orders (MO) constitute a separate group. The numbers in parentheses are each order class' fraction of total orders. Panel B provides descriptive statistics on the distribution of order book volume. The numbers are daily average fractions of accumulated volume, and are reported for all firms, for the bid and ask side separately, for minimum tick sizes, and for the four market capitalization groups.

PANEL A: Order types and order sizes

		Submitted orders					Order sizes			
	Firms	Total orders	Passive	Quote impr.	Aggr.	MO	Passive	Quote impr.	Aggr.	MO
All firms	108	94	42 (0.44)	15 (0.16)	34 (0.36)	4 (0.04)	6428	7063	5882	1715
Market capitalization quartiles										
1 (small)	27	45	22 (0.45)	10 (0.21)	14 (0.31)	3 (0.06)	10708	11501	9824	4341
2	27	52	23 (0.43)	10 (0.19)	18 (0.34)	3 (0.05)	6244	7460	5634	1382
3	27	53	22 (0.41)	10 (0.19)	19 (0.37)	3 (0.05)	3437	3900	3038	531
4 (large)	27	224	100 (0.45)	31 (0.14)	87 (0.39)	7 (0.03)	5324	5392	5032	605

PANEL B: Order book volume distribution (normalized)

Minimum tick size	ATQ	+/- 1 tick	+/- 5 tick	+/- 10 tick	+/- 20 tick	+/-50 tick	+/-100 tick
All firms	20.9%	34.7%	56.8%	69.4%	78.4%	88.6%	100.0%
Bid side	23.0%	40.0%	62.9%	73.8%	81.4%	89.7%	100.0%
Ask side	20.8%	29.3%	50.8%	64.9%	75.5%	87.4%	100.0%
Minimum tick size							
0.01	20.2%	30.8%	37.8%	49.0%	60.1%	82.2%	100.0%
0.1	22.2%	34.2%	53.2%	67.4%	79.4%	91.7%	100.0%
0.5	22.3%	39.1%	65.8%	78.4%	88.1%	95.5%	100.0%
1	7.0%	10.7%	17.6%	25.1%	38.8%	70.0%	100.0%
Market capitalization quartiles							
1 (small)	19.1%	29.7%	45.2%	56.6%	68.2%	84.0%	100.0%
2	21.6%	34.9%	56.3%	69.6%	79.9%	91.1%	100.0%
3	23.6%	38.3%	62.7%	75.5%	83.8%	92.6%	100.0%
4 (large)	19.3%	34.6%	62.9%	75.9%	84.3%	91.0%	100.0%

book is averaged over the 6 order book snapshots.[22] The table shows the order book distribution across minimum tick sizes and market capitalization quartiles.[23] Around 35 percent of the order book depth is concentrated at the quotes or plus/minus one tick from the quotes. This is quite stable both across tick sizes and across market cap quartiles. However, when we separate the bid and ask sides, we find that the volume on the bid side is more concentrated at the inner quotes than the volume on the ask side. This is in line with the findings in several other empirical papers, and is consistent with the interpretation that the price impact is larger for buy orders than for sell orders.[24] Note that the depth within +/- 5 ticks, which is what Biais et al. (1995) investigate, only includes 56 percent of the total order book depth in our sample. There does not seem to be large differences in order depth across market capitalization quartiles. The largest tick size category is special in that it only contains one, highly volatile and very actively traded, company.[25] One interesting thing to note about this firm is that as much as 30 percent of the order book depth lies between 50 and 100 ticks away from the quotes, even though it has been one of the most heavily traded companies at the exchange during our sample period.

3.4 Intraday analysis of the order book

In this section, we discuss how to measure the shape of the order book, and present statistics on the limit order book at an intraday level.

3.4.1 The shape of the order book

Figure 3.2 shows the average order books for two companies listed on the OSE. The order books are averaged over the five last trading days in May 2001, and are normalized in the sense that they show the percentage of shares in all orders within an increasing/decreasing number of ticks away from the quotes (zero in the figure is the best quote on each side of the market). The upper graph shows the average order book for Norsk Hydro (NHY) while the lower graph shows the average order book for Opticom (OPC). Both companies are among the most liquid on the exchange.[26] Norsk Hydro

[22] For instance, on the ask side of the book for one company/snapshot, we divide the aggregate number of shares at each tick by the total number of shares supplied (offered) at that time/snapshot. We do this for each snapshot, and average across all snapshots on the particular date to obtain the average fraction supplied on each tick for the security. Since we limit the order book to orders within +/- 100 ticks from the bid/ask midpoint, the fraction of aggregate volume at +/- 100 ticks is 100%.

[23] If a firm trades across two minimum tick size regimes on the same day, we remove that company for that day from the sample. The results do not change if we include these observations.

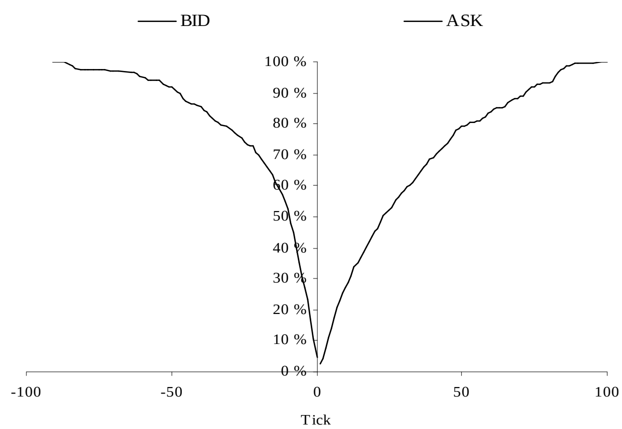
[24] See Chan and Lakonishok (1993), Chan and Lakonishok (1995), and Kalay et al. (2003)

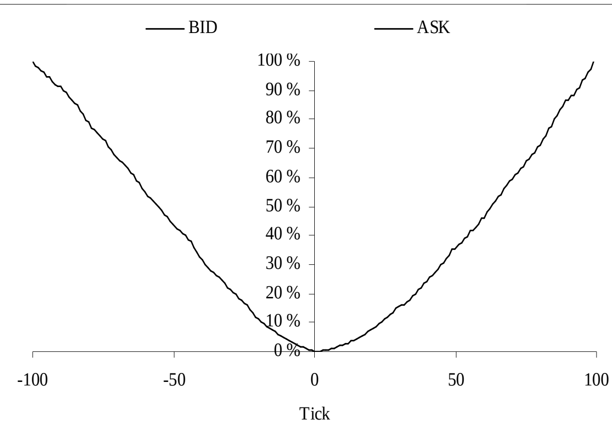
[25] The company is Opticom (OPC).

[26] During the period illustrated in the figure, both companies traded in prices around NOK 400-500 and had a tick size of NOK 0.5. For Norsk Hydro the calculated average order book is based on around 2000 orders with a share volume of around 400 000 shares. For Opticom the similar calculations are based on around 4000 orders with a share volume of around 200 000 shares.

FIGURE 3.2 Average order books for Norsk Hydro and Opticom

The figure illustrates the order books for two different companies listed on the OSE. The upper graph shows the average normalized (with respect to the total number of orders in the order book) order book for Norsk Hydro (NHY), a large Norwegian blue chip company, and the lower picture shows the average normalized order book for Opticom, a Norwegian IT company. The order books are averaged over the last five days of May 2001. (For each day the average order book is calculated from hourly snapshots of the book.) The picture shows the percentage of shares in all orders within varying ticks away from the quotes. Zero represents the best quote on each side of the market.





is a leading energy, aluminium and fertilizer company, based in Norway. It has 50,000 employees in 60 countries worldwide. The company's operations are well known and there is a a large amount of available information about the company, including experts' analysis. Opticom, on the other hand, is a relatively new IT company which currently has under 100 employees. The company describes its business concept as pioneering research and development in new technology in electronics. The company has no cash flow and very uncertain future income possibilities. Discussions in the popular press have been largely focused on how difficult it is to value the company, and there have been large differences in analysts' valuations. The picture shows that the order book of the two companies are quite different: while on average about 50 percent of the orders for Norsk Hydro has limit prices which lie within 5 ticks from the quoted spread, the similar percentage for Opticom is only about 10 percent.

This difference in the average shape of the order book results from the fact that traders systematically submit orders further away from the midpoint in Opticom than in Norsk Hydro. One possible reason for this is that investors are more uncertain about the true value of Opticom than Norsk Hydro, and that this higher valuation uncertainty in Opticom is reflected in orders being submitted across a wider range of prices than in Norsk Hydro. The difference in the order book shapes may also come from pick-off risk, i.e. the reservation prices reflect a compensation for the risk of being picked off by better informed traders. Probably both effects contribute to explaining the pictures we see in figure 3.2. However, while it is obvious that there are huge differences in valuation uncertainty between the two companies, it is not so obvious that there should be such a big difference in pick-off risk. More importantly, pick-off risk should mainly concern the orders submitted close to the midpoint price. Thus, pick-off risk should affect the spread and volumes at the inner ticks, not the distribution of orders across the the entire order book. The figure also illustrates the difference in order book liquidity between the bid and the ask side, which we documented for the whole sample in panel B in table 3.3. Although it is more pronounced for Norsk Hydro, both pictures indicate that the ask side of the book is more elastic than the bid side.

Measuring the order book slope To capture the shape of the order book, we use the average elasticity/slopes of the supply and demand schedules in the order book. The more gentle (steeper) the slope, the more widely distributed (concentrated) are the bid and ask prices in the order book. Note that we use the inverse of the elasticity, with prices on the x-axis and accumulated volumes on the y-axis, as in Biais et al. (1995).

To obtain an average slope of the order book, we divide the trading day into hourly spaced intervals. At the end of each interval, we take a snapshot of the order book. These snapshots occur at 10:30, 11:30, 12:30, 13:30, 14:30 and 15:30 each trading day for each firm. Note that the first snapshot is half an hour after the regular trading session starts. Alternatively, we could end the last snapshot at 16:00, but then the order book would be affected by the large amount of order cancellations at the end of the trading day. To rebuild the order book we start at the beginning of the trading day with the orders still remaining after the opening auction has been executed at 10:00. Then we track all types of orders being submitted throughout the day, and update the order book accordingly. Thus, all deletions and/or amendments of earlier orders as well as new orders are accounted for when we update the order book.[27] After having obtained the full order book for each snapshot we calculate our slope/elasticity estimate for each company of the order book in the following steps:

1. First, for each side of the order book, and each snapshot, we accumulate the aggregate number of shares supplied/demanded at each price level, such that at each price level we get the total volume supplied (demanded) at that price or lower (higher).

2. To account for large differences in liquidity between firms, we normalize the accumulated shares at each tick level (on the ask and bid side separately) relative to the total number of shares supplied/demanded at the relevant snapshot. Thus, the percentage of the shares in the order book supplied (demanded) at the highest (lowest) ask (bid) price/tick is 100 percent.

3. Next, we calculate the "local" elasticity at each price level (illustrated in equation 3A.2 and equation 3A.3 in the appendix).

4. Then, we average across all price levels (local slopes) to obtain an average elasticity/slope for the bid and ask side for that snapshot.

5. Finally, we take the average of the bid and ask slope to get one slope measure for the snapshot and average across all the snapshots during the trading day to obtain the average slope for each company on that day.

We normalize the order book because we want to take into account that there is a close relationship between our slope measure and the liquidity of the underlying stock. Less liquid firms generally have a higher volatility since the order book does not contain enough volume to absorb large trades without moving prices too much. In addition, less liquid stocks generally have a higher spread since investors require a discount when buying and a premium when selling the stock. Thus, a positive relationship between order book elasticity and volatility is expected a priori. By normalizing the order book, we get the fraction of total shares supplied/demanded at each price level regardless of

[27]The original dataset from the Oslo Stock Exchange includes order book data for the best 5 quotes on each side whenever a new order is submitted or there is a deletion or amendment of an existing order. We use this information to check that our order book is correct for these 5 levels of the book.

the total volume in the order book. This makes the order books more comparable across firms and time.

In addition to the equally weighted slope of the order book (across tick levels), we calculate a slope measure where we weight each local slope by its distance (in ticks) from the inner quote. The tick-weighting implies that local slopes further out in the book have a lower impact on the average slope than local slopes closer to the midpoint price. The main reason for doing this is to reduce the effects that "stale" orders may have on the "tails" of the order book.

Figure 3.3 illustrates how the local elasticities, Δ_τ^A and Δ_τ^B, are calculated. For illustrative purposes, the order book in the figure stretches only across 4 price levels on each side. In the figure, p_1^A is the best available ask price (inner ask quote) with volume fraction of v_1^A supplied at that ask price. The volume fraction at the next tick level (v_2^A) is thus the accumulated volume supplied at price p_1^A and p_2^A relative to the total volume in the order book on each side. The local elasticity of the supply curve at p_1^A would thus be the slope Δ_2^A in the figure. A more specific explanation of the calculation is provided in the appendix.

When we normalize the order book, the slope measures the average percentage change in normalized volume when the price level changes by one percent. For example, suppose that the current bid price is 49 (ask price is 50), the normalized depth is 10 percent and the slope is 10. If the bid-price decreases by 1 percent to 48.5 (or the ask price increases by 1 percent to 50.5), the normalized depth will increase by 10 percent to 11 percent.

3.4.2 Intraday Statistics

Table 3.4 shows intraday statistics for our slope measure (calculated at the end of each time interval), the price volatility (measured as the absolute hourly return between midpoint prices closest to the end of each time interval), the quoted and the effective spread, the number of trades executed during the time interval, the trade and order sizes measured in shares, and the number of orders submitted during the time interval. All numbers are daily averages across all firms in the sample, and the time intervals correspond to those used for rebuilding the order book.

Notable characteristics of the intraday statistics in table 3.4 are;

- The average slope increases at a decreasing rate throughout the day.
- The quoted and the effective spread both have a U-shape, with the highest spread at the beginning of the day.
- The average trade size is smallest at the beginning of the day, and increasing throughout the trading day.

FIGURE 3.3 Calculation of the demand and supply elasticities

The figure illustrates how the local slopes/elasticities on the bid and ask side of the order book are calculated for one "snapshot" time on one date for one company. There are only 4 price levels on both sides of the book. The left y-axis shows the fraction of aggregate share volume on the demand (bid) side of the order book at each tick level. Similarly, the right y-axis shows the fraction of aggregate share volume on the supply (ask) side of the order book at each tick level. The solid step-line is the supply (right) and demand (left) curves over the various price levels. On the x-axis, we have the various price levels. p^M is the bid/ask midpoint. Prices greater than p^M are ask prices and prices below p^M are bid prices. The difference between p_1^B (best bid) and p_1^A (best ask) is the quoted spread. The dotted line-segments connecting each level of the order book have local slopes denoted by Δs. These are the normalized local elasticities of the demand and supply curves calculated in equation 3A.2 and equation 3A.3 in the appendix.

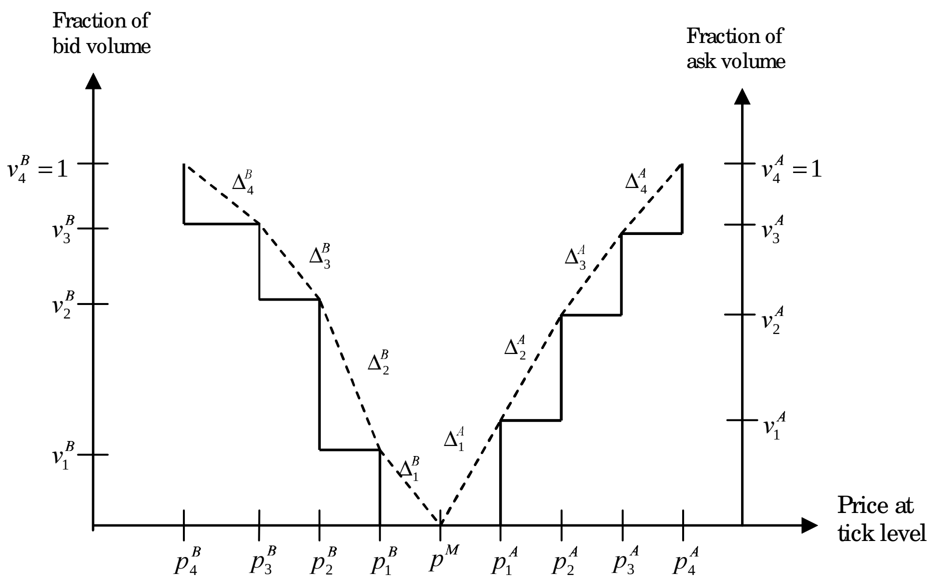


TABLE 3.4
Intraday statistics

The table provides intraday statistics for the data sample, including the slope measure, the volatility (the absolute hourly return between trade prices closest to the end of each interval), the quoted spread, the effective spread, the number of trades executed during the time interval, the trade size (in shares), the number of orders submitted during the time interval, and the order size (in shares). All numbers are daily averages across all firms in the sample. Note that the first and last time windows are half an hour while the rest of the time windows are hourly. The slope is calculated at the end of each interval.

	Time window						
	10:00 to 10:30	10:30 to 11:30	11:30 to 12:30	12:30 to 13:30	13:30 to 14:30	14:30 to 15:30	15:30 to 16:00
Slope (end of time window)	30.51	34.37	35.78	36.34	36.80	36.97	-
Volatility (absolute return)	-	1.34%	0.81%	0.72%	0.74%	0.88%	0.86%
Quoted spread	2.36	1.73	1.47	1.37	1.33	1.31	1.39
Effective spread	1.79	1.27	1.05	1.00	0.95	0.95	1.05
Trades	10.38	11.81	9.38	9.05	9.52	10.81	10.40
Trade size (shares)	2314	2653	2759	2774	2834	3027	3123
Orders	15.45	18.16	13.10	12.36	12.47	14.02	11.66
Order size (shares)	6858	6385	5723	5818	5795	6383	6706

- The average number of orders and trades both follow a U-shape, with fewer orders being placed and trades being executed in the middle of the day, and most orders being placed and trades being executed at the beginning of the day.

These regularities are also systematic across sub-periods.[28] Similar systematic intraday regularities have been found in other markets (e.g. US, France, Hong Kong, Sweden).[29] Following the sequential trading model in Glosten and Milgrom (1985), these data features can be explained by higher uncertainty about other traders' valuations at the beginning of the trading day than during the day. If this explanation is correct, a patient liquidity trader who fears being picked off by informed investors at the beginning of the day has two main options. If she believes that the probability of trading with informed traders will diminish during the day, she can act strategically and delay her trading. Alternatively, she can submit her orders at the beginning of the day and take account of the increased probability of incurring a loss by placing them at prices including a discount (buys) or a premium (sells). This can explain the higher spread at the beginning of the trading day. The increase in spreads towards the end of the day may be due to higher liquidity demand and possibly more cancellation of orders just before the close. Assuming that the informed traders are trying not to reveal their information too quickly, we would also expect to see a higher number of small trades at the beginning of the trading day (stealth trading).

To obtain a measure of order aggressiveness during the trading day, we calculate a separate index similar to Harris and Hasbrouck (1996), where the aggressiveness of an order is measured by the average number of ticks the order is placed away from the best quote (on the same side). Thus an index number of zero means that the average order is placed at the quote, a positive index number means that the order is placed above (below) the bid (ask), and a negative number means that the average order is placed below (above) the bid (ask).[30] Formally, for an order of type k, the aggressiveness of a buy order with a limit price p^B is calculated as,

$$\lambda_k^{buy} = (p^B - bid)/ticksize \tag{3.2}$$

Similarly, a sell order with a limit price p^S is calculated as,

$$\lambda_k^{sell} = (ask - p^S)/ticksize \tag{3.3}$$

where bid and ask are the best bid quote and best ask quote, respectively, when the

[28] We also calculate the statistics across sub-periods of years, half-years and quarters and find that the results are both qualitatively and quantitatively similar.

[29] For the US, see French and Roll (1986) and Harris (1986). For Sweden, see Niemeyer and Sandas (1995).

[30] We cannot calculate the aggressiveness for market orders since these orders do not have a price limit.

order is submitted.

Table 3.5 shows the intraday pattern in order aggressiveness, average number of orders, fraction of order types, and order sizes. Figure 3.4 illustrates graphically the intraday patterns in order aggressiveness, order size, order book slope, quoted and effective spread, and fraction of order types.

If uninformed investors believe that there is more asymmetric information at the beginning of the trading day, we would expect to see that they place orders at limit prices further away from the midpoint price at the beginning of the trading day, and then, closer to the midpoint prices later in the day, as the market price adjusts to reflect the private information. This is consistent with a Glosten and Milgrom (1985) type of model where trading is sequential and uncertainty is greatest at the opening of the trading session. Moreover, we would expect that the orders placed by better informed investors were most aggressive at the beginning of the day, especially if informed investors are competing to extract profits from the same information. This is exactly what is indicated in our data sample. Table 3.4 and figure 3.4 show that there are systematic differences in the aggressiveness of different types of orders in the course of the trading day.

"Away from market" orders, which make up a large part of the order book, are placed further away from the inner quotes at the beginning than at the end of the day. If this type of order is mainly submitted by uninformed traders, it indicates that they require a higher compensation for trading early in the day relative to later in the day. Another interpretation is that uninformed traders have not yet processed all publicly available information (e.g. newspapers, new analyzes, gossip etc.), and are more passive when submitting their orders before they have been able to read and interpret this information. Orders that are more aggressive, and likely to stem from better informed investors or pre-committed liquidity traders, are relatively more aggressive at the beginning of the day than later in the day. Thus, a pre-committed trader or informed trader, demanding liquidity, needs to be relatively more aggressive at the beginning of the day to get his order executed since the liquidity suppliers submit their orders relatively much further away from the midpoint. At the end of the trading day all types of orders are submitted closer to the inner quotes, indicating that the adverse selection cost is reduced. Assuming that all other cost components of the spread, except the adverse selection component, are fixed through the day, the decrease in spreads may also reflect that the adverse selection cost is the largest at the beginning of the day and smaller at the end of the day.

The average number of passive orders ("away from market") and market orders decreases throughout the day, while the average number of quote-improving orders and aggressive orders has a U-shape. The intraday pattern in the relative fraction of each order type indicates that more orders are submitted closer to the midpoint at the end of the day. "Away from the market" orders are the largest at the open and close, while

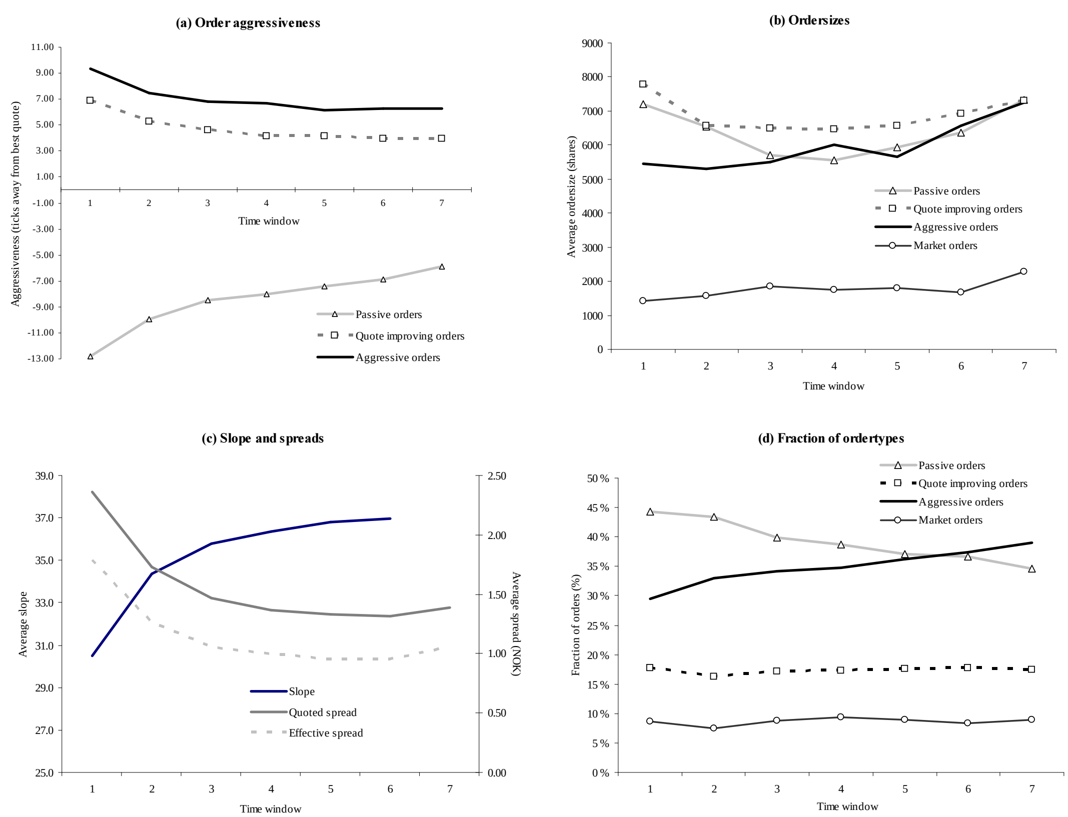
Table 3.5
Order aggressiveness

In the table, all orders within each time interval are decomposed into four groups based on their aggressiveness. The least aggressive orders, "away from market", are orders placed at or away from the quote on the same side of the book. This would be e.g. a buy order with a price (bid) equal to or lower than the current best bid, or a sell order with a price (ask) equal to or higher than the best ask price. The second type of orders, "quote-improving orders", are orders that improve the best quotes. This would be e.g. a buy order with a price higher than the current best bid, but lower than the best ask quote. The third type of orders, "aggressive orders", are orders placed at the opposite quote or higher(buys)/lower(sells). The table reports the average number of orders of each type within each time window, the percentage of all orders of each type, and the average order size in shares and NOK. For each type of order we also calculate an aggressiveness index equal to the average number of ticks away from the best quote (on the same side) that an order is submitted. Thus an index number of zero means that the average order is placed at the quote, a positive index number means that the order is placed above/below the bid/ask, and a negative index number means that the average order is placed below/above the bid/ask. We do not calculate the aggressiveness for market orders since these by definition do not have any limit price. Note that the first and last time windows are half an hour while the rest of the time windows are hourly.

	Time window						
Order type	10:00 to 10:30	10:30 to 11:30	11:30 to 12:30	12:30 to 13:30	13:30 to 14:30	14:30 to 15:30	15:30 to 16:00
	Aggressiveness (avg. ticks away from best quote)						
Passive orders	-12.81	-9.96	-8.45	-8.02	-7.44	-6.90	-5.87
Quote-improving orders	6.90	5.30	4.65	4.17	4.16	3.94	3.96
Aggressive orders	9.36	7.46	6.82	6.68	6.17	6.29	6.29
Average aggressiveness (weighted)	-1.69	-1.00	-0.25	-0.06	0.20	0.52	1.11
	Average number of orders						
Passive orders	8.2	9.1	6.4	5.9	5.7	6.2	5.0
Quote-improving orders	3.3	3.4	2.7	2.6	2.7	3.0	2.5
Aggressive orders	5.4	6.9	5.5	5.3	5.5	6.3	5.6
Market orders	1.6	1.6	1.4	1.4	1.4	1.4	1.3
	% of orders of type						
Passive orders	44.2%	43.4%	39.9%	38.7%	37.2%	36.7%	34.6%
Quote-improving orders	17.7%	16.3%	17.1%	17.3%	17.6%	17.7%	17.4%
Aggressive orders	29.4%	32.9%	34.2%	34.7%	36.2%	37.3%	39.0%
Market orders	8.6%	7.4%	8.8%	9.3%	9.0%	8.3%	8.9%
	Order size (shares)						
Passive orders	7202	6548	5716	5557	5938	6370	7317
Quote-improving orders	7793	6568	6486	6470	6561	6915	7294
Aggressive orders	5461	5301	5498	6008	5649	6569	7239
Market orders	1412	1576	1855	1751	1795	1678	2281
	Order size (1000 NOK)						
Passive orders	275	235	222	221	242	267	346
Quote-improving orders	274	253	258	265	274	290	328
Aggressive orders	188	204	204	214	227	376	307
Market orders	36	39	46	42	40	43	69

FIGURE 3.4 Intraday characteristics of the order book

The figures shows cross-sectional averages across 7 intraday windows for various measures. The windows and numbers correspond to those in tables 3.4 and 3.5. Note that windows 1 and 7 are half-hour intervals from 10:00 to 10:30 and 15:30 to 16:00 respectively, while windows 2 to 6 are hourly intervals starting every half hour. Figure (a) shows the average aggressiveness of different order types. The first type of orders, "passive orders", are placed at or away from the quote on the same side of the book. This would be e.g. a buy order with a price (bid) equal to or lower than the current best bid, or a sell order with a price (ask) equal to or higher than the best ask price. The second type of orders, "quote-improving orders", are orders that improve the best quote (on the same side). This would be e.g. a buy order with a price higher than the current best bid, but lower than the best ask quote. The third type of orders, "aggressive orders", are orders placed at the opposite quote or higher(buys)/lower(sells). Figure (b) shows the average order size within each limit order group and the average order size of market orders. Figure (c) show the average slope on the left axis and the average quoted and effective spreads on the right axis. Note that the slope is calculated from the order book snapshot taken at the end of each window. Figure (d) shows the fraction of each order category which is placed within each window.



the most aggressive limit orders and market orders are the smallest and increase in size throughout the day. If informed investors mainly use aggressive limit orders and market orders, this may indicate that they submit smaller orders when their information is the most valuable (stealth trading).

The evidence that there is more asymmetric information at the beginning of the trading day is also captured by the intraday pattern of our slope estimate. The slope increases (at a diminishing rate) across the day, with a minimum at the beginning of the day and a maximum at the end of the day, which indicates that the order book is more dispersed in the morning relative to later in the day. Note that the average slope is calculated from the normalized order book, i.e. the slope does not merely reflect that there are fewer orders in the order book early in the day, but rather that orders are submitted across a wider price range.[31] Over time windows, the average slope increases at a diminishing rate as the order book becomes more concentrated and inelastic at the end of the day.

3.5 The Volume-Volatility Relation

In this section, we first document that there exist a volume-volatility relation in the Norwegian equity market as has been found for the US by e.g. Jones et al. (1994) and in the UK by Huang and Masulis (2003). When we decompose volume into trades and order size, and interpret the number of trades as a proxy for the mixing variable, we find support for the MDH. We then investigate the relationship between volume, volatility and the slope of the order book.

3.5.1 The Volume-Volatility Relation in a Limit Order Market

To investigate if there is a volume-volatility relation in our data sample, we follow the regression approach in Jones et al. (1994). First, we measure the daily return volatility using the standard procedure in similar empirical studies,[32] by running the following regression for each firm i,

$$R_{i,t} = \sum_{k=1}^{5} \alpha_{i,k} D_{k,t} + \sum_{j=1}^{12} \beta_{i,j} R_{i,t-j} + \hat{\epsilon}_{i,t} \tag{3.4}$$

where $R_{i,t}$ is the return of security i on day t, and $D_{k,t}$ is a day-of-the-week dummy for day k. To avoid measurement errors due to the bid-ask bounce, we calculate returns from the average of bid-ask prices at the close. The 12 lagged return regressors estimate short-term movements in conditional expected returns. The residual, $\hat{\epsilon}_{i,t}$, is our

[31] A lower average slope reflects that the order book is more elastic, which implies that a lower fraction of the order volume is close to the inner quotes relative to further out in the book.

[32] See Schwert (1990), Bessembinder and Seguin (1993), Jones et al. (1994), and Daigler and Wiley (1999).

estimate of the unexpected return of security i on date t. The absolute value of this measure constitute our measure of volatility. Next, we estimate the regression equations suggested in Jones et al. (1994) to determine the relative effects of number of trades (N) and trade-size (AV) for volatility,

$$\textbf{Model I: } |\hat{\varepsilon}_{t,i}| = \alpha_i + \alpha_{i,m}M_t + \beta_i AV_{i,t} + \sum_{j=1}^{12} \rho_{i,j}|\hat{\varepsilon}_{i,t-j}| + \eta_{i,t} \tag{3.5}$$

$$\textbf{Model II: } |\hat{\varepsilon}_{t,i}| = \alpha_i + \alpha_{i,m}M_t + \gamma_i N_{i,t} + \sum_{j=1}^{12} \rho_{i,j}|\hat{\varepsilon}_{i,t-j}| + \eta_{i,t} \tag{3.6}$$

$$\textbf{Model III: } |\hat{\varepsilon}_{t,i}| = \alpha_i + \alpha_{i,m}M_t + \beta_i AV_{i,t} + \gamma_i Ni,t + \sum_{j=1}^{12} \rho_{i,j}|\hat{\varepsilon}_{i,t-j}| + \eta_{i,t} \tag{3.7}$$

The $\rho_{i,j}$'s measure the persistence in volatility across 12 lags. M_t is a dummy variable that is equal to 1 for Mondays and 0 otherwise, $AV_{i,t}$ is the average trade size (total number of shares traded divided by the number of transactions for stock i on date t), and $N_{i,t}$ is the number of transactions in security i on date t. The regressions are run for each firm and then the parameter estimates are averaged across firms.

The first part of table 3.6 provides the results from the estimation of regression equations 3.5-3.7 using daily returns for all companies in our filtered sample. Overall, our results are very much in line with the results in Jones et al. (1994). The explanatory power of model 2 (with respect to the adjusted R-squared), where volume is measured by the average number of daily trades, is almost the double of the explanatory power of model 1, where volume is measured by the average trade size. Moreover, the average trade size has little marginal explanatory power when volatility is conditioned on the number of transactions in model 3. These results are further supported by the characteristics of the sampling distributions of individual-firm coefficients and t-statistics of the two variables. In model 3, 95.4 percent of the coefficients for the average number of trades are statistically significant, and 99.1 percent of the average number of trades coefficients were greater than zero. Similar numbers for the average trade size are respectively 24.1 percent and 57.4 percent.

As a robustness check we also estimate the equations for sub-periods of half-years. Although not reported in a table, the results from the whole sample regression are confirmed in the sub-sample regressions. Most notably, the $\hat{\gamma}$ estimates of the effect of trades (N), as well as their distributional properties, are very stable across sub-periods. The $\hat{\beta}$ estimates, however, vary considerably across sub-periods and are less significant than $\hat{\gamma}$ for model 1 relative to model 3.

Jones et al. (1994) find that trade size has some information content for some of the smaller Nasdaq-NMS firms. This finding is interpreted as supportive of the notion that private information based trading is important only for the smallest firms on the stock market. To check for similar features in our data sample, we re-estimate the three regression models on the four size portfolios. The results from these estimations are presented in the second part of table 3.6. In general, the results from estimating separate regression models for each size portfolio are similar to the results from running one regression for the whole sample. However, we find the opposite result from Jones et al. (1994) that the explanatory power of trade size is the strongest for the largest firms. On the other hand, only about half of the parameter estimates for trade size in the single firm regressions are greater than zero, indicating that the effect may not be very systematic across firms.

3.5.2 Volume, volatility and the limit order book

We now turn to the question whether the slope of the order book affect volatility and trading activity. The reported results are based on the equally weighted slope calculated from the normalized order book. As discussed in section 3.4 and appendix 3.A, we also calculate a tick-weighted slope measure. The two slope measures are highly correlated (0.98), and the results from using the weighted slope measure are quite similar to those obtained using the equally weighted measure.[33] The correlations between the equally weighted slope and the other variables used in our analysis are reported in table 3.7. Table 3.8 provides some descriptive statistics on the distribution of the daily slope estimate over the whole sample, for the separate years, and for the four market capitalization groups.

Table 3.7 shows that the slope measure has the expected close relationship to measures of liquidity such as market capitalization (positive correlation of 0.44) and quoted percentage spread (negative correlation of -0.32). Thus, larger firms are generally more liquid, with a smaller spread and a steeper slope. One reason for this may be that larger firms generally are easier to value, making the dispersion of prices in the order book more concentrated around the midpoint price. In addition, we see that there is a positive correlation of 0.13 between the slope and the number of trades. Further, table 3.8 shows that larger and more liquid stocks have a higher fraction of the order book volume concentrated at or around the best quotes, while smaller firms have more elastic order books. This is also evident from panel B in table 3.3.

Figure 3.5 illustrates the relationship between the daily slope and the contemporaneous daily price changes at an aggregate level. Daily price changes are measured as the average daily absolute return over the trading day.[34] Both variables are daily equally weighted averages across all traded securities. Interestingly, even at this aggregate level the figure indicates that the price volatility is higher (lower) when the average daily slope of the order book is low (high). Another notable feature is that the average slope

[33] Estimation results for when we use the weighted slope version are reported in appendix 3.C.
[34] cf equation 3.4.

TABLE 3.6
A volume-volatility regression model

The table reports the results from the estimation of three regression models of the volume/trade size -volatility relation. The models are estimated on the whole data sample and separately for each market capitalization group. The models are based on Jones et al. (1994):

$$\textbf{Model I: } |\hat{\epsilon}_{t,i}| = \alpha_i + \alpha_{i,m} M_t + \beta_i AV_{i,t} + \sum_{j=1}^{12} \rho_{i,j} |\hat{\epsilon}_{i,t-j}| + \eta_{i,t}$$

$$\textbf{Model II: } |\hat{\epsilon}_{t,i}| = \alpha_i + \alpha_{i,m} M_t + \gamma_i N_{i,t} + \sum_{j=1}^{12} \rho_{i,j} |\hat{\epsilon}_{i,t-j}| + \eta_{i,t}$$

$$\textbf{Model III: } |\hat{\epsilon}_{t,i}| = \alpha_i + \alpha_{i,m} M_t + \beta_i AV_{i,t} + \gamma_i Ni,t + \sum_{j=1}^{12} \rho_{i,j} |\hat{\epsilon}_{i,t-j}| + \eta_{i,t}$$

Using the Jones et al. (1994) notation we have that $|\epsilon_{t,i}|$ is the absolute value of the return of security i in period t, conditional on its own 12 lags and day-of-week dummies, M_t is a dummy variable that is equal to 1 for Mondays and 0 otherwise, $AV_{i,t}$ is the average trade size, $N_{i,t}$ is the number of transactions for security i on day t, and the coefficients $\rho_{i,t}$ measure the persistence in volatility. Column 3-5 show parameter estimates averaged across all individual firm regression equations, while columns 6-9 show the parameter distribution across firms. $\hat{\beta}$ is the average parameter estimate for the average trade size variable (AV), $\hat{\gamma}$ is the average parameter estimate for the number of trades variable (N). In the distribution of estimates column we report, respectively, the percentage of $\hat{\beta}$ and $\hat{\gamma}$ estimates over all single firm regression equations that are significant. In the last two columns we report the percentage of parameter estimates that are greater than zero. The first part of the table shows the results from running the regression equations over the whole sample. The second part of the table shows the similar results when we split the sample into four size portfolios.

		Parameter estimates			Distribution of estimates			
Model	Firms	$\hat{\beta}$ (AV)	$\hat{\gamma}$ (N)	adj. R^2	%t($\hat{\beta}$)>2	%t($\hat{\gamma}$)>2	%$\hat{\beta}$>0	%$\hat{\gamma}$>0
Model I (AV)	108	0.145	-	0.057	26.9%	-	81.5%	-
Model II (N)	108	-	0.031	0.145	-	95.4%	-	100.0%
Model III (AV,N)	108	0.053	0.031	0.149	22.2%	94.4%	58.3%	100.0%
Model I (AV)								
1 (small)	27	0.145	-	0.080	16.2%	-	78.4%	-
2	27	0.219	-	0.055	18.2%	-	77.3%	-
3	27	0.274	-	0.048	19.0%	-	64.3%	-
4 (large)	27	1.021	-	0.038	30.8%	-	79.5%	-
Model II (N)								
1 (small)	27	-	0.052	0.174	-	89.2%	-	97.3%
2	27	-	0.028	0.147	-	75.0%	-	95.5%
3	27	-	0.036	0.136	-	81.0%	-	95.2%
4 (large)	27	-	0.014	0.174	-	79.5%	-	92.3%
Model III (AV,N)								
1 (small)	27	0.079	0.053	0.175	10.8%	86.5%	64.9%	97.3%
2	27	0.076	0.030	0.148	4.5%	75.0%	54.5%	95.5%
3	27	0.075	0.036	0.140	16.7%	78.6%	45.2%	95.2%
4 (large)	27	0.237	0.014	0.179	30.8%	82.1%	35.9%	94.9%

Table 3.7
Variable correlations

The table shows Pearsons' correlation coefficients between our elasticity variable (SLOPE) and various trading activity and liquidity variables.

	Trades (N)	Trade size shares (AV)	MCAP	SPREAD	SLOPE	Order volume (OV)
Trade size shares (AV)	-0.02					
MCAP	0.25	-0.04				
SPREAD	-0.20	0.16	-0.17			
SLOPE	0.13	-0.08	0.44	-0.32		
Order volume shares (OV)	0.19	0.16	0.06	-0.06	0.04	
Trade volume shares (V)	0.43	0.33	0.14	-0.13	0.08	0.45

is steeper in the first half of the sample, with an average slope of about 41, than during the second part of the sample when the average slope drops to about 35. These two periods coincide quite well with the boom and burst of the internet bubble. It is not obvious that increased trading activity due to arrival of new information can explain the volatility pattern during this period. If the slope proxies for valuation uncertainty, the pattern in the figure reflects greater agreement among traders about asset values during the build-up of the bubble than during the subsequent market down-turn.

3.5.3 Daily volatility and order book shape

To examine whether our slope measure can explain the contemporaneous volatility across firms and time, we estimate modified versions of the volume-volatility regression equations in section 3.5.1. More specifically, we estimate 3 different versions of the following cross-sectional time-series regression model with one-way fixed effects,

$$\mid \epsilon_{it} \mid = \sum_{k=1}^{K} \mathbf{X}_{itk} \beta_k + \eta_{i,t} \tag{3.8}$$

where $\mid \epsilon_{it} \mid$ is the daily volatility estimate from equation 3.4, $\mathbf{X}_{itk}$ is the matrix of explanatory variables (k) across time (t) for each company (i) and $\eta_{i,t} = \nu_i + \varepsilon_{i,t}$ defines the error structure with ν_i as the non-random fixed, firm-specific, effect. Since we use one-way fixed effects specification, the estimation is analogous to a least-squares dummy variable (LSDV) regression with firm-specific constants ν_i. Since not all firms are traded every day, our sample is unbalanced[35]. However, results from estimating the same models on a balanced sample are quantitatively similar.[36]

[35] We use the TSCSREG procedure supplied with SAS v.8.2 for estimating the models. The procedure is capable of processing data with different numbers of time-series observations across different cross sections.

[36] In the unbalanced sample, all firms with 400 trading days or more throughout the sample period of 597 days are included. In the balanced sample, we filter out all firms which are not traded every day during the sample period. This filter reduces the sample to 25 firms. See appendix 3.B for estimation

TABLE 3.8
Distribution of slope estimates

The table shows the distribution of the slope estimates where each local slope is equally weighted, and each side of the order book is normalized with respect to the total number of shares on each side. Panel A report the estimates for the entire sample and across minimum tick sizes. Panel B report the estimates across market capitalization groups and years. Each company is assigned to a market capitalization quartile at the end of every trading day. N reflects the number of firm/date observations, MCAP is the average market capitalization in NOK millions, price is the average price, P5, P10, P25, P75, P90, and P95 are the 5th, 10th 25th 75th, 90th and 95th percentiles respectively.

PANEL A

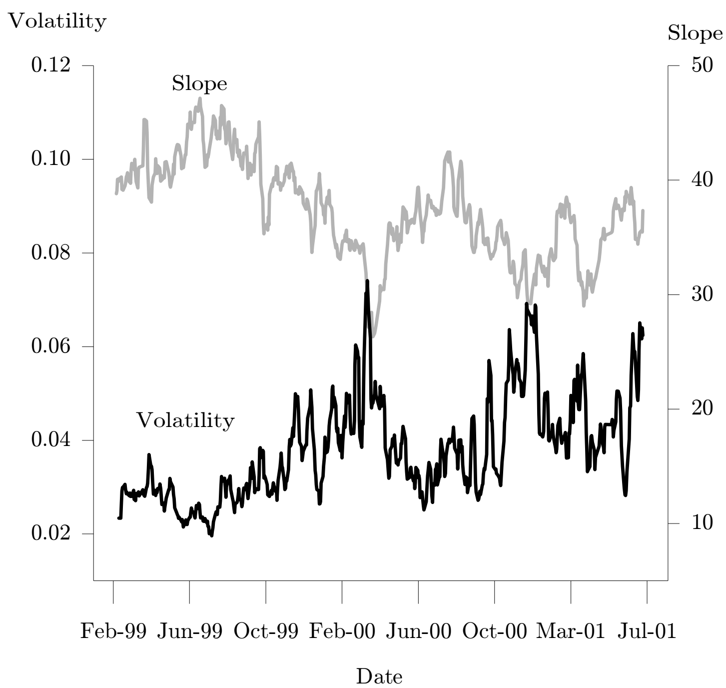
				Distribution of daily SLOPE estimates							
	N	MCAP	Price	P5	P10	P25	Median	Mean	P75	P90	P95
All firms	51015	7294	145	9.1	11.9	18.3	29.2	37.2	46.7	70.9	91.5
1999	16968	5948	110	9.4	12.6	20.3	33.2	41.4	53.0	79.2	101.3
2000	23853	7737	180	9.6	12.2	18.0	27.6	35.3	43.5	66.3	86.0
2001	10194	8498	122	7.8	10.6	16.5	27.0	34.7	43.4	65.2	85.7

PANEL B

				Distribution of daily SLOPE estimates							
	N	MCAP	Price	P5	P10	P25	Median	Mean	P75	P90	P95
MCAP Q1 (small)	12532	259	21	5.7	7.4	11.4	17.2	20.9	25.9	38.2	47.9
1999	4163	213	19	5.9	7.5	11.4	17.5	21.2	26.7	39.3	48.2
2000	5864	282	22	6.3	8.2	12.1	17.6	20.9	25.7	36.6	45.9
2001	2505	283	22	4.6	6.0	10.0	15.9	20.5	25.2	40.4	50.9
MCAP Q2	12828	1005	64	10.6	12.9	18.1	26.3	31.8	39.0	56.4	70.9
1999	4264	869	50	11.3	14.0	19.7	28.8	34.0	41.8	59.3	74.4
2000	5999	1035	69	10.7	12.8	17.7	25.1	30.2	36.9	53.1	66.8
2001	2565	1158	76	9.8	12.0	16.9	25.2	31.8	39.2	57.8	73.2
MCAP Q3	12672	2786	121	12.0	15.3	22.2	32.5	39.0	48.1	69.9	87.2
1999	4210	2289	106	15.3	19.1	26.5	38.1	45.2	55.8	78.9	98.1
2000	5934	2914	133	11.6	14.7	21.1	30.4	36.5	44.3	65.0	82.4
2001	2528	3315	121	10.6	13.1	19.5	28.9	34.5	43.0	61.3	75.8
MCAP Q4 (large)	12983	24698	369	18.0	22.1	31.6	47.1	56.5	69.4	101.6	128.8
1999	4331	20016	261	23.0	28.2	38.9	55.7	64.2	79.0	111.6	136.6
2000	6056	26320	491	16.7	21.0	29.2	44.0	53.1	64.6	94.6	120.3
2001	2596	28727	263	15.7	19.9	27.8	41.1	51.5	61.5	96.6	125.9

FIGURE 3.5 Average slope and volatility

The figure illustrates the relationship between the estimates of the average daily slope of the order book and the contemporaneous daily price changes. The left axis measures the equally weighted average absolute return across firms traded on the respective date. The right axis measures the slope estimate calculated as the daily equally weighted slope, averaged over all companies that were traded during the trading day.



As indicated by the correlation structure in table 3.7, our slope measure may also proxy for liquidity. We therefore control for other liquidity measures in the regression model. The estimated model can be written as;

$$\begin{aligned} |\epsilon_{i,t}| = {} & \beta_0 M_{i,t} + \beta_1 N_{i,t} + \beta_2 AV_{i,t} + \beta_3 MCAP_{i,t} + \beta_4 SPR_{i,t} + \\ & \beta_5 OV_{i,t} + \beta_6 SLOPE_{i,t} + \sum_{j=1}^{12} \rho_{i,j} \, |\epsilon_{i,t-j}| + \eta_{i,t}. \end{aligned} \tag{3.9}$$

where SLOPE is our slope estimate, MCAP is the market capitalization value (in mill. NOK), SPR is the quoted percentage midpoint spread, and OV is the average order book volume in thousand shares and $\eta_{i,t} = \nu_i + \varepsilon_{i,t}$ defines the error structure with ν_i as the non-random fixed, firm-specific, effect. Results from the estimation for the full sample period are provided in panel A of table 3.9. Model 1 is essentially the same as in the analysis in section 3.5.1, but with the addition of the slope variable and the

results for the balanced sample.

additional variables accounting for stock liquidity (SPR, MCAP, and OV). In model 2, we estimate the model excluding the two variables which are highest correlated with the slope (SPR and MCAP), and in model 3 we exclude the trading activity (mixing) variables. We also estimate the same regression equation across 3-month sub-periods. The results from this estimation are reported in panel B of the table. Because we use lagged versions of the dependent variable, $| \epsilon_{i,t-j} |$, as explanatory variables to adjust for autocorrelations in volatility, we choose a fixed effects model.[37]

The first thing to note in Panel A in table 3.9 is that the slope variable (SLOPE) is negative and highly significant across all three model specifications. Thus, volatility increases the more gentle the slope are. This may be linked to differences of opinion about public news, “noise trading” from uninformed investors[38], or pick-off risk.[39] We will discuss several interpretations of our findings at the end of the section.

Both the number of trades (N) and the trade size (AV) have a positive significant effect on volatility as we found earlier. When we remove trade size from the regression model, the reduction in R-squared is small (not shown in the table). Thus, the Jones et al. (1994) result that trade size does not include information that is not already included in the number of trades, is also evident in the panel analysis after we have controlled for additional liquidity variables. Moreover, the total volume in the order book (OV) is shown to have a significant positive effect on volatility. This result is consitent with the result in Biais et al. (1995) that more trades are executed when the order book is thick. The correlations shown in table 3.7 between order book volume and trade volume (45 percent) and between the order book volume and trades (19 percent) also suggest that the volume-volatility relation depends on the incoming order flow and the state of the order book. Finally, the estimation results show that larger firms are less volatile and that higher spreads coincide with higher volatility.

One important issue to note is that there is an indeterminacy with respect to the causality between volatility and several of the explanatory variables such as the average order book volume, number of trades, the spread and the slope measure. Although this probably is most important at the transaction level, several of our measures are averages across hourly snapshots. Thus, dynamic interactions between order submissions and the status of the order book, as examined in detail by Biais et al. (1995), is left out of our regression model. For instance, Biais et al. (1995) find that a thin book attracts new orders while a thick book increases trading activity. Another example is that a higher

[37]For a random-effects model to be applicable, the firm-specific constants, ν_i, must be uncorrelated with the regressors. This requirement is likely to be violated by the lagged variables. Later in the paper, we test whether we should use a random-effects model more formally by running Hausman tests.

[38]A problem could be that a steeper slope implies a less pronounced bid-ask bounce, and thus a lower volatility. However, as outlined in section 3.5.1, we try to avoid measurement errors due to the bid-ask bounce by calculating returns using the average of bid-ask prices.

[39]If some liquidity suppliers are informed about the volatility, as in the Foucault et al. (2003) model, they may find it optimal to bid less aggressively when they know that the volatility is high.

volatility may reduce the number of orders coming into the market, which again lowers the average slope of the book on that day. To examine this issues, we run simple Granger causality tests between our slope measure and various order types and trading activity variables, both on an hourly and a daily frequency. Overall, we are unable to determine a clear one-way causality relation between the variables, rather we find a two-way causality for most variable combinations.

The estimation results for models 2 and 3 are essentially the same as for model 1. The important thing to note is that the parameter estimate for SLOPE is significantly negative and relatively stable across the three model specifications. The slope parameter is most negative and most significant in model 2, when we remove the spread (SPR) and market capitalization (MCAP) variables. This suggests that the slope captures liquidity effects captured by these variables. Both the F-test of no firm-specific effects (firm-specific constants) and the Hausman specification test of whether a random-effects model would be more appropriate relative to the fixed effects specification, are rejected at the 1 percent level for all three models.[40] This suggests that our firm-specific dummies are correlated with the regressor, such that a fixed-effects specification is more appropriate. The reason for this is that we have lagged versions of the dependent variable, which makes ν_i correlated with the regressors.

To examine the stability of the slope measure, we estimate model 1 for non-overlapping sub-periods of three months through the entire sample period. The results from these regressions are reported in panel B in table 3.9. We only report the parameter estimates and tests for the slope variable, number of trades, and trade size. The SLOPE parameter is remarkably stable across the sub-samples. In addition, it is significant at the 1 percent level within all sub-samples, except for the first. Also, the number of trades is highly significant across all sub-periods while the average trade size is significant at the 1 percent level only in half of the sub-sample regressions, suggesting that the number of trades is the important component of volume in the volume-volatility relation, as also suggested by our analysis in section 3.5.1. The parameter estimate for the number of trades decreases over the sample period. This is most likely due to the fact that the mean number of trades across companies increases through the sample period.

F-tests of no fixed effects within each sub-period regression is rejected at the 1 percent level.[41] Our results suggest that both the order flow and the status of the order book are significantly related to contemporaneous volatility in addition to trading volume.

[40] The Hausman test compares an inefficient but consistent OLS estimator (the fixed effects case) to an efficient GLS estimator (the random effects case). Thus, the Hausman test is a test of H_0, that random effects would be consistent and efficient, versus H_1, that random effects would be inconsistent. Rejecting H_0 would suggest that we should use a fixed effects specification.

[41] In addition, the Hausman test rejects a random effects specification at the 1 percent level for each sub-sample model.

TABLE 3.9

A volume-volatility regression model including the (full) order book slope

The table shows the results from estimating a panel regression model with one-way fixed effects (least squares dummy variable estimation) for the whole sample (Panel A) and for sub-periods of 3 months (Panel B). The estimated model (model 1) is,

$$| \epsilon_{i,t} |= \beta_0 M_{i,t} + \beta_1 N_{i,t} + \beta_2 AV_{i,t} + \beta_3 MCAP_{i,t} + \beta_4 SPR_{i,t} + \beta_5 OV_{i,t} + \beta_6 SLOPE_{i,t} + \sum_{j=1}^{12} \rho_{i,j} \mid \hat{\epsilon}_{i,t-j} \mid + \eta_{i,t}.$$

where $\eta_{i,t} = \nu_i + \varepsilon_{i,t}$ defines the error structure with ν_i as the non-random fixed, firm-specific, effects. $| \epsilon_{i,t} |$ is the absolute return adjusted for day of week effects and autocorrelation in returns. M is a dummy variable for Monday, N is the number of transactions, AV is the average trade size in shares, $MCAP$ is the market capitalization (in mill. NOK), SPR is the relative spread (quoted spread as a percent of the midpoint price), OV is the total number of shares in the order book (sum of all orders on bid and ask side of the order book) and $SLOPE$ is the average slope of the bid and offer side of the order book. Panel A, shows the parameter estimates for 3 variations of the full model (model 1), t-values, and standard errors for the parameter estimates. In model 2, we do not control for the market capitalization ($MCAP$) and spread (SPR) variables, and in model 3 we exclude the trading activity (N) and trade size (AV) variables. The table shows the associated t-values as well as the R^2 for each portfolio regression. The autoregressive estimates have been excluded from the table. For the F-tests, ** denotes significance at the 1 percent level. Panel B, shows the sub-period estimates for model 1 for the $SLOPE$, N and AV variables with associated t-values. For each period, the model R-squared, F-test for fixed effects, and number of cross-sectional observations (N) and number of time series observations (T) are reported in the last four rows of the table.

PANEL A: Whole sample regression

	MODEL 1			MODEL 2			MODEL 3		
Variables	Est.	t-value	std.err	Est.	t-value	std.err	Est.	t-value	std.err
M (Monday)	0.021	0.60	0.035	0.037	1.05	0.036	-0.014	-0.38	0.036
N (trades)	0.005	43.95	0.000	0.005	41.06	0.000	-	-	-
AV (tradesize)	0.025	6.18	0.004	0.023	5.68	0.004	-	-	-
$MCAP$ (firmsize)	-0.013	-2.79	0.005	-	-	-	-0.001	-0.18	0.005
SPR (rel.spread)	0.234	24.65	0.009	-	-	-	0.181	18.86	0.010
$SLOPE$	-0.007	-11.82	0.001	-0.009	-14.43	0.001	-0.008	-12.35	0.001
OV (ordervolume)	0.023	6.32	0.004	0.023	6.34	0.004	0.050	13.77	0.004
R^2	21.8%			20.7%			18.3%		
N (firms)	98			98			98		
T (time series)	572			572			572		
F-test (no fixed effects)	17.5**			15.13**			11.34**		

PANEL B: Sub-period regression

	$SLOPE$		N (trades)		AV (trade size)		Model			
Quarter	β_6	t-value	β_1	t-value	β_2	t-value	R^2	F test	N	T
1999.1	-0.008	-1.39	0.016	4.90	0.082	1.50	37.6%	2.57**	61	14
1999.2	-0.005	-2.74	0.013	10.97	0.059	3.00	26.6%	4.31**	87	59
1999.3	-0.005	-3.19	0.011	11.24	0.061	3.99	36.7%	7.71**	96	66
1999.4	-0.006	-2.67	0.014	16.04	0.039	2.90	27.5%	5.54**	97	64
2000.1	-0.007	-3.22	0.013	26.42	0.032	1.65	31.0%	7.96**	98	65
2000.2	-0.006	-2.89	0.013	18.86	0.019	1.06	30.7%	5.23**	98	58
2000.3	-0.007	-4.36	0.010	20.86	0.004	0.52	29.6%	6.41**	98	65
2000.4	-0.009	-4.29	0.007	16.12	0.018	2.08	21.6%	4.11**	97	63
2001.1	-0.008	-4.41	0.003	6.26	-0.005	0.05	25.6%	5.17**	93	64
2001.2	-0.008	-4.63	0.002	8.92	0.027	2.08	25.9%	4.67**	88	54
Average	-0.007	-3.38	0.010	14.06	0.034	1.88	29.3%			

A robustness check In a limit order market, most trades originate from limit orders, i.e. there must be a strong relationship between order book shape, volatility and trading volume. One interpretation of our slope measure is that it is essentially a liquidity measure, and that the inner part of the order book is capturing the main effect on volatility. A useful way to check this is to examine whether the slope calculated from different sets of the order book contain different information about volatility. One way of doing this is to calculate the slope based on truncated versions of the order book.

We re-calculate the slope measure based on two different subsets of the book. The resulting estimate distributions are shown in figure 3.6. Figure 3.6a shows the frequency distribution of slope estimates calculated from an order book which is truncated to 5 ticks away from the best quotes.[42] Figure 3.6b shows the distribution of daily slope estimates when we calculate the average slope based on twice as much of the order book (+/- 10 ticks). Finally, figure 3.6c shows the frequency distribution when we base our slope estimates on the entire order book (+/- 100 ticks). The slope decreases the more of the order book we use. This is expected, if the supply and demand curves in the order book are concave.[43] The mean slope when we use the full order book is about 37 (median 28), while it increases to 57 (median 46) and 76 (median 62) when we calculate it from the order book truncated to +/- 10 and +/- 5 ticks respectively.

To examine whether the inner part of the order book captures the relationship between volatility and slope, we re-estimate the regression models in table 3.9 with slope measures calculated from the two sub-sets of the order book. Panel A in table 3.10 reports the estimation results. The results when we use the slope calculated from the order book truncated to +/- 10 ticks (SLOPE10) from the best quote on each side are reported in model 1a, and the results when we truncate the order book to +/- 5 ticks (SLOPE5) are reported in model 1b. All other variables are identical to the previous analysis. Panel B of the table shows the correlation between each slope measure and other variables. The main result from the estimation is that the slope parameter remains negative and significant. In addition, the parameter estimates become smaller compared to the case where we used the full order book. The decrease in parameter size is mainly due to the fact that the mean of the slope estimates increases (as shown in figure 3.6) while the dependent variable remains unchanged. Thus, the relationship seems to be similar when we use only the inner levels of the order book to calculate the slope. Also R-squared of the different models does not change when we change the slope variable. Overall, our results suggest that the different slope measures capture mainly the same relationship.

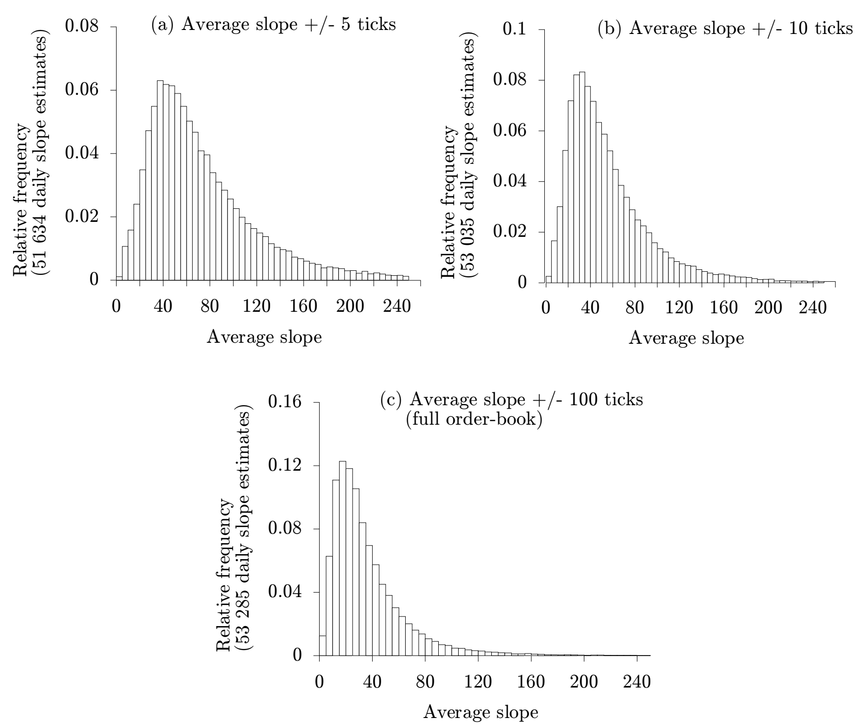
Panel B in table 3.10 shows the correlations between the three slope measures and the activity and liquidity variables. One interesting thing to note is that the correlation

[42] That is, we use only the cumulative volume at the five first ticks on each side of the order book when we calculate the average slope.

[43] Concave when we have price on the x-axis and volume on the y-axis.

FIGURE 3.6 Frequency distribution of slope estimates

The figures show the frequency distributions for (average) daily equally weighted normalized slope estimates for all firms for the entire sample period. In figure (a) the slope calculations are calculated using only the first 5 levels of the order book, in figure (b) we use the first 10 levels of the order book and in figure (c) we use the entire order book up to 100 tick levels.



between the slope and number of trades and between the slope and the trade volume in shares increases substantially the more we truncate the order book. This may reflect that the relationship found in Biais et al. (1995), that a thicker (more concentrated) order book results in trades, is more pronounced when we evaluate the relationship closer to the inner quotes.

Table 3.11 shows the estimation results when estimating the model using the truncated slope measures across sub-periods. Similar to our findings when we estimate the model over the whole sample period, we find that the size of the parameter estimate as well as its significance declines the more we truncate the order book. For model 1b, when we truncate the order book to 5 ticks, the slope estimate is only significantly different from zero for half of the sub-samples. Thus, the significance of the slope variable is greatly reduced within sub-periods when we only use the inner part of the book. Note also that when we use the slope based on the full order book, the relationship between volatility and slope is stronger across sub-periods, as shown in panel B in table 3.9.

3.5.4 Number of trades and order book shape

In this sub-section, we examine the relationship between the slope and the contemporaneous trading volume.

In table 3.12 we estimate a cross-sectional time series regression with the number of trades as the dependent variable. As before, we control for liquidity variables which are expected to be important with respect to the number of trades. When we base our slope measure on the the full order book (model 1 in panel A), a significant negative relationship between the slope and the number of trades is documented. Thus, the more gentle the order book slope, the higher the trading volume represented by the number of trades. Models 2 and 3 in table 3.12 are estimated with slope measures calculated from the truncated order books. Interestingly, we find that the parameter estimate switches sign and becomes more positive the closer we get to the inner quotes. Thus, the slope at the inner quotes is positively related to the number of trades, while the average slope for the full book is negatively related to trade execution. In other words, the relationship between liquidity and trading activity becomes more evident when we restrict the analysis to the inner part of the order book.

We also find that the number of trades is lower on Mondays, that the average trade size is unrelated to the number of trades, and that larger firms are more frequently traded. In addition, we find that there is less trading when the quoted percentage spread is large, and that there are more trades when the volume of shares in the order book is high. Again, one caveat with respect to the analysis is that we do not take into account the dynamic interactions between the order flow and status of the order book. For example, as found by Biais et al. (1995), a thinner book may attract new orders which in the next step increases the number of transactions. The most interesting result

TABLE 3.10
The relationship between volatility and truncated order book

The table shows the results from the estimation of two panel regression models where we use slope measures calculated from different sub-sets of the full order book. In model 1a in Panel A, the average slope variable is calculated from the order book truncated to contain only the first 10 tick levels on the bid and ask side. In model 1b in Panel A, the slope is calculated from the order book truncated to quotes and volumes including the first 5 tick levels. All other variables are the same as the ones we use in the regression model described in table 3.9. The models are estimated with one-way fixed effects for the whole sample. The estimated model is,

$$
\begin{aligned}
\mid \epsilon_{i,t} \mid = \beta_0 M_{i,t} + \beta_1 N_{i,t} + \beta_2 AV_{i,t} + \beta_3 MCAP_{i,t} + \beta_4 SPR_{i,t} + \\
\beta_5 OV_{i,t} + \beta_6 SLOPE_{i,t} + \sum_{j=1}^{12} \rho_{i,j} \mid \hat{\epsilon}_{i,t-j} \mid + \eta_{i,t}.
\end{aligned}
$$

where $\eta_{i,t} = \nu_i + \varepsilon_{i,t}$ defines the error structure with ν_i as the non-random fixed, firm specific, effects. $\mid \epsilon_{i,t} \mid$ is the absolute return adjusted for day of week effects and autocorrelation in returns. M is a dummy variable for Monday, N is the number of transactions, AV is the average trade size in shares, $MCAP$ is the market capitalization (in NOK mill.), SPR is the relative spread (quoted spread as% of the midpoint price), OV is the total number of shares in the order book (sum of all orders on bid and ask side of the order book) and $SLOPE$ is the average slope of the bid and offer side of the truncated order book. The autoregressive estimates have been excluded from the table. Panel B shows the correlation between various variables and the three slope measures calculated from the full order book as well as the two slope measures calculated from the restricted order books. ** indicates that the F-test from a test of no fixed effects is rejected at the 1 percent level.

PANEL A: Whole sample regression

	MODEL 1a (+/- 10 ticks)			Model 1b (+/- 5 ticks)		
Variables	Estimate	t-value	std.err	Estimate	t-value	std.err
M (Monday dummy)	0.023	0.6	0.035	0.028	0.8	0.036
N (trades)	0.005	45.2	0.000	0.005	45.5	0.000
AV (avg. trade size)	0.023	5.7	0.004	0.022	5.5	0.004
$MCAP$ (market capitalization)	-0.010	-2.0	0.005	-0.009	-1.8	0.005
SPR (% quoted spread)	0.236	24.8	0.010	0.234	23.1	0.010
$SLOPE10$ (+/- 10 ticks)	-0.005	-11.4	0.000	-	-	-
$SLOPE5$ (+/-5 ticks)	-	-	-	-0.003	-9.9	0.000
OV (order-book volume)	0.023	6.3	0.004	0.023	6.3	0.004
R^2	21.8%			21.8%		
N (cross section)	98			98		
T (time series)	572			572		
F-test no fixed effects	18.33**			17.93**		

PANEL B: Variable correlations

	$SLOPE$ (Full order-book)	$SLOPE10$ (+/- 10 ticks)	$SLOPE5$ (+/- 5 ticks)
N (trades)	0.13	0.25	0.28
Trade volume shares (V)	0.08	0.45	0.45
AV (avg. trade size)	-0.08	-0.09	-0.11
$MCAP$ (market capitalization)	0.44	0.42	0.41
SPR (% quoted spread)	-0.32	-0.31	-0.33
OV (order-book volume)	0.04	0.04	0.03

Table 3.11
The relationship between volatility truncate order book across sub-periods

The table shows the results from estimating the two panel regression model in table 3.10 for sub-periods of three months. In model 1a, the average slope variable is calculated using an order book truncated to the first 10 tick levels on the bid and ask side. In model 1b, the average slope is calculated using an order book truncated to prices and volumes within the first 5 tick levels. All other variables are the same as the variables used in table 3.9. The models are estimated with one-way fixed effects for each sub-period. The estimated model is,

$$\begin{aligned}|\epsilon_{i,t}| = {} & \beta_0 M_{i,t} + \beta_1 N_{i,t} + \beta_2 AV_{i,t} + \beta_3 MCAP_{i,t} + \beta_4 SPR_{i,t} + \\ & \beta_5 OV_{i,t} + \beta_6 SLOPE_{i,t} + \sum_{j=1}^{12} \rho_{i,j} \,|\, \hat{\epsilon}_{i,t-j} \,| + \eta_{i,t}.\end{aligned}$$

where $\eta_{i,t} = \nu_i + \varepsilon_{i,t}$ defines the error structure with ν_i as the non-random fixed, firm-specific, effects. $|\epsilon_{i,t}|$ is the absolute return adjusted for day of week effects and autocorrelation in returns. M is a dummy variable for Monday, N is the number of transactions, AV is the average trade size in shares, $MCAP$ is the market capitalization (in NOK mill.), SPR is the relative spread (quoted spread as% of the midpoint price), OV is the total number of shares in the order book (sum of all orders on bid and ask side of the order book) and $SLOPE$ is the average slope of the bid and offer side of the restricted order book. The table shows the parameter estimates for 2 variations of model 1 in table 3.9 with the associated t-value, std.error of the estimate, the model R-squared. ** indicates that the F-test for no fixed effects is rejected at the 1 percent level.

	Model 1a (+/- 10 ticks)					Model 1b (+/- 5 ticks)				
Quarter	SLOPE10	t-val.	std.err	R^2	F-val.	SLOPE5	t-val.	std.err	R^2	F-val.
1999.1	0.000	-0.1	0.004	39%	3.4**	-0.003	-1.1	0.003	31%	2.2**
1999.2	-0.004	-2.4	0.002	27%	4.2**	-0.001	-0.9	0.001	27%	4.5**
1999.3	-0.002	-1.6	0.001	33%	5.2**	-0.001	-0.7	0.001	34%	5.0**
1999.4	-0.003	-1.7	0.002	28%	6.1**	-0.001	-1.1	0.001	28%	6.5**
2000.1	-0.004	-2.6	0.001	31%	8.4**	-0.002	-1.9	0.001	31%	8.5**
2000.2	-0.003	-2.4	0.001	30%	5.1**	-0.002	-2.0	0.001	30%	5.1**
2000.3	-0.003	-2.8	0.001	31%	6.9**	-0.001	-1.2	0.001	31%	6.8**
2000.4	-0.006	-4.6	0.001	24%	4.1**	-0.005	-4.2	0.001	24%	4.0**
2001.1	-0.004	-3.1	0.001	26%	5.2**	-0.003	-2.6	0.001	26%	5.2**
2001.2	-0.006	-4.0	0.001	25%	4.8**	-0.004	-3.3	0.001	26%	4.8**
Average	-0.004	-2.5	0.002	29.4%		-0.002	-1.9	0.001	28.8%	

from the estimation is that a slope measure calculated on the basis of the full order book seems to provide different information compared to a slope measure calculated on the basis of the volume at the inner quotes.

In the previous sub-section, we found that the relationship between price volatility and the slope was well proxied by a slope measure based on the inner part of the book. In this section, we have documented a significant difference between slope measures based on different order book truncations.

3.5.5 Interpretation of the results

The relationships documented in this study are interesting in several respects. First, although most of the activity occur at the inner part of the order book, the order book data shows that the liquidity provided at the inner quotes in many cases reflect only a modest part of the total liquidity supplied in the full order book. Second, the characteristics of the order book vary systematically over the trading day as well as across firms. Third, as far as we know, no previous studies have examined in detail the relationship between the characteristics of the full order book and volume and volatility in a cross-sectional time series setting.

One question is why orders persist further out in the book? One reason may be that traders are slow in revising their orders in response to new information. Another reason suggested by Sandås (2001) is that the placement of orders deep in the book are based on strategic choices where, in a multi-period setting, the gains from obtaining price priority of the orders further out in the book are traded off the costs of monitoring them. When we examine the slopes of the order books across companies over time, we find that there are marked differences across firms in the amount of volume provided throughout the order book, and that these differences persist through time. As shown in table 3.8 some firms have generally a very large fraction of their liquidity concentrated close to the best quotes, while other firms have a relatively larger fraction of the order volume further out in the book. A second question is why such differences in slope estimates across firms appear? The systematic patterns found may indicate that the shape of the order book capture some underlying characteristics of the the trading strategies of liquidity suppliers across firms. One possible explanation is related to asymmetric information. In general, we find that smaller firms have order books with a gentler slope than larger firms, which is in line with the hypothesis that there is more private information in smaller than in larger firms.

In summary, our main findings about the relationship between the slope of the book and the volume-volatility relation are;

- A more gentle slope (more dispersed order book) coincide with a higher volatility across firms and over time.

Table 3.12
The relationship between the number of trades and the order book slope

The table shows the results when we estimate the relationship between different slope measures and the number of trades. The model is estimated as a one-way fixed effects model. The estimated model is,

$$N_{i,t} = \beta_0 M_{i,t} + \beta_1 AV_{i,t} + \beta_2 MCAP_{i,t} + \beta_3 SPR_{i,t} + \beta_4 SLOPE_{i,t} + \beta_5 OV_{i,t} + \eta_{i,t}.$$

where $\eta_{i,t} = \nu_i + \varepsilon_{i,t}$ defines the error structure with ν_i as the non-random fixed, firm specific, effects. The dependent variable, N is the number of transactions, M is a dummy variable for Monday, AV is the average trade size in shares, $MCAP$ is the market capitalization SPR is the relative spread (quoted spread in% of the midpoint price), OV is the total number of shares in the order book (sum of all orders on bid and ask side of the order book) and $SLOPE$ is the average slope of the bid and offer side from the full order book, $SLOPE10$ is the slope calculated from the order book truncated to +/- 10 ticks, $SLOPE5$ is the slope calculated from the order book truncated to +/- 5 ticks. Panel A shows the estimation results from the whole sample, while panel B shows the estimation results from sub-periods. ** indicate that the F-test for fixed effects is significant at the 1 percent level.

PANEL A: Whole sample regression

	MODEL 1			MODEL 2			MODEL 3		
Variables	Est.	t-val.	std.err	Est.	t-val.	std.err	Est.	t-val.	std.err
M (Monday)	-6.17	-4.0	1.55	-6.01	-3.9	1.56	-6.25	-3.9	1.59
AV (trade size)	-0.06	-0.4	0.18	-0.17	-0.9	0.18	-0.14	-0.8	0.18
$MCAP$ (firm size)	3.34	15.7	0.21	2.94	13.7	0.22	2.79	12.8	0.22
SPR (spread)	-9.13	-22.0	0.41	-8.49	-20.3	0.42	-9.03	-20.0	0.45
$SLOPE$ (full book)	-0.30	-11.1	0.03	-	-	-	-		
$SLOPE10$ (+/- 10)	-	-	-	0.14	6.9	0.02	-		
$SLOPE5$ (+/- 5)	-	-	-	-	-	-	0.20	12.9	0.02
OV (order-book vol.)	5.15	32.3	0.16	5.17	32.4	0.16	5.16	32.0	0.16
R^2	39.4%			39.3%			39.3%		
N cross section	95			95			95		
Time series	572			572			572		
F-test (no fixed effects)	235.5**			214.3**			200.3**		

PANEL B: Sub-period regression

	Full order book				+/- 10 ticks				+/- 5 ticks			
Quarter	β_4	t-val.	R^2	F-val.	β_4	t-val.	R^2	F-val.	β_4	t-val.	R^2	F-val.
1999.1	-0.05	-0.77	84%	18**	-0.06	-1.19	84%	18**	-0.06	-1.48	83%	17**
1999.2	-0.10	-3.72	77%	44**	-0.09	-3.89	77%	44**	-0.06	-2.95	76%	42**
1999.3	-0.12	-4.95	83%	45**	-0.09	-4.23	83%	45**	-0.06	-3.40	83%	42**
1999.4	-0.01	-0.28	71%	68**	0.06	2.17	71%	67**	0.07	3.35	71%	65**
2000.1	-0.37	-5.82	56%	61**	-0.18	-4.14	56%	60**	-0.08	-2.12	56%	59**
2000.2	-0.11	-2.16	73%	46**	-0.06	-1.72	73%	44**	-0.03	-1.00	73%	41**
2000.3	-0.13	-2.70	72%	68**	-0.08	-2.37	72%	63**	-0.08	-2.89	72%	61**
2000.4	-0.12	-2.02	70%	113**	-0.05	-1.26	70%	101**	-0.00	-0.02	70%	92**
2001.1	-0.02	-0.42	85%	172**	0.03	0.72	85%	158**	0.04	1.32	85%	149**
2001.2	-0.21	-1.70	69%	91**	0.08	0.81	69%	81**	0.15	1.98	69%	73**
Average	-0.13	-2.45	74%		-0.05	-1.51	74%		-0.01	-0.72	74%	

- The relationship between the number of trades and the slope of the book depends on which subset of the order book is used.
  - When we use the slope from the inner book (+/- 5 ticks) there is a positive relationship in which a steep slope coincide with a high number of trades.
  - When the entire order book is used (+/- 100 ticks), the relationship is reversed, i.e. a more gentle slope coincide with a higher number of trades.

One interesting interpretation of these results is that the differences in the limit order books across firms reflect valuation uncertainty and heterogenous valuations among the liquidity suppliers. Although no models exist that offer any predictions to how the full limit order book would look like in a market with heterogenous liquidity suppliers, models assuming strategic behavior of uninformed investors provide an interesting framework which could motivate such an interpretation. Shalen (1993) shows that the strategic behavior of liquidity traders may be an important contributor to both volume and volatility in addition to information arrivals. In her model, when uninformed investors has dispersed beliefs about asset values, they are faced with a signal extraction problem, making them react to all types of trades in the order-flow which may or may not be related to informed trading. Due to this, they increase both trading volume and price volatility above what would be expected in equilibrium. Thus, the relationship between volume and volatility is not merely due to the information arrival process (as in the mixture of distributions framework), but also due to strategic trading by uninformed traders. The higher the fraction of uninformed traders in the population, the greater the dispersion of beliefs, and the greater the excess volume and excess volatility.

Valuation uncertainty (dispersion of beliefs) may to some degree be captured by the shape of the order book, as different levels of the book reflect the reservation prices of liquidity suppliers. This provides an interesting interpretation for why the order volumes observed in the limit order book are more dispersed than predicted by theoretical models such as Glosten (1994). If the uncertainty about the value of a firm is high and liquidity traders differ in their private valuations, they may submit their orders across a wider range of prices relative to the case when there is greater agreement about the true value, cf the example in figure 3.2 where we show the difference in the average order books between two companies which obviously differ in their valuation uncertainty.

If valuation uncertainty coincide with a more gentle order book slope, our results support several predictions from Shalen (1993). First, increased dispersion of beliefs is predicted to increase (excess) trading volume. Our finding that a more gentle slope coincide with a greater number of trades is in line with this prediction. Second, a peak volume and volatility is predicted at the beginning of the trading day because dispersion of beliefs is greater when the price signal is more noisy. As shown in section 3.4, the slope of the order book is relatively more gentle in the beginning of the trading day than later in the day. However, this feature of the data may also be due to adjustments in liquidity demand.

There are also models that relate the status of the order book to the order submission strategies of homogeneous liquidity providers and how they provide the limit order book when there is a probability of informed trading. If one takes the one period model by Glosten (1994) as a benchmark, the slope of the supply and demand schedules in the order book results from the probability of informed trading. Sandås (2001) tests the predictions in Glosten (1994) in the Swedish market which is very similar to the Norwegian market. He finds strong evidence that there is insufficient depth in the observed order book relative to the theoretical prediction. In other words, the slope of the demand and supply schedules in the order book, at the inner quotes, is much too gentle to be explained by theory.

Our results for the inner part of the order book are consistent with models where a higher liquidity at the inner quotes increases the number of trades. However, our results for the full order book provide some additional results that are not captured by any theoretical model. Our finding that the volume and volatility in financial markets may be affected by valuation uncertainty and heterogenous beliefs among liquidity suppliers provides a motivation for future research on this topic. From a more practical point of view, the discussions in the popular press about the value of companies, and sometimes very different buy and sell recommendations by analysts for the same stock, suggest that the differences in valuations may be an important factor driving trading activity in financial markets.

3.6 Conclusion

A positive correlation between price volatility and trading volume has been documented in a variety of studies. Investigating plausible explanations for this relation is important because it can enhance our understanding of how information is disseminated into market prices.

There are two, mainly complementary, hypotheses relating trading volume and volatility. The mixture of distributions hypothesis states that the volume-volatility relation is driven by a directing process that can be interpreted as the flow of information. The dispersion of beliefs hypothesis states that both trading volume and volatility should be higher the greater the dispersion of beliefs about security values among investors. One explanation behind this statement is based on asymmetric information and strategic investor behavior. Uninformed traders cannot distinguish informed trades from liquidity trades, and by reacting to trades with no information content, they increase both volume and volatility relative to equilibrium values in a situation with symmetric information. A positive relation between dispersion of beliefs and the volume-volatility relation can also be explained in a non-informational setting where investors have different opinions about the value of the same news. Thus, while the mixture of distributions hypothesis states that trading volume and price movements result from new information arrivals, the dispersion of beliefs hypothesis also relates a part of the volume-volatility relation to increased trading by uninformed traders or symmetrically informed investors who disagree on the same news.

Using a detailed data sample from the Oslo Stock Exchange (OSE), we examine whether information about the volume-volatility relation is contained in the shape of a limit order book. We first document that our data exhibit a standard volume-volatility relation. Moreover, we show that the result in Jones et al. (1994), that the average size of trades has little marginal explanatory power when volatility is conditioned on the number of daily transactions, also applies in a limit order market. A unique feature of our data sample is that we can rebuild the whole order book at any time during the trading day. This enables us to investigate whether the characteristics of the limit order book contain information about the volume-volatility relation.

Our main findings show that more gentle demand and supply schedules increases volatility and trading volume in a cross-sectional time series setting. One possible interpretation of this is that the number of trades is not a proxy for the mixing variable, but the mixing variable itself as suggested in models with heterogenous agents.

3.A Calculating slope measures

To explain the slope calculation more specifically, let N_A and N_B be respectively the total number of bid and ask prices (tick levels) containing orders. Let τ denote the tick level, with $\tau = 1$ representing the best quote with a positive volume. Furthermore, let p_1^B and p_1^A be respectively the best bid and ask prices, and p^M denote the bid-ask midpoint (which is the average of p_1^B and p_1^A). Let ν_τ^B and ν_τ^A be respectively the percentage of total share volume at each tick level on the bid and ask side of the book. E.g. $\nu_{\tau=1}^A$=0.1 would mean that 10% of the total number of shares supplied on the ask side of the order book is located at the best ask quote at that point in time. Finally, let ω_τ^B and ω_τ^A denote the weight of the local slope calculated at tick level τ for respectively the bid and the ask side of the book. These weights are set equal in the case when we equally weight the local slopes across all tick levels. In the case when we weight each local slope differently, we use a simple linear weighting scheme where the weight at each tick level, τ, is calculated as,

$$\omega_\tau^A = \frac{|\tau^{max}| - |\tau| + 1}{\sum_\tau (|\tau^{max}| - |\tau|) + 1} \tag{3A.1}$$

for the ask side, and similarly for the bid side. τ^{max} is the maximum tick level with non-zero volume. Thus, the quotes which are the furthest out in the order book (e.g. at τ=80) get a relatively smaller weight than orders closer to the midpoint (e.g. at τ=10). The summation is done across all ticks with a non-zero volume. This ensures that the weights sum to one on each side of the book.

The average elasticity for the supply curve, SE, on day t at snapshot time $s \in [1..6]$ for company i can then be represented as,

$$SE_{i,t}^s = \left\{ \frac{\nu_1^A}{p_1^A / p^M - 1} \omega_{i,1}^A + \sum_{\tau=1}^{N_A} \frac{\nu_{\tau+1}^A / \nu_\tau^A - 1}{p_{\tau+1}^A / p_\tau^A - 1} \omega_{i,\tau}^A \right\} \tag{3A.2}$$

Similarly, the demand curve, DE, can be represented as,

$$DE_{i,t}^s = \left\{ \frac{\nu_1^B}{| p_1^B / p^M - 1 |} \omega_{i,1}^B + \sum_{\tau=1}^{N_B} \frac{\nu_{\tau-1}^B / \nu_\tau^B - 1}{| p_{\tau-1}^B / p_\tau^B - 1 |} \omega_{i,\tau}^B \right\} \tag{3A.3}$$

The first term of both equations expresses the slope between the bid-ask midpoint and the best bid and ask prices, while the second term of both equations expresses the sum of the local elasticities for the rest of the order book. The average elasticity in the order book at snapshot s is just the average of $SE_{i,t}^s$ and $DE_{i,t}^s$,

$$\mathsf{SLOPE}^s_{i,t} = \frac{\mathsf{SE}^s_{i,t} + \mathsf{DE}^s_{i,t}}{2} \tag{3A.4}$$

The order book is rebuilt at 10:30, 11:30, 12:30, 13:30, 14:30 and 15:30 each trading day for each firm. We exclude order volume above/below 100 ticks away from the inner quotes. For a stock trading at NOK 100 with a minimum tick size of NOK 0.5 this would mean that orders above NOK 150 and below NOK 50 are excluded from our calculations. Also, if we based our estimates of daily elasticities on one snapshot only (e.g. at noon), they could be biased due to large trades having temporarily reduced the liquidity of one side of the book or systematic time of day effects. To obtain a less noisy representation of the average daily supply and demand curves for each firm on each date, we therefore average the slopes across the 6 snapshots, i.e.

$$\mathsf{SLOPE}_{i,t} = \frac{1}{6}\sum_{s=1}^{6} \mathsf{SLOPE}^s_{i,t} \tag{3A.5}$$

3.B Balanced sample estimation

To examine the robustness of our results, we restrict our sample to firms that were traded every day through the sample period of 572 trading days. This leaves us with a balanced sample of 25 firms with 572 time series observations each. In addition, the filtering leaves us with a sample of the largest, most liquid and actively traded firms on the exchange. If the previous results are mainly due to noise or outliers introduced by small illiquid firms or the unbalanced dataset, the balancing of the sample should reveal this. In table 3.B1 we re-estimate model 1 in panel A of table 3.9 and model 1a and 1b in panel A of table 3.10 for the balanced sample. The estimation results are quantitatively similar to the results when we use the full sample. Most interestingly, the parameter estimate for SLOPE is negative and of similar size as before. In addition, the SLOPE estimate becomes smaller (less negative) the more we truncate the order book. As before, this is mainly due to the increase in the size of the slope estimates the more the order book is truncated. The largest difference between the models estimated for the balanced and unbalanced sample is that the R-squared of the models is much higher for the balanced sample, suggesting that there is more noise in the unbalanced sample.

In table 3.B2 we re-estimate the model for trading activity in panel A of table 3.12 for the balanced sample. Although the parameter estimates change more in size than what was the case for the volatility models, the parameters are qualitatively similar. Most importantly, the SLOPE parameter estimate is negative when it is calculated using the full order book, and becomes increasingly more positive the more the order book is truncated. Thus, also for the balanced sample, the results suggests that the more

TABLE 3.B1

Volatility/slope regression with balanced data sample

The table shows the estimation results of a cross-sectional time series model for the relationship between different slope measures and the daily volatility when using a balanced sample. The models are similar to those estimated (for the unbalanced sample) in table 3.9 (Model 1) and table 3.10. The estimated model is,

$$| \epsilon_{i,t} | = \beta_0 M_{i,t} + \beta_1 N_{i,t} + \beta_2 AV_{i,t} + \beta_3 MCAP_{i,t} + \beta_4 SPR_{i,t} + \beta_5 OV_{i,t} + \beta_6 SLOPE_{i,t} + \sum_{j=1}^{12} \rho_{i,j} | \hat{\epsilon}_{i,t-j} | + \eta_{i,t}.$$

where $\eta_{i,t} = \nu_i + \varepsilon_{i,t}$ defines the error structure with ν_i as the non-random fixed, firm-specific, effects. $| \epsilon_{i,t} |$ is the absolute daily return, N is the number of transactions, M is a dummy variable for Monday, AV is the average trade size in shares, $MCAP$ is the market capitalization (in NOK mill.), SPR is the relative spread (quoted spread as % of the midpoint price), OV is the total number of shares in the order book (sum of all orders on bid and ask side of the order book) and $SLOPE$ is the average slope of the bid and offer side from the full order book, $SLOPE10$ is the slope calculated from the order book truncated to +/- 10 ticks, $SLOPE5$ is the slope calculated from the order book truncated to +/- 5 ticks. $| \hat{\epsilon}_{i,t-j} |$ are lagged absolute returns to take into account autocorrelations.

PANEL A: Volatility/slope regressions for balanced sample

	Volatility/slope (full book)			Volatility/slope (+/- 10 ticks)			Volatility/slope (+/- 5 ticks)		
Variables	Est.	t-value	std.err	Est.	t-value	std.err	Est.	t-value	std.err
M (monday dummy)	-0.083	-1.5	0.057	-0.081	-1.4	0.057	-0.078	-1.4	0.057
N (trades)	0.004	34.6	0.000	0.004	35.6	0.000	0.004	35.7	0.000
AV (avg. trade size)	0.017	2.5	0.007	0.014	2.0	0.007	0.013	1.9	0.007
$MCAP$ (market cap.)	-0.015	-2.7	0.006	-0.009	-1.6	0.006	-0.008	-1.4	0.006
SPR (% quoted spread)	0.345	16.3	0.021	0.358	16.9	0.021	0.351	16.6	0.021
$SLOPE$ (full book)	-0.008	-10.0	0.001	-	-	-	-	-	-
$SLOPE10$ (+/- 10 ticks)	-	-	-	-0.007	-10.6	0.001	-	-	-
$SLOPE5$ (+/-5 ticks)	-	-	-	-	-	-	-0.005	-9.6	0.001
OV (order book volume)	0.011	3.1	0.004	0.010	3.0	0.004	0.011	3.0	0.004
R^2	37.6%			37.6%			37.5%		
N (cross section)	25			25			25		
T (time series)	572			572			572		
F-test (no fixed effects)	41.6**			41.2**			40.9**		

dispersed prices are across the order book, the more trades are executed. Furthermore, when the slope is calculated from the truncated order book, only using the volume at the inner levels of the book, the results suggests that a thick book coincides with high trading activity.

Table 3.B2
Volume/slope regression for balanced sample

The table shows the results from estimating the relationship between the slope measures based on different truncations of the order book and the number of trades using a balanced sample. The models are similar to those estimated for the full (unbalanced) sample in table 3.12. The estimated model in panel B is,

$$N_{i,t} = \beta_0 M_{i,t} + \beta_1 AV_{i,t} + \beta_2 MCAP_{i,t} + \beta_3 SPR_{i,t} + \beta_4 SLOPE_{i,t} + \beta_5 OV_{i,t} + \eta_{i,t}.$$

where $\eta_{i,t} = \nu_i + \varepsilon_{i,t}$ defines the error structure with ν_i as the non-random fixed, firm-specific, effects. N is the number of transactions, M is a dummy variable for Monday, AV is the average trade size in shares, $MCAP$ is the market capitalization (in NOK mill.), SPR is the relative spread (quoted spread as % of the midpoint price), OV is the total number of shares in the order book (sum of all orders on bid and ask side of the order book) and $SLOPE$ is the average slope of the bid and offer side from the full order book, $SLOPE10$ is the slope calculated from the order book truncated to +/- 10 ticks, $SLOPE5$ is the slope calculated from the order book truncated to +/- 5 ticks.

PANEL B: Volume/slope regressions for balanced sample

	Trades/slope (full book)			Trades/slope (+/- 10 ticks)			Trades/slope (+/- 5 ticks)		
	Est.	t-value	std.err	Est.	t-value	std.err	Est.	t-value	std.err
M (monday dummy)	-15.05	-3.6	4.224	-14.01	-3.3	4.227	-13.98	-3.3	4.216
AV (avg. trade size)	-0.50	-0.9	0.514	-0.49	-0.9	0.514	-0.34	-0.7	0.513
$MCAP$ (market cap.)	8.10	19.7	0.411	7.41	17.8	0.417	6.89	16.4	0.420
SPR (% quoted spread)	-32.39	-21.0	1.543	-32.47	-21.0	1.545	-32.07	-20.8	1.540
$SLOPE$ (full book)	-0.50	-8.1	0.062	-	-	-	-	-	-
$SLOPE10$ (+/- 10 ticks)	-	-	-	0.33	6.7	0.049	-	-	-
$SLOPE5$ (+/- 5 ticks)	-	-	-	-	-	-	0.44	11.3	0.039
OV (order book volume)	3.33	12.8	0.262	3.43	13.1	0.262	3.45	13.2	0.261
R^2	33%			33%			34%		
N cross section	25			25			25		
Time series	572			572			572		
F-test (no fixed effects)	233.2**			224.0**			211.9**		

3.C An alternative slope measure and separating the bid/ask side

As a final exercise, we examine whether the weighted slope estimate, where we weight each local slope with the distance from the inner quote (tick-weighted slope)[44], changes our results. The two slope measures are highly correlated (98%) so we do not expect to see any large differences. However, in addition to examining the alternative slope estimate, we also estimate the effect of the slope of the bid and ask side of the order book separately, both in the balanced and unbalanced case as well as for the various truncations of the order book. In table 3.C1 we report slope estimates for the volatility regressions, and in panel B we report slope estimates for the trading activity regressions. To preserve space we only report the slope estimates for the average slope, the bid and ask slope as well as the p-value from an F-test for equality between the slope estimate for the bid and ask side.

Starting with the first column (slope calculated from the full order book), we see that the estimate for both the equally weighted slope and the tick-weighted slope are negative and significant both for in the balanced and unbalanced case. The main difference is that the weighted slope estimate is more negative than for the equally weighted estimate. Furthermore, when examining the slope estimates for the bid and ask side separately, they are only significantly different at the 5% level for the tick-weighted slope in the unbalanced case. In the two next columns (when we use the truncated order books for calculating the slope) the results are essentially similar, in the sense that the parameter estimate for the tick-weighted slope is more negative than for the equally weighted slope. Both slopes become less negative the more the order book is truncated. With respect to differences between the ask and bid slopes, the parameter estimates are significantly different at the 5% and 10% level for both measures in the balanced case, while they are not different in the unbalanced case.

In table 3.C2 we perform a similar analysis for the trading activity regressions. Looking first at the first column (slope calculated from the full order book), we see that the parameter estimate is significantly negative both for the equally weighted and tick-weighted slope in the balanced and unbalanced case. Thus, in both cases a more dispersed order book coincides with high trading activity. Interestingly, for the equally weighted slope (both in the balanced and unbalanced case) the ask slope estimate is significantly positive while it is significantly negative for the bid slope. For both slope measures, the bid slope is more significant than the ask slope in explaining the number of trades. This may reflect the asymmetry in the order book. With respect to our interpretation of the slope as potentially proxying for dispersion, it may reflect that the bid side of the market is more important with respect to dispersion of beliefs,

[44]See appendix 3.A for explanation.

Table 3.C1

Alternative slope measures and the effect of bid and ask slope on volatility

The table shows slope estimates from the volatility/slope regressions for the equally weighted slope measure and tick-weighted slope measure calculated from different order book truncations in the balanced and unbalanced sample.

	Volatility/slope (full book)		Volatility/slope (+/- 10 ticks)		Volatility/slope (+/- 5 ticks)	
	Estimate	t-value	Estimate	t-value	Estimate	t-value
Balanced sample:						
Equally weighted slope (SLOPE)	-0.008	-10.0	-0.007	-10.6	-0.005	-9.6
-Ask slope	-0.006	-4.0	-0.005	-6.2	-0.004	-6.2
-Bid slope	-0.004	-8.8	-0.003	-7.3	-0.002	-5.2
p-value (bid-ask=0)	0.22		0.03		0.01	
Tick-weighted slope	-0.016	-9.5	-0.014	-9.8	-0.010	-8.9
-Ask slope	-0.008	-1.8	-0.012	-4.8	-0.008	-4.8
-Bid slope	-0.008	-9.0	-0.006	-7.6	-0.004	-5.9
p-value (bid-ask=0)	0.97		0.03		0.06	
	Estimate	t-value	Estimate	t-value	Estimate	t-value
Full sample:						
Equally weighted slope (SLOPE)	-0.007	-11.8	-0.005	-11.4	-0.003	-9.9
-Ask slope	-0.002	-2.3	-0.003	-5.9	-0.002	-5.8
-Bid slope	-0.004	-11.4	-0.002	-8.1	-0.001	-5.8
p-value (bid-ask=0)	0.07		0.54		0.23	
Tick-weighted slope	-0.015	-11.5	-0.010	-10.4	-0.006	-8.8
-Ask slope	-0.001	-0.4	-0.004	-3.6	-0.003	-3.5
-Bid slope	-0.008	-11.5	-0.005	-8.8	-0.003	-6.8
p-value (bid-ask=0)	0.02		0.62		0.60	

while the ask side may be more related to liquidity supply. Furthermore, when we examine the parameter estimates, both for the equally weighted and tick-weighted slope estimates, for the slope measures calculated from the truncated order books (in the last two columns), we see that the importance of the ask slope increases while the bid slope becomes more positive and less significant. This is in line with an interpretation, that the ask side is important in facilitating trading (and may capture increased trading activity by impatient liquidity traders) while the bid side reflects valuation uncertainty.

Table 3.C2
Alternative slope measures and the effect of bid and ask slope on trading activity

The table show slope estimates from the trading activity/slope regressions for the equally weighted slope measure and tick-weighted slope measure calculated from different order book truncations in the balanced and unbalanced sample.

	Trades/slope (full book)		Trades/slope (+/- 10 ticks)		Trades/slope (+/- 5 ticks)	
	Estimate	t-value	Estimate	t-value	Estimate	t-value
Balanced sample:						
Equally weighted slope (SLOPE)	-0.50	-8.1	0.33	6.7	0.44	11.3
-Ask slope	0.95	8.6	1.55	26.4	1.05	22.8
-Bid slope	-0.40	-11.8	-0.29	-9.8	-0.15	-5.7
p-value (bid-ask=0)	0.00		0.00		0.00	
Tick-weighted slope	-1.41	-11.0	-0.05	-0.4	0.54	6.4
-Ask slope	-0.62	-1.8	2.48	13.0	1.54	12.7
-Bid slope	-0.71	-10.6	-0.41	-6.9	-0.10	-1.9
p-value (bid-ask=0)	0.80		0.00		0.00	
Full sample:						
Equally weighted slope (SLOPE)	-0.30	-11.11	0.14	7.0	0.20	12.9
-Ask slope	0.08	2.1	0.46	22.5	0.30	18.6
-Bid slope	-0.19	-12.8	-0.12	-9.2	-0.02	-1.7
p-value (bid-ask=0)	0.00		0.00		0.00	
Tick-weighted slope	-0.78	-13.9	-0.07	-1.8	0.21	6.3
-Ask slope	-0.86	-7.1	0.29	5.3	0.19	5.16
-Bid slope	-0.34	-11.3	-0.13	-5.2	0.07	2.91
p-value (bid-ask=0)	0.00		0.00		0.01	

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Chapter 4

The Market Impact and Timing of Open Market Share Repurchases in Norway

Abstract

This paper examines a detailed dataset on open market repurchase announcements and actual repurchases conducted by Norwegian firms during the period 1998-2001. Firms that announce a repurchase plan experience a positive excess return around the announcement date. However, these firms also experience an abnormal performance after the announcement, suggesting that the market underreacts to the positive signal conveyed through the announcement. When examining the sample of actual repurchases, we find that there is a positive price impact around the execution dates, indicating that the market puts a positive value on the information conveyed through the actual repurchases. In the long run, only announcing firms that *do not* repurchase experience a significant abnormal performance, while a portfolio tracking the repurchasing firms perform according to expectations. In addition, announcing firms that do not repurchase are less liquid than repurchasing firms. One suggested explanation for the finding is that firms by executing repurchases mitigate the undervaluation by confirming their initial signal through actual transactions such that these firms perform as expected in the long run. Due to the lower liquidity of non-repurchasing firms, they are likely to be constrained from exploiting mispricing and unable to signal undervaluation to the market. If this is the case, the price remains too low, and information surprises in later periods contribute to the long term abnormal return drift for these companies.

4.1 Introduction

Corporations distribute an increasingly larger amount of their cash to shareholders through repurchases relative to cash dividends. Grullon and Michaely (2002) show that, in the US, expenditures on share repurchase programs relative to total earnings increased from 4.8% in 1980 to 41.8% in 2000. Moreover, they also report that the number of firms repurchasing shares as a fraction of firms initiating a cash distribution increased from 26.6% in 1972 to 82% in 2000, and that US firms used as much money on repurchases as on cash dividends in 2000. This result suggests that share repurchases has become the preferred payout method for many firms in the US. Also outside the US, in e.g. Canada, France, Australia and the UK, there has been a growth in the repurchase activity. In recent years several countries where repurchases previously were prohibited now allow firms to repurchase their own shares. Among these countries is Norway, where share repurchases were allowed from 1999. The main objective of this paper is to provide a detailed examination of the open market repurchase activity among Norwegian firms from 1999 through 2001. Furthermore, we examine whether an announcement effect and support for the underreaction hypothesis in Ikenberry et al. (1995, 2000) is found in the Norwegian data. The underreaction hypothesis states that the market treats the announcement of an open market share repurchase program with scepticism, incompletely reacting to the information conveyed through the announcement such that prices adjust slowly over time. One reason for this slow adjustment may be that information is incorporated into prices at later points in time when the firm disclose new information to the market. In line with results for other countries, we find that announcing firms experience a positive announcement effect, and a long run drift in abnormal returns in the same direction as the announcement effect relative to several model specifications.

Due to the strict disclosure rules in Norway, we are also able to study the price effect of actual repurchases at a daily level. By combining the announcement and repurchase data, we investigate whether the abnormal performance after announcements of repurchase programs depend on the repurchase activity of announcing firms. The motivation for this is that if the market treats the initial announcement with skepticism, the actual repurchases may be a more credible signal about undervaluation since it involves real transactions by the firm. Thus, the actual repurchase may confirm the initial signal such that the market adjust prices closer to the true value in response to the actual repurchases.

Our results provide additional insight into the long term performance of announcing firms. The findings suggest that the abnormal performance of announcing firms as a group, to a large degree is related to firms that *do not* execute any repurchases after they have announced. In addition, the results suggest that liquidity constraints may restrict these firms from executing repurchases. One interpretation of this finding is that these firms experience excess returns when information is revealed to the market through public information surprises in later periods, and that they are unable to confirm their initial signal through actual repurchases. On the other hand, the firms that actually repurchase shares, may successfully confirm their initial signal of undervaluation through real transactions such that subsequent returns (after the first repurchase) fall to expected levels. If this is the case, requiring firms to report their repurchase activity in a timely fashion, as in Norway, may help improve price discovery and efficiency. An alternative interpretation of the result may also be that firms that actually repurchase shares are expected to do so. In other words, these companies may be those that successfully (and most credibly) are able to signal that they are undervalued through the announcement such that they are no longer undervalued after the announcement. However, we would not expect these firms to repurchase shares for undervaluation reasons after the announcement. In addition, we do not find that there is a significant different announcement effect for announcements that result in subsequent repurchases and those that do not.

Overall, in addition to providing evidence on open market share repurchases in a market where repurchases has recently been allowed, we believe that repurchases in Norway are particularly interesting to study due to the legal requirement that firms report their repurchase activity on a daily basis. By exploiting these unique data, we provide new evidence with respect to open market repurchases, and how the market reacts to the actual repurchase executions.

Why firms choose to repurchase shares has gained a lot of attention, especially in the US which has the longest history of repurchases. At a general level, a repurchase is merely an alternative way of paying out cash to shareholders. Initially, whether a firm chooses one payout method over the other should not matter for firm value, and hence the shareholders of the firm. In a perfect world with no frictions or information asymmetries, whether the firm chooses to pay out some of its cash pro rata through dividends, or use the same cash to buy shares back from some shareholders should not affect the value of the firm because a buyback reduces assets in a way that offsets the reduced number of shares with cash flow rights, and should leave the price for the remaining stocks unaffected. In addition, since investors allocate their funds relative to their preferences and risk tolerances, any changes in the payout policy of the firm can be offset by portfolio rebalancing. However, several studies (e.g. Vermaelen (1981), Comment and Jarrell (1991), Ikenberry et al. (1995), Ikenberry et al. (2000)) find that firms announcing a repurchase plan experience an abnormal price increase around the announcement, indicating that the announcement must have some economical benefits to shareholders. This is not surprising in the sense that we know that information asymmetries are important with respect to the pricing of assets and that actions by the firm (e.g. payout announcements) may help the market extract enough information to move the price closer to the full information value (Miller and Rock, 1985).

The literature on repurchases provides a vast amount of suggestions for why one should expect a positive announcement effect. However, one of the most prevalent hypotheses, which is the main topic of this paper, is the signalling hypothesis. The signalling hypothesis assumes that there is asymmetric information between the managers and the market, and argue that the initiation of a repurchase plan is a positive signal about the value of the firm that the market yet has failed to incorporate into prices. If the managers of a firm have better information about the current earnings and future prospects of the firm, and the firm is priced too low relative to their information set, they can convey this to the market by announcing a repurchase plan. In short, a repurchase announcement indicates that the firm's managers believe that the stock is trading below fair value, such that the stock price should rise as the market reacts to the new earnings information that it infers from the signal.[1] If the signalling hypothesis is true, and markets are semistrong efficient, the announcement of a repurchase plan should induce the market to quickly correct the mispricing. To assess the market valuation of the repurchase signal, the price impact of repurchase announcements have been studied across several countries and time periods. The results in Vermaelen (1981), Dann (1981), Comment and Jarrell (1991), Stephens and Weisbach (1998), Ikenberry et al. (1995, 2000) among others, find support for the signalling hypothesis in that there is a significant abnormal return of about 2% around the announcement date.[2]

Although the signalling hypothesis is the most frequently mentioned explanation for why firms announce repurchase programs, and the observed announcement effect, there is also a vast amount of other explanations which will be discussed in more detail in section 4.2. Among these are capital structure adjustments (Vermaelen, 1981; Opler and Titman, 1996), disgorgement of excess cash (Jensen, 1986; Stephens and Weisbach, 1998; Jagannathan et al., 2000), substitution for cash dividends (Grullon and Michaely, 2002), takeover defense (Denis, 1990; Bagwell, 1991; Dittmar, 2000), shareholder expropriation (Brennan and Thakor, 1990), to counter the dilution effects of employee and management options (Fenn and Liang, 1997), personal taxes (Masulis, 1980; Lie and Lie, 1999; Grullon and Michaely, 2002) and manipulating EPS figures (Bens et al., 2002).

Although, support for the signalling hypothesis has been found for many markets and time periods, one puzzle is that the market seem to underreact to the announce-

[1] In the early literature there is also a negative signal interpretation of stock repurchases which argue that a repurchase is a signal that the firm does not have any profitable investment opportunities.

[2] Comment and Jarrell (1991) and Ikenberry et al. (1995) find an announcement effect in the US of 2.3% (for the period 1985-1988) and 3.5% (1980-1990) respectively. In addition Comment and Jarrell (1991) examine Dutch auction repurchases and tender offer repurchases, which have a 11% and 8% price impact respectively. They argue that tender offer repurchases have the strongest signalling ability of the three. For Canada, Li and McNally (2002) find a announcement effect of 0.9% (for the period 1995-1999). Lasfer (2000) find the effect to be 1.64% in the UK, 1% for continental Europe, 0.78% in France and 0.63% for Italy over the period 1985 to 1998.

ment signal. This lines up with an emerging body of empirical literature suggesting that the market underreacts to new information about firms cash flows. Events that are likely to contain relevant information about current or future cash flow, such as earnings surprises, dividend initiations and omissions, as well as the announcements of repurchase plans, are followed by an abnormal stock-price drift in the same direction as the initial announcement return. For repurchase announcements, this is documented by Ikenberry et al. (1995) for the US, and for Canada by Ikenberry et al. (2000). Initially, if the market efficiently, and in an unbiased fashion, adjusts the price as a response to the announcement signal, these firms should *not* experience an abnormal performance following the announcement. However, both studies find that firms announcing an open market repurchase plan experience a positive drift in abnormal return in the long run (up to 4 years) after the announcement. This finding suggests that the market underreacts to the initial signal by ignoring a large part of the signal value. In other words, the observed positive price adjustment around the repurchase announcement is not sufficient to correct the mispricing. In Ikenberry et al. (1995) the market's valuation of the signal conveyed through the repurchase announcement is about 3.5% while a portfolio of the same firms experience a risk adjusted performance of 12.1% the years following the announcement.

However, one problem with the signalling hypothesis is that, in the case of open market repurchases, the announcement of a repurchase plan is not a commitment from the firm to repurchase shares. Furthermore, as argued in Comment and Jarrell (1991), the announcement of an open market repurchase plan is a weak signal since it does not impose any costs to the manager if it is false. Thus, the apparent underreaction observed for open market repurchases may be a rational reaction (as opposed to an irrational underreaction) since the signalling power of the announcement is weak. Moreover, the market is unable to distinguish truly undervalued firms from falsely signalling firms, and treat the signal with skepticism. On the other hand, if managers owns shares in the firm and commit themselves to retaining their shares during the repurchase period, the power of the signal would be stronger.[3] Such commitments are rarely observed for open market repurchases. However, as discussed by Comment and Jarrell (1991), one type of repurchase where managers often pre-commit to retaining their shares are tender offer repurchases. In these cases, a false signal would be more costly to the manager since it would reduce his wealth if the firm distributes cash to tendering shareholders above the true value. Their findings support this as tender offer repurchases experience a much stronger announcement effect than open market repurchases.

Further, tender offer repurchases are generally for larger volumes than open market repurchases, and the repurchases are executed very close in time to the announcement.

[3]However, managers rarely commit to retaining their shares during the repurchase period such that they may also use the repurchases to sell their own shares at a high price (Fried, 2002).

Thus, there is no uncertainty with respect to whether the firm will repurchase or not. In the case of open market repurchases, on the other hand, the actual repurchases may occur a long time after the announcement, if at all. Since actual repurchase executions reflect real transactions, they potentially reduce the manager's wealth if he has a stake in the company, retains his shares and execute repurchases when the firm is overvalued. Thus, it is plausible that an actual repurchase may constitute a stronger signal (or a confirmation of the initial signal) of undervaluation than the initial announcement. This is one of the issues we will investigate in this paper. An additional motivation for studying the actual repurchases in detail is a survey in Institutional Investor (1998), which notes that less than one quarter of the companies that had announced a repurchase plan during a specific period in the US had actually completed the amount that they announced that they intended to repurchase. Furthermore, as discussed by Stephens and Weisbach (1998), an issue that has not been addressed in the academic literature, but has been a concern among practitioners and the popular press, is that the actual repurchase activity among firms that announce a repurchase plan is small relative to what the intention is at announcement.[4] A concern that has been raised in the popular press is that the announcement of a repurchase plan is a way for the management to raise the stock price at little or no cost in the short run. In fact, Kracher and Johnson (1997) argue that many firms in the US announce repurchase plans with no intention of repurchasing. One of their arguments is that since the reporting standards in the US, with respect to open market repurchases, are very loose, it is difficult for investors to actually know whether announcing firms under normal circumstances are actually going through with the repurchase plan. Their main suggestion is that US firms should be required to report the progress of the repurchase plan such that they are motivated to only announce a repurchase plan when their intentions are true. Interestingly, this is exactly the case for Norwegian firms, in that they are required by law to report their repurchases within the same trading day or before the trading session starts the next day.

This brings us back to the main topic of the paper. If the market is concerned with the announcements of repurchase plans being false signals due to the lack of commitment to actually repurchase, it is interesting to examine whether the actual repurchases is perceived by the market as valuable information, confirming the firms's initial intentions. It may be that requiring firms to report their repurchase activity help improve price discovery and price efficiency when there is asymmetric information between the managers of the firm and the market. Especially if the firm is unable to convey this information through explicit announcements.

The paper has three contributions to the existing literature. First, we examine the

[4] They refer to two articles in *The Wall Street Journal* (March 7, 1995) and *Fortune* (September 4, 1995). More recent articles expressing the same concern are articles in *Fortune* (September 8, 1997) and *Forbes* (June 21, 2001).

announcement effect and long-term performance of repurchasing firms in a market where repurchases recently has been allowed. The paper provides a descriptive examination of the growth of repurchases in Norway for the period 1999 through 2001, and test whether an announcement effect and a long term abnormal performance (underreaction) is observed for Norwegian firms that announce a repurchase program.

The second contribution is that we are able to examine the actual repurchase activity of announcing firms. While the literature to a large extent has focused on the announcements of repurchase plans, we examine in more detail the market reaction to actual repurchases transactions on a daily frequency as well. Due to the difficulty in measuring actual repurchases in the US[5] only a few studies examine the actual repurchase activity of firms. Notable exceptions are Stephens and Weisbach (1998), Jagannathan et al. (2000), Dittmar (2000), Ikenberry et al. (2000) and Chan et al. (2003).[6] However, since these papers only have access to monthly, quarterly and annual data, and use noisy measures of the actual repurchase activity (for the US) they are unable to examine in detail any price effects and the timing of these repurchases in the short term. Thus, by exploiting detailed information on actual repurchases we are able study the timing of repurchase executions and the price effect around these repurchases on a daily frequency. Moreover, we are able to examine whether the repurchases represent trading opportunities/undervaluations exploited by the managers of these firms, and whether the market perceives the repurchase as a signal about firm value. In a related paper by Stephens and Weisbach (1998), they examine the determinants of actual repurchases during the repurchase period and find that managers repurchase more shares when the stock price falls and that firms adjust their repurchase activity to their cash position.

The third contribution of the paper is to combine the announcement and actual repurchase data to examine wether the long run performance of firms that actually repurchase shares is different from firms that do not repurchase any shares.

The empirical section of the paper consists of four main parts. The first part provide a description of the repurchase activity among Norwegian firms during the first three years that repurchases were allowed in Norway.[7] The second part part examines whether the empirical regularities (announcement effect and long term positive excess performance) found in other studies (especially in the US and Canada) also are evident in the Norwegian data. The third part of the paper examines whether the performance of firms that actually repurchase are different from announcing firms that do not. The fourth part of the paper examines in more detail the price impact and timing of actual repurchases. Before we present the results we will in the next section go through the

[5] Due to the loose reporting requirements of repurchases in the US, previous studies have to rely on estimating the repurchase activity based on financial statements or other data sources.

[6] In a recent paper by Brockman and Chung (2004) they exploit a similar dataset as examined in this paper from Hong Kong where the disclosure requirements are similar as in Norway.

[7] Note that firms were allowed to announce repurchase programs before 1999, but were not allowed to execute any repurchases before 1999.

empirical and theoretical literature on repurchases in more detail to review the proposed reasons for why one should expect a positive price impact at the announcement. In section 4.3 we give an overview of the institutional and regulatory aspects of repurchases in Norway. In section 4.4 we discuss the dataset, and explain the empirical methodology in section 4.5 before the results from the various analyzes are presented in section 4.6 and a summary is provided in section 4.7.

4.2 Theoretical predictions

The decision taken by the firms to initiate a repurchase program is a strategic choice between debt and equity as well as a choice of how much dividend to pay out. In a Miller and Modigliani (1961) setting where capital markets are perfect, this choice does not matter for the value of the firm. However, as the perfect market assumption is relaxed, one gains the insight that capital market imperfections and taxes are important determinants of corporate financial policies. Although this study mainly focus on the signalling hypothesis, we also review some of the most commonly proposed hypotheses aimed at explaining the price impact and its direction with respect to repurchase announcements. Many of the hypotheses are not mutually exclusive, and most of the hypotheses predict a positive price impact.

Asymmetric information explanations

The traditional signalling hypothesis is motivated by asymmetric information between the managers of a firm and the market place. Since managers through their positions in the firm are expected to have important private information, they, based on their information set, may assess the true value of the firm to be different than the current market valuation. It is important to note that this relate to information that is not easy or impossible to convey to the market through a public disclosure. For example, the company may not want to explicitly disclose the information for competitive reasons or because it is constrained by confidentiality agreements. This information may both indicate that the current market valuation is above or below what the manager perceives as the true value of the firm. Vermaelen (1981), Dann (1981) and Comment and Jarrell (1991) among others, argue that the announcement of a repurchase plan is a valuable signal to the less informed marketplace about undervaluation because the managers of a firm potentially know more about the future prospects of the firm, current earnings and current investment opportunities. Thus, a repurchase is a vehicle for communicating valuable information to shareholders and the market, and is perceived by investors as a signal of managements assessment of company value. Furthermore, in Brav et al. (2003), managers often mention undervaluation as an important motive for why they repurchase shares. As a consequence, the observed stock-price increase around the announcement of a repurchase program is often interpreted as support for the signalling hypothesis. Alternatively, a repurchase announcement may also be interpreted by the market as if the firm do not have any profitable use of its internally generated funds. Thus, the direction of this signal may be ambiguous, but is most commonly hypothesized to be positive.

However, there are a few sensitive issues with respect to the signalling hypothesis, especially with respect to open market repurchase announcements. First, for a signal about undervaluation to be credible, it needs to impose substantial costs on the manager. If managers could commit to retaining their shares through the repurchase period, as well as committing the firm to actually execute repurchases, the credibility of the signal would be stronger the greater the ownership of the manager or other primary insiders. Through such commitments, it would be costly to the manager if the firm initiates a repurchase program when the firm is overvalued since the repurchase would increase the managers ownership in the overvalued firm. However, since firms seldom commit to actually repurchasing any shares (unless in the case of tender offer repurchases), and managers rarely commit themselves to retaining their own shares through the repurchase period, the credibility of the open market repurchase announcement may be questionable.

As discussed in Fried (2002), there is a theoretical inconsistency with respect to the signalling hypothesis in the sense that it requires managers to sacrifice their own wealth to increase that of shareholders. If managers act opportunistically, Fried (2002) argue that they will use open market share repurchases in two situations. First, they do not use repurchases to signal undervaluation, but rather initiate repurchases when the firm is undervalued with the motivation of transferring wealth to themselves (and the remaining shareholders). This however this is still consistent with the signalling hypothesis since the market will observe the repurchase announcement (and subsequent repurchases) and interpret this as the firm being undervalued. Moreover, while the signalling hypothesis predicts that managers attempts to credibly communicate that the stock is underpriced, the managerial opportunism theory predicts that managers try *not* to reveal that the stock is underpriced. However, this may be difficult or even impossible since repurchases, at least in Norway, are observable (the day after the repurchase) to the rest of the market.[8] In the US on the other had, the firm is not required to report their repurchase activity, such that it would be easier for the the manager to repurchase shares without revealing this to the market. Furthermore, Fried (2002) argue that the second situation in which opportunistic managers announce repurchase plans is to increase the price before they sell their own shares.

[8]Fried (2002) do not discuss another alternative in which an opportunistic manager instead buy undervalued shares on his own account without initiating a repurchase plan.

A model that directly addresses the credibility issue related to open market share repurchase announcements is Isagawa (2000). In that model, the credibility of the announcement is restored when the manager's monetary compensation depends on the future stock price (either through share-ownership or options). Whether the manager chooses to invest free cash in an unprofitable project or not depends on the private benefits to the manager. Moreover, if the private benefit of investing in the unprofitable project (and decreasing the firm value) is smaller than the monetary compensation from increased firm value, he will repurchase shares instead of investing in the unprofitable project. Thus, the announcement of the repurchase program conveys information about the managers private benefits and signals to the market that the manager is committed not to waste cash on unprofitable projects. Thus, in firms where the manager has a high ownership stake or options, the announcement of a repurchase plan may be a credible signal to the market. In this model, the manager does not signal undervaluation, but rather convey information that agency costs of free cash is less likely to occur.

Another theoretical contribution related to asymmetric information between the firm and the market is a paper by Barclay and Smith (1988) who argue that the implicit costs of trading the stock in the market increases after the firm has announced a repurchase plan. The main motivation of their model is to explain why firms in the US distribute more cash through dividends relative to repurchases despite the tax benefit of repurchases relative to dividends. Their main argument is that the adverse selection component of the bid ask spread increases due to the increased probability of trading with an informed investor, the firm. The wider spread raises the required rate of return, reduces corporate investments and lowers firm value. Because of this they argue that firms prefer to use dividends to pay out cash. The early literature on repurchases in the US was puzzled by the fact that so few firms repurchased shares. However, later years there has been a large increase in cash distributed through share repurchases relative to dividends in the US (Grullon and Michaely, 2002).

In a model by Brennan and Thakor (1990), they argue that different incentives of becoming informed among shareholders, when information gathering is costly, is important when firms decide to repurchase shares. They argue that share repurchases causes a wealth redistribution from small, uninformed, shareholders to large, informed shareholders. The main assumption is that information gathering is costly, inducing only large shareholders to becoming informed. Thus, informed investors are able to bid for undervalued stocks and avoid over-valued ones. Since the small investors are unable to condition their trading on the trading of the better informed investors, they will be left with a higher stake in overvalued firms and a lower stake in undervalued firms. Since dividends do not have this problem because they are pro-rata, the Brennan and Thakor (1990) model predicts that large shareholders will prefer cash to be distributed through repurchases, while small investors prefer cash dividends. Thus, an implication of their model is that the choice of cash distribution method depends on the ownership composition in the firm, and that firms with high ownership concentration would be more likely to use repurchases.

Free cash-flow hypothesis

As discussed in Jensen (1986), repurchases is an alternative to increasing dividends, or issue new debt, to pay out excess cash to mitigate agency costs of free cash.[9] In line with the suggestions in Jensen (1986), both Stephens and Weisbach (1998), Dittmar (2000) and Jagannathan et al. (2000), among others, find that firms in fact uses repurchases to pay out cash flows that have a low probability of being sustainable, while dividend increases reflect higher expected permanent cash flows. Moreover, since firms seem to smooth dividends, and are reluctant to reducing dividends (Lintner, 1956; Brav et al., 2003), a repurchase is a way for firms with volatile cash flows to distribute temporary cash without increasing dividends. Thus, since a repurchase may mitigate agency costs of free cash, one would expect a positive price impact from a repurchase announcement. In addition, as discussed earlier, in firms where the manager has an ownership in the firm, the announcement of a repurchase plan may be a credible signal that the manager do not want to waste free cash on unprofitable projects (Isagawa, 2000).

Personal taxes

The personal tax hypothesis argues that firms repurchase their own shares so that the shareholders can benefit from the tax advantage of a repurchase, which (in the US) is taxed at capital gains rates, relative to dividends, that are taxed at higher ordinary income tax rates. Thus, if the cash payout is kept fixed, personal taxes are reduced if the firm uses repurchases instead of dividends to distribute cash. This argument implies that the announcement should have a positive effect on the stock price due to the relative tax advantage to shareholders. However, there are several problems with this hypothesis. First, for the US, the tax differential is not necessarily the main explanation due to the US tax code which states that repurchases only qualify as capital gains if the distribution is essentially not equivalent to paying dividend. Thus, if the repurchase program is of the same magnitude and at the same frequency as dividend payments, the repurchase is not classified as capital gains, but instead taxed at ordinary income tax rates. On the other hand, as mentioned by Allen and Michaely (2003), they are not

[9] As defined by Jensen (1986), free cash flow is the remaining cash within a firm after all projects with positive net present values have been funded. Alternative ways of reducing the agency cost of free cash flow is through e.g. new debt, dividends or repurchases. Debt is the most credible method to counter the free cash flow agency problems since it is a binding commitment whereas repurchase announcements and dividend increases are not.

aware of any cases where the IRS has taxed a repurchase as ordinary income. Secondly, studies from countries where there is no tax advantage to repurchases, find a positive announcement effect of the same magnitude as in the US. Thirdly, Black and Scholes (1974) argue that in an equilibrium where companies have adjusted their payout policies to match the payout policies demanded by investors with different tax schedules, a further adjustment in payout policy should not affect the stock price. Finally, results in Brav et al. (2003) suggest that the relative taxation of capital gains and dividends is unimportant when mangers choose between dividends and repurchases. Thus, the predicted effect of the personal tax argument is not clear, and empirical results does not show strong support for it.[10]

Leverage hypothesis

Another explanation for the announcement effect is that the repurchase can be financed by an issue of debt. The leverage argument is that due to the tax subsidy from interest payments, and that a part of this subsidy is passed on to the shareholders, the price of the stock is expected to rise in connection to the repurchase. Thus, the firm will exploit the benefits of higher leverage by altering its capital structure and this will affect the value of the firm and the wealth of the remaining shareholders. Repurchases may also be used to obtain an optimal leverage ratio. As discussed in e.g. Vermaelen (1981) and Opler and Titman (1996), repurchases are used by firms firms to reduce its equity and increase its leverage ratio. When firms are below their target ratio, firms are more likely to repurchase stock. A related hypothesis is the bondholder expropriation hypothesis discussed in Dann (1981), where a repurchase reduces the assets of the company in such a way that the value of the claims of the bondholders is reduced. Thus, if this potential expropriation of the bondholders has not been taken into account in the pricing of the bond issues, there will be a wealth transfer from bondholders to the stockholders of the firm.

Takeover defense

A repurchase may also be used by a firm as a defensive payout in response to hostile takeover attempts. Denis (1990) examine defensive changes in corporate payout policy[11] for a sample of firms in the US. The main finding is that repurchases is an effective device for countering hostile takeovers, as there is a high probability of the target firm maintaining independence.[12] The effect of a firm announcing a defensive repurchase

[10] Much of the earlier literature on repurchases in the US were motivated by the puzzle that despite the relative tax advantage of repurchases to dividends, firms preferred dividends as the main payout method.

[11] Denis (1990) examine defensive share repurchases and special dividends.

[12] Those firms that remain independent show a significantly lower abnormal returns after the takeover

is highly negative which suggests that defensive repurchases are associated with losses for the shareholders of the target firm. This in the sense that defensive repurchases reduce the probability that there will be a valuable restructuring within the firm that could lead to a more efficient use of firm resources. Bagwell (1991) proposes a model with heterogenous valuations among current shareholders and an upward sloping supply curve for for the company shares. A repurchase removes current shareholders with the lowest valuations such that a more expensive pool of shareholders are left. Also Bagnoli and Lipman (1989) propose a model where there is asymmetric information between the manager and the marketplace, and that repurchases convince current shareholders that the firm value is higher, revising their price upwards, such that a takeover attempt becomes more costly for the bidder.

Other hypotheses

There are also several other hypotheses that aim at explaining why firms repurchase shares as well as the positive price effect associated with (non defensive) repurchase announcements. Dittmar (2000) find evidence that repurchases are used to counter the dilution effect of management- and employee options, while Fenn and Liang (1997, 2001) find evidence that repurchases are used to increase the value of such stock options and that the increase in management stock options may explain the increased use of repurchases. Bens et al. (2002) argue that repurchases are used to increase earnings per share (EPS) figures and Grullon and Michaely (2002) find evidence that dividends are substituted for repurchases due to several of the issues discussed above.

4.3 Repurchases in Norway

4.3.1 Repurchase methods

There are mainly three methods for firms to repurchase their own shares; through tender offers (fixed price offers), open market transactions or via Dutch auction repurchases. The two first methods are used to a larger extent than the latter, and in the US, open market transactions are observed more frequently than tender offers. In fact, 90% of the cases between 1985 and 1993 were open market transactions as discussed in Ikenberry et al. (1995) and Stephens and Weisbach (1998). Open market repurchase programs, where there is an upper limit on how much shares the company can repurchase, are often referred to as “Normal Course Issuer Bids”, whereas fixed price tender offers which do not have any limit to the amount of stock that can be repurchased is commonly called “Substantial Issuer Bids”. In a tender offer, the reacquiring firm offers to repurchase a fraction of its shares at a specific price, usually at a premium to the market price.

attempt than those that were successful takeovers.

In an open market repurchase, on the other hand, the purchase is executed through brokers in the open market at normal commissions rates, and no premium is paid.[13] Thus, open market repurchases may be viewed as a sequence of tender offer repurchases, where the bid price of the order is the tender price. Since tender offers are generally larger in magnitude than open market repurchases, the alternative of trading the shares directly in the market may induce a price impact to the firm that would exceed the premium offered through the tender price. With respect to Dutch auction repurchases, the repurchasing firm set a range of prices at which it is willing to repurchase shares. Then, each shareholder informs the firm of their supply at these price levels. When all price schedules are collected, the firm has an aggregate supply curve, and chooses the lowest price that will fill their demand, and the transactions are executed at this clearing price.

The 1st of January, 1999, the Securities Act of June 13 1997 (Aksjeloven) went into effect, and Norwegian firms were allowed to repurchase their own shares. The Securities Act states that firms are not allowed to hold more than 10% of their issued shares at any point in time. In addition, the firm's total equity value in excess of the firm's own stock-holdings must at all times be higher than NOK 1 mill. For a company to be able to initiate a repurchase plan, it requires 2/3 of the voting shares represented at the shareholder meeting to vote in favor of the repurchase plan.[14] In addition, the maximum length that a repurchase plan can be in effect before it requires a new vote is 18 months, and a shorter time if specified. After the Securities Act went into the effect, Norwegian firms were allowed to announce a repurchase plan, but not execute any repurchases before January 1999. When a firm has repurchased shares, the shares are first assigned as treasury stock with no voting or cash flow rights as long as the company owns them. Firms may then reduce the number of treasury stock by retiring these shares or as a payment in various transactions. What firms do with the shares after the repurchase varies, but commonly firms use them as payment in acquisitions, sell them in the market or distribute them to employees or managers as a part of a bonus plan etc. The dataset also contain data on the sale of treasury stock. However, the paper only consider the part of the sample related to the repurchases. Table 4.B1 in appendix 4.B show some aggregate statistics for the sale/reduction of treasury stock. There are about six times as many repurchase transactions as sales. However, the number of shares in the repurchases are only twice that of the sales, and the average repurchase is about 1/3 of the size of a reduction in treasury stock. This is probably because firms accumulate treasury stock through many smaller transactions, and use

[13] At least no direct premium is paid. As argued by Barclay and Smith (1988), the announcement of a repurchase plan may lead to increased implicit transaction costs in the market due to an increased adverse selection component in the spread. Thus, by announcing a repurchase plan, the firm itself may experience higher trading costs in the primary market.

[14] It also requires 2/3 vote of all shares represented at the meeting (including non-voting shares).

the repurchased shares as payment in relatively large transactions or retire relatively large amounts of shares in a single event.

The sample examined in this paper only includes announcements of open market share repurchase programs and actual repurchases related to these announcements. Other types of repurchases are rarely observed during the sample period.[15] Recall that open market share repurchase programs also are the most frequently observed repurchase method in the U.S. and Canada as well. Furthermore, Norwegian listed firms do not have to receive approval from the stock exchange before initiating a repurchase program. In the U.S. the same rule applies as in Norway. However, Canadian firms (see Ikenberry et al. (2000)), must receive approval from the exchange before they can initiate a repurchase program. When a firm actually execute an open market repurchase the law requires the firm to report this to the OSE on the same day or before the trading starts the following day. This is very different from the US, where firms are not required to report their actual repurchase activity. Moreover, several studies note that firms actual repurchase activity in the US is very hard to measure (see e.g. Jagannathan et al. (2000)). Canadian firms are required to report their aggregate repurchase activity every quarter.

4.3.2 The Norwegian tax system

Dividends distributed from a Norwegian tax resident public- or private limited company were taxed fully on the investor's hand until 1992. As a result of an extensive tax-reform in 1992, dividends became tax-exempt while the capital gains tax was set at a flat rate of 28%, both for individuals, companies and private pension funds.[16] However, shareholders in firms that retain a part of their after tax earnings, may experience that some of the capital gains when the shares are sold reflect a price increase due to the retained earnings. To eliminate the double taxation this would imply, an adjustment is made. The retained earnings per share is added to the cost basis (usually the purchase price) such that the capital gain/tax basis is reduced accordingly (RISK adjustment).[17] Thus, during the period 1992 until 2001, dividends were not taxed on the investor's hand at all, and tax on capital gains linked to retained earnings was eliminated. However, in 2001, personal tax on dividends was re-introduced, at a rate of 11%, while the capital gains tax and corporate tax remained at 28%. With respect to the dividend taxation, a basic deduction of NOK 10 000 was introduced. Thus, small investors in dividend

[15] One example is Storebrand (STB) which at the beginning January 1999 gave an offer to shareholders that owned less than 8 shares to sell their shares back to the company. Of the total 74000 shareholders at the time, 39000 owned less than 8 shares.

[16] labor unions, non-profit organizations and public pension funds are exempt from taxation.

[17] RISK is the acronym for "Regulering av Inngangsverdien med Skattlagt Kapital". Translated, it means that there is an adjustment of the cost basis by the retained earnings after corporate tax. To be eligible to the RISK adjustment within a given year, the shareholder must have owned the shares over the turn of the year.

paying firms were not directly affected by the tax increase. However, for larger investors the total taxation on dividends increased from 28% to 35.92%, due to the double taxation of parts of the earnings. In 2002 the personal taxation of dividends was removed. With respect to foreign shareholders, dividends distributed from a Norwegian tax resident public or private limited company to its non-resident shareholders are subject to 25% withholding tax. Tax treaties may make the withholding tax deductible in the shareholder's home country. Non-resident shareholders gain on a sale of shares in a Norwegian company is not subject to any Norwegian taxation, unless the shares form part of a permanent establishment in Norway or the seller is an individual who fulfill certain conditions that would make the gain taxable at a rate of 28%.

With respect to the relative tax treatment of dividends and repurchases in Norway, we see that there has been a change during our sample period from 1999 through 2001. However, in 1999 and 2001, dividend distributions were not taxed. On the other hand repurchases where the shareholder sell shares above the tax basis was taxed at 28%. Thus, in cases where the firm uses already taxed earnings for repurchasing shares at a price above the tax basis, the shareholder that sell shares back to the firm would experience a double taxation on the excess capital gains. In 2000, when a dividend tax of 11% was introduced, the tax differential between capital gains and dividends was reduced, favoring repurchases. With respect to foreign investors, they have been subject to 25% withholding tax on dividends through the entire sample period. However, since the capital gains for foreigners is subject to the tax in the home country, the preference between dividends and repurchases may vary between foreign investors depending on the tax treatment in their home country.

4.4 Data description

4.4.1 Announcements of repurchase programs

In panel A of table 4.1, we report some general statistics for the announcement data. Over the entire period period from 1998 through 2001 there were 318 announcements of repurchase plans by 163 different firms. Of these firms, 70 announced one repurchase plan, 46 announced two plans, 32 announced 3 plans and 15 announced 4 repurchase plans during the sample period. Over the different sample years, the number of announcing firms increased from 30 to 109, while the maximum number of announcements by a single firm in one year was two. For the individual years, we also show statistics on the announcement frequencies in the middle section of panel A. In column n=1, the numbers represent the number of firms that announced for the first time in the respective year, column n=2 report the number of firms that announce for the second time in the respective year and so on. Thus, in 2001 32 firms announced for the first time, 30 for the second time, 35 for the third time and 12 for the fourth time. When looking at the distribution of authorized repurchase amounts across firms, we see that they are highly skewed with a maximum (and median) amount of 10% and a mean amount of 9.5% while the lowest repurchase amount announced by a firm was 1% of outstanding shares. Thus, the majority of the announcements was for the maximum legal limit of 10%.[18]

Panel B in table 4.1 report the completion rates across firms that announced a repurchase plan. For the whole sample about 60% (100 firms) of the announcing firms repurchased at least some shares following at least one of their announcements, while 63 of the firms that announced a repurchase program never repurchased any shares within the repurchase period.[19] With respect to the firms that actually executed repurchases, the mean fraction of outstanding shares that was repurchased was 2.9%, while the median firm repurchased 1.8%. The maximum accumulated fraction repurchased by any firm during a repurchase period was 22.1%. This is above the legal limit of 10%. And for some firms there is an apparent breach of the legal limit, but this is probably because these firms during the repurchase period used some of the repurchased shares as payment in transactions, wrote down some of the repurchased shares or distributed them to employees, managers as part of a bonus program or other events that is not captured in our data.[20] The median number of days between the announcement of a repurchase plan and the first repurchase was 169 days, while the mean number of days was 198. Thus, on average it seems like the repurchase plan is put in place not for immediate executions. However, the minimum number of days indicate that some firms also repurchase shares immediately after the announcement has been made. For announcements in 1998 these numbers are biased upwards because firms were not allowed to execute repurchases before 1999, but could announce a repurchase plan in 1998. Across months (not reported), there is some degree of clustering in May and June. The reason for this is that many repurchase plans are voted on at the annual shareholders meetings, which for many firms are conducted during spring.

4.4.2 Actual repurchases

The sample of actual repurchases reported to the OSE from January 1999 through December 2002 was obtained from the Oslo Stock Exchange. In addition, the dataset was updated and cross checked using detailed records from the equity feed database of Oslo Exchange Information (OBI).[21]

Panel A in table 4.2 show various statistics for the actual repurchase activity across

[18] Since some firms do not explicitly report a maximum amount to be repurchased, we assume that these firms are subject to the maximum legal limit of 10%.

[19] The repurchase period is defined as the period in which the shareholders give the manager authorization to repurchase shares.

[20] The Securities Act (Aksjeloven) only require the holding of treasury shares to be no more than 10% of the firms outstanding shares.

[21] More specifically, Record E 19, Trading in Company Shares, in the Equity Feed data from Oslo Exchange Information (OBI) was used to track companies repurchase activity.

Table 4.1
Descriptive statistics of announcements

Panel A shows descriptive statistics for the announcements of repurchase plans for the entire sample period from 1998 through 2001 as well as for separate years. The first column report the number of announcements, the second column report the number of different firms that announced at least one repurchase plan, and the third column report the maximum announcements by one firm within the specified period. The next four columns decompose the frequency of repurchase announcements. For the whole sample, n=1 counts the number of firms that announce once, and n=4 counts the number of firms that announce 4 times. For the separate years, n=1 counts the number of firms that announce for the first time in the respective year, while n=2 counts the number of firms announcing for the second time etc. For example, in 2001 there were 32 firms that announced for the first time, 30 firms that had announced once in one of the previous three years, 35 firms that had announced a repurchase plan in two of the previous three years and 12 firms that had announced four times during the previous four years. The last three columns of the table report the cross-sectional minimum, mean and maximum amount of shares that the firm was authorized to repurchase by the current owners. Panel B shows statistics with respect to the completion rates where "Repo" denotes the number of firms that actually repurchase after an announcement, and "Norepo" denote the number of firms that announce a repurchase plan but do not execute any repurchases. The median, mean and max completion rates are calculated relative to the number of shares repurchased divided by the total number of outstanding shares. The last four columns report distribution of days between announcement of a plan and the first repurchase.

Panel A: Announcement statistics

				Number of firms (i) announcing n times				Authorized repurchase amount		
Period	Announce-ments	Different firms (i)	Max ann.	n=1	n=2	n=3	n=4	Min.	Mean	Max.
Whole sample	318	163	4	70	46	32	15	1.0%	9.5%	10.0%
1998	28	28	1	28	-	-	-	2.5%	9.1%	10.0%
1999	85	85	1	70	15	-	-	1.0%	9.5%	10.0%
2000	93	90	2	33	47	10	-	1.0%	9.4%	10.0%
2001	112	109	2	32	30	35	12	3.3%	9.6%	10.0%

Panel B: Completion rates for announcing firms

	Repurchasing firms		Completion rates			Days until first repurchase			
Period	Repo	Norepo	Median	Mean	Max	Min	Median	Mean	Max
Whole sample	100	63	1.8%	2.9%	22.1%	1	169	198	502
1998	15	13	1.9%	2.9%	10.0%	20	364	326	469
1999	41	44	1.9%	3.2%	19.0%	9	203	216	502
2000	65	25	1.8%	2.9%	16.1%	2	217	206	498
2001	60	49	1.3%	2.7%	22.1%	1	123	138	459

firms for the whole sample as well as for separate years. The firms that repurchased shares executed a total of 1719 repurchases including all repurchases executed in 2002 (denoted as 2002[a] in the table). When excluding repurchases in 2002 that were not related to repurchase plans initiated in 2001 or earlier[22] (denoted as 2002[b] in the table), the total number of repurchases related to announcements in 1998-2001 was 1375. In the rest of the paper we will examine the repurchases related to these announcements and ignore the 344 repurchases that was executed due to repurchase plans announced in 2002 since we do not have this information yet. The median firm executed 7 repurchases for the entire sample period, while the maximum number of repurchases executed by a single firm was 197. The average size of the repurchases was 166 thousand shares or about NOK 7.8 mill. Overall, the repurchases related to plans announced in 1998-2001 resulted in Norwegian firms repurchasing 210 million shares worth more than NOK 15 bill. During the same period, the total market value of all firms on the OSE was about NOK 600 bill. on average. The total dividends paid out by all firms at the OSE (including firms that did not announce) during the same period amounted to about NOK 60 bill.[23] Since Norwegian firms were first allowed to repurchase shares in 1999, they have increased their spending on repurchases as a percentage of cash dividends to 25% in 1999 and to 44% in 2000 and 2001. However, for 2002 there was a drop in the repurchase activity, while dividend payments was high compared to the other years. Examining the other statistics across different years, the first thing to note is the increase in repurchasing firms and repurchases (N) from 1999 through 2001, and then a significant drop in repurchase activity in 2002. This trend is also evident when looking at the total number of shares and the NOK volume of all repurchases. One main reason for this drop in repurchases in 2002 may be related to the fact that the personal tax on dividends, which was introduced in 2001, was removed in 2002 which made it relatively more attractive for private investors to get cash paid out as dividends.[24] Another interesting observation is that, while the repurchase volume increased from 1999 through 2001, the average NOK size of each repurchase decreased while the average number of shares in each repurchase increased. Panel B in table 4.2 report monthly summary statistics of our repurchase sample. The table shows the number of different firms that executed repurchases, the number of repurchases conducted by these firms, as well as the aggregate share volume and NOK volume of these repurchases for each sample month. As can seen from the table there is an increasing trend until September 2001. In fact, for the entire sample, September 2001, was the month in the sample that most firms executed repurchases and the share volume of repurchases was the highest.

[22] These repurchases are repurchases up until 18 months after the most recent announcement in 2000/2001, or until a new announcement in 2002.

[23] Note that these dividend numbers are aggregates for all companies listed on the OSE, not only for the firms executing repurchases. The dividend statistics are official numbers from the Oslo Stock Exchange.

[24] This reasoning require that firms take into account the tax schedule of their investors.

This is probably related to the large drop in share-prices due to the terrorist attacks in the US on September 11th. In fact, when looking more closely on the amount of repurchases that were executed within that specific month, there was a huge increase in repurchases just after the terror events. More than 75% of the repurchases and 65% of the share-volume that month occurred in the week after the attacks. This is similar to what was observed in the US when a large amount of US firms increased their repurchase activity to supply liquidity and support their share prices. In fact, on September 13th, the Securities and Exchange Commission (SEC) suspended regulations on repurchases allowing firms to repurchase shares without any volume limits. About 75 corporations responded during the first day of trading after the attacks by announcing the initiation or renewal of a repurchase plan, and the dollar value of their buybacks on the opening day was estimated at more than USD 45 billion.[25]

4.5 Estimation methodology

4.5.1 Measuring abnormal announcement returns

In the paper we investigate the short term price impact related both to the announcement of repurchase plans as well as when the market learns that the firm actually has repurchased shares. For these purposes, we apply a standard event study methodology. To investigate the short term effect around an event, we examine various event windows surrounding the event. We use daily returns which are indexed relative to an event, and define τ as the event time, with the event date at τ=0. The event date is the date at which the event (the repurchase plan or actual repurchase) is announced to the market. For the various event windows we denote the beginning of the event window as τ_1 and the end of the event window as τ_2. We apply three model specifications to characterize normal returns; the market model, the Fama and French (1993) three factor model and the Carhart (1997) four factor model. All benchmarks models are calibrated during the estimation period running from two years prior (τ=-571) to the event until the start of the event period at τ_1 for each firm, i.[26] Since many of the companies at the OSE, and hence in our sample, are not traded every day, our OLS beta estimates may be biased due to the intervaling effect. To reduce the potential bias, we also estimate adjusted betas for the market model as suggested by Scholes and Williams (1977) and Dimson (1979). In the regular market model, normal returns are expressed as,

$$\widehat{E[R_{i\tau}]} = \alpha_i + \beta_i R_\tau^m \tag{4.1}$$

[25] Also during the market crash in 1987 there was a surge in repurchase activity after the market collapse. During the fourth quarter of 1987 Stephens and Weisbach (1998) report that 995 firms announced a repurchase plan.

[26] Some firms have a shorter price history. However, since none of these firms have less than half a year of price observations, we do not exclude them from the analysis.

TABLE 4.2

Descriptive statistics of actual repurchases

Panel A reports the actual repurchase activity across firms for the whole sample as well as for separate years. The columns in panel A report the number of different firms that executed repurchases (Firms), the cross sectional distribution of repurchases (minimum, median, mean and max repurchases across firms), the average size of repurchases in thousand shares and Norwegian kroner (NOK) and the total share-volume and NOK volume in all repurchases. The last column of the table report the aggregate NOK value of dividend payments for all firms at the OSE. Panel B shows the repurchase activity for each month within each year. For each month, the reported statistics is the number of different firms that executed repurchases in the respective month (Firms), the number of repurchases executed by these firms (N), the total number of shares (in thousands) in these repurchases and the total volume in million Norwegian kroner (NOK).

Panel A: Cross sectional repurchase statistics

		Number of repurchases					Repurchase size		Repurchase volume		Dividends[c]
	Firms	N	min	median	mean	max	shares (1000)	NOK (1000)	Mill. shares	Mill. NOK	Mill. NOK
Whole sample[a]	100	1719	1	10	16.7	197	159	7223	247	16505	59760
Whole sample[b]	100	1375	1	7	13.3	195	166	7861	210	15219	-
1999	41	205	1	3	5.0	17	168	13259	35	3679	14444
2000	60	463	1	5	7.7	64	186	12770	65	5320	12194
2001	69	659	1	4	9.6	120	281	7480	107	5947	13767
2002[a]	39	392	1	5	10.1	50	122	3780	41	1560	19356
2002[b]	11	48	1	3	4.4	10	89	5420	4	273	-

[a]Includes all repurchases conducted in the period 1999 through 2002. [b]Includes only repurchases in 2002 that was related to announcements in 2000/2001 which had not yet expired. These repurchases are repurchases conducted up to 18 months after the most recent announcement (in 2001 or 2000) or until a new announcement in 2002. [c]The dividend statistics are official aggregates from the Oslo Stock Exchange (www.ose.no).

Panel B: Repurchase activity by month

	1999				**2000**				**2001**				**2002**			
	Firms	N	Shares (1000)	Mill. NOK	Firms	N	Shares (1000)	Mill. NOK	Firms	N	Shares (1000)	Mill. NOK	Firms	N	Shares (1000)	Mill. NOK
January	5	7	1787	64	6	13	624	40	15	51	7130	315	10	34	11942	97
February	3	3	499	52	9	21	1987	153	7	17	2790	170	10	14	1471	78
March	3	6	3581	57	11	34	6493	531	18	43	7482	567	11	16	2387	91
April	5	10	780	16	7	18	2799	142	10	40	1914	133	9	12	1163	63
May	3	6	307	20	12	22	2827	159	19	80	11537	1097	8	19	1826	106
June	5	14	975	35	14	39	4095	251	20	86	11077	789	14	37	2705	267
July	5	11	2629	213	11	23	4499	426	21	69	5732	255	9	32	2251	229
August	14	35	7118	1118	14	35	5873	478	20	72	14001	712	15	35	5206	235
September	12	29	6463	816	17	56	5894	313	34	125	26003	1274	18	77	4125	203
October	11	18	1967	234	8	17	3270	232	14	29	11880	287	12	50	4693	80
November	15	47	6387	864	20	62	7072	935	11	24	3445	155	12	36	1596	57
December	12	19	2064	189	26	123	19693	1661	13	23	3932	194	12	30	1206	55

where $R_{i\tau}$ is the return on security i on event date τ, R_τ^m is the value weighted total return on the OSE all share index, and $E[\varepsilon_{i,\tau}] = 0$ and $Var[\varepsilon_{i,\tau}] = \sigma^2_{\varepsilon_i}$. In the Dimson (1979) specification, we run an multivariate version of eq.(4.1) of securities returns against lagged ($R^m_{\tau-1}$), contemporaneous (R^m_τ) and leading ($R^m_{\tau+1}$) market returns. As proposed in Dimson (1979), we obtain a consistent estimate of beta by summing the slope coefficients from this regression. The Scholes and Williams (1977) procedure is similar, but instead of estimating the β's simultaneously, the three betas are estimated separately and the aggregated beta estimate is adjusted for the autocorrelation in the market return to obtain a consistent estimate of β. Thus, by denoting the lagged-, matching- and leading beta estimates as β_i^+, β_i and β_i^- respectively, the consistent beta estimate, relative to the Scholes/Williams approach, is calculated as,

$$\hat{\beta}_i^{SW} = \frac{\hat{\beta}_i^+ + \hat{\beta}_i + \hat{\beta}_i^-}{1 + 2\hat{\rho}_M} \tag{4.2}$$

where $\hat{\rho}_M$ is the autocorrelation coefficient of the market index, and $\hat{\beta}_i^{SW}$ denotes the Scholes/Williams estimate. In addition to applying the market model, we use the Fama and French (1993) three factor model as well as the four factor model suggested by Carhart (1997) adding momentum to the Fama/French factors.[27] With respect to the four factor model, expected returns are described as,

$$\widehat{E[R_{i\tau}]} = \alpha_i + \beta_i^m R_\tau^m + \beta_i^h R_\tau^{hml} + \beta_i^s R_\tau^{smb} + \beta_i^{mom} R_\tau^{mom} \tag{4.3}$$

where R_τ^m, R_τ^{hml}, R_τ^{smb} and R_τ^{mom} are the returns on the market-, the book to market-, the size- and the momentum factors respectively, and the β's are the factor exposures. The book-to-market and size factor returns are calculated as the difference between two value weighted portfolios containing firms with a book to market value (or size) above the median and below the median. All firms at the OSE are assigned to one of the two portfolios at the beginning of each year. With respect to the momentum portfolios, firms are assigned to one of two portfolios based on the return over the previous year.[28] The exposures are estimated over the same post-event period as the market model in eq.4.1.

Having estimated the parameters in the various model specifications described above, we measure the daily abnormal returns as the daily prediction errors relative to the

[27] However, Brown and Weinstein (1985) and Campbell et al. (1997) argue that the use of more sophisticated models has little practical advantages relative to an unrestricted market model when we examine the short term market impact. The main reason is that the marginal explanatory power of additional factors to the market factor is usually relatively small, and therefore there is little reduction in the variance of abnormal returns.

[28] A number of filters are applied before a stock can enter the portfolios. Minimum number of trading days of 20, minimum price of 10 and minimum firm value of 1 mill NOK.

expected return, $\widehat{E[R_{i\tau}]}$ as,

$$\widehat{AR}_{i\tau} = R_{i\tau} - \widehat{E[R_{i\tau}]} \tag{4.4}$$

where $\widehat{E[R_{i\tau}]}$ is the expected return of security i, defined by either the market model, the Fama and French (1993) model or the Carhart (1997) model, on date τ given the return on the market and the contemporaneous factor returns. For each firm in the sample, we calculate cumulative abnormal returns (CAR) across the event window from τ_1 to τ_2. By cumulating the $\widehat{AR}_{i\tau}$ from τ_1 up to, and including, τ_2 for the different time windows, for each firm, we can calculate the the estimated average $\widehat{CAR}$ across all firms as,

$$\widehat{CAR}(\tau_1, \tau_2) = \frac{1}{N} \sum_{i=1}^{N} \sum_{\tau=\tau_1}^{\tau_2} \widehat{AR}_{i\tau} \tag{4.5}$$

where N is the total number of firms/events.

The main null hypothesis to be tested is that the cumulative abnormal return during the main event-window across firms is equal to zero. We use the standard test statistic proposed in Brown and Warner (1985) who argue that standard procedures are typically well-specified even when special daily data characteristics are ignored. The test statistic we apply is the ratio of the average cumulative abnormal return, across firms, to its estimated standard error, which can be expressed as,

$$t = \frac{\widehat{CAR}(\tau_1, \tau_2)}{[\overline{\sigma}_{\varepsilon}^2(\tau_1, \tau_2)]^{1/2}} \tag{4.6}$$

where $\overline{\sigma}_{\varepsilon}^2(\tau_1, \tau_2)$ is the average estimated variance for the abnormal returns across firms. Two estimators of the variance is commonly used in event studies. The most frequently applied estimator uses the standard deviation of abnormal returns from the expected return model estimated in the estimation period prior to the event. The second estimator uses the standard deviation of the cross-sectional CARs from the event window. The latter estimator is generally used when the event is expected to change the risk of the firm, and the pre-event estimator for the variance may be biased. In our case, we use the first estimator for variance when examining the announcement effect, since the announcement itself is not expected to affect the risk of the firm. When we later in the paper (section 4.6.4) examine the abnormal returns around the actual repurchases, on the other hand, we provide results using the second approach, since the transactions potentially change the riskiness of the firm.[29]

[29] If the AR_τ are independent identically distributed and normal, the test statistic is distributed Student-t under the null hypothesis.

4.5.2 Measuring long run performance

Portfolio creation

We also examine the long run performance of portfolios of announcing firms and for portfolios conditional on whether the firm actually execute repurchases or not. To facilitate this we apply a calendar time approach used in e.g. Ikenberry et al. (1995), Womack (1996) and Ikenberry et al. (2000) among others. To explain how this applied in this paper, we will use the case when we construct a portfolio of firms conditional on that they have announced a repurchase plan.[30]

More specifically, we create a portfolio of firms given that they have announced a repurchase plan and calculate the daily returns of this portfolio through calendar time, t. We rebalance the portfolio the first day of every month. Moreover, all firms that have announced a repurchase plan in the previous month are added to the portfolio, and all firms are rebalanced to equal weights. We write the return on the equally weighted portfolio, $R_{p,t}$ on date t as,

$$R_{pt} = \sum_{i} w_{it} R_{it} \tag{4.7}$$

where $w_{i,t}$ denotes the weight of each firm in the portfolio which in our case is just $1/N_{i,t}$ where $N_{i,t}$ is the number of securities in the portfolio at date t. To minimize the idiosyncratic risk in our portfolio, we do not start our portfolio construction before 10 companies have announced a repurchase plan. We also examine several holding periods, where firms are kept in the portfolio for one year, two years and three years as well as for the remaining sample period (buy and hold). For e.g. the yearly holding period, a firm is removed from the portfolio after one year. These portfolio strategies represents simple and realistic trading strategies, where the inclusion of stocks depends on whether they have announced a repurchase period in the previous month. It should be noted that we do not take into account transaction costs, but since we rebalance the portfolio on a monthly basis, these costs would not be very large.[31]

Benchmark models

The long term abnormal performance may to a large degree depend on the benchmark model against which we compare our portfolio returns. In addition, several papers note that long-term abnormal performance tests may be due to misspecification rather than mispricing. Thus, as argued by Kothari and Warner (1997) among others, caution

[30] However, later in the paper we will also use the same methodology when measuring the performance of portfolios conditional on the actual repurchase activity of the announcing firms.

[31] The transaction costs would in reality depend on the size of the portfolio. For a small portfolio, the total commissions related to the rebalancing could constitute a large fraction of invested wealth. For a large portfolio, on the other hand, the commissions would be a smaller part of invested amount, while the implicit costs related to price impact and delay when the portfolio is rebalanced is likely to constitute a larger fraction of total costs.

should be used when interpreting the results.[32] We try to reduce this problem by measuring our sample portfolio returns generated from the trading strategy relative to several models. We evaluate the performance of our repurchase portfolio by estimating Jensen's alpha relative to a one factor CAPM model as well as the Fama and French (1993) model and the Carhart (1997) model, E.g. for the Carhart model we run the following regression,

$$R_{pt} - R_t^f = \alpha + \beta^m(R_t^m - R_t^f) + \beta^h R_t^{hml} + \beta^s R_t^{smb} + \beta^{mom} R_t^{mom} + \varepsilon_t \qquad (4.8)$$

where $R_{p,t}$ is the return on the equally weighted portfolio of announcing firms created through calendar time, R_t^f is our proxy for the risk free rate,[33] R_τ^m, R_τ^{hml}, R_τ^{smb} and R_τ^{mom} are the returns on the market-, the book to market-, the size- and the momentum factors respectively, and the β's are the factor exposures. The factor returns are calculated similarly as in eq. 4.3 and α measures the average daily excess performance of the portfolio.

4.6 Results

Our empirical analysis consists of four parts. The first part in section 4.6.1 evaluate the short term market reaction around the announcement of repurchase plans. The second part, in section 4.6.2, tests the underreaction hypothesis in Norway by examining the long term performance of a portfolio of firms that have announced a repurchase plan. The third part, in section 4.6.3, combines the announcement data with the actual repurchase data and examine whether the long-run performance depend on whether firms repurchase or not. The fourth part, in section 4.6.4, examines the short term market impact of the actual repurchases.

4.6.1 The short term effect of announcing a repurchase plan

In table 4.3 we report the average cumulative abnormal returns surrounding the announcement of repurchase plans. For all announcements, the table shows the average excess return relative to the market model (unadjusted and adjusted as proposed in Dimson (1979) and Scholes and Williams (1977)), the Fama and French (1993) three-factor model and the Carhart (1997) four-factor model. In the table we also show the average announcement effect for separate years and when split the sample into announcements that specify that the firm will repurchase more or less than 5% of their

[32] Kothari and Warner (1997) argue that bootstrapping procedures may help mitigating the potential biases in long-term performance measurement. With respect to bootstrapping, it is important to have a large number of firms to match against. One problem in Norway is that there are very few similar companies, in addition to that we want to match against non-announcing firms, which makes this approach difficult to implement in a satisfactory way in this study.

[33] As the risk free rate we use the 3 month Norwegian interbank offered rate (NIBOR).

outstanding shares. In these cases we report results only from a Carhart (1997) specification for normal returns. In the table we use an event window staring two days before the announcement and ending two days after the event. The main reasons for why we use a relative large event window is that the announcements of the outcome of the vote on the repurchase plans are in some cases on the same day as the shareholder meeting, while it in other cases is announced up to a few days after the shareholder meeting. Thus, for those announcements that are delayed, the outcome of the vote is likely to be known to the market before the announcement. In fact, when looking at the cumulative abnormal return from 60 days prior to the announcement of the repurchase plan through 60 days after the announcement in figure 4.1, there is some indication that there is a positive impact starting before the announcement. Thus, the relatively large window reduces the power of the tests, but since we want to capture the entire market reaction we use a relatively large window. In addition, the table report the average cumulative abnormal return from 60 days prior to the announcement and until 60 days after the announcement.

The first thing to note from the table is that the announcement effect is positive and significant for the whole sample, with an average significant announcement effect of about 2.5%. This is very similar to what is found for other markets and time periods in e.g. Comment and Jarrell (1991) and Ikenberry et al. (1995, 2000). With respect to the different model specifications, the results are quantitatively similar. We do not, however, find a significantly negative CAR for the 60 day period prior to the announcement for all announcements of for announcements within separate years. This is in contrast to other studies that find a significant negative abnormal return prior to the announcement. Thus, in the Norwegian market, it does not seem that firms decision to announce a repurchase plan is influenced by the (risk adjusted) prior performance of the firm at least relative to the three months prior to the announcement. This may be explained by the findings in panel B in table 4.1, where we found that the number of days between the announcement of the plan and the first repurchase execution was almost 200 days. Thus, the announcement does not, on average, seem to be triggered by a negative drift prior to the announcement.

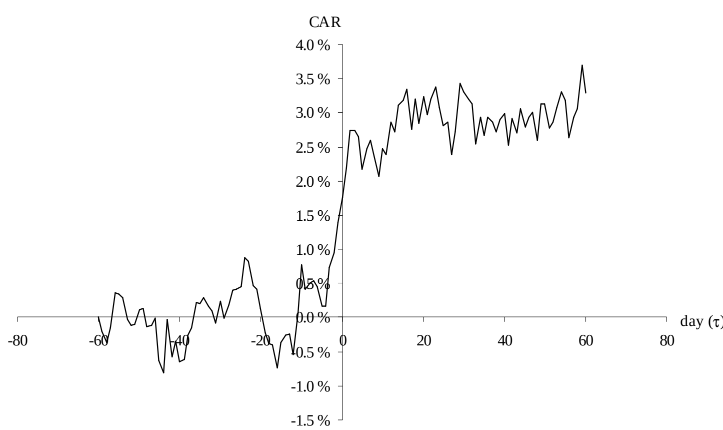
When examining the announcement effect for different years, we find a positive effect for all years, but the announcement effect is only significantly different from zero for announcements in 1999 and 2001. In addition, only firms that announce that they are planning on repurchasing more than 5% of their outstanding shares experience a significant abnormal price impact, while the excess return for firms that announce a lower repurchase fraction is positive but insignificant. Table 4.A1 in appendix 4.A shows the results from a robustness check where all firms with an announcement CAR below the 5th and above the 95th percentile are removed from the sample. The announcement effect falls to about 1.9%, but is still significant at the 1% level.

TABLE 4.3
Abnormal returns around announcements of repurchase plans

The table shows the abnormal return (in percent) around announcements of repurchase plans. The abnormal return is measured relative to a one factor market model (unadjusted and adjusted for biases induced by infrequent trading as proposed in Dimson (1979) and Scholes and Williams (1977)), Fama and French (1993) three factor model and the Carhart (1997) four factor model, with the value weighted OSE general index as the market portfolio. The sub-sample regressions and the repurchase% regressions are cumulative excess returns relative to the Carhart four factor model. Numbers in bold represent numbers significantly different from zero at the 1% level, and numbers in parenthesis are the associated t-values.

		Days relative to announcement date τ_1 to τ_2					
	n	-60 to -3		-2 to +2		+3 to +60	
		Whole sample (1998-2001)					
Unadjusted market model	318	-0.23	(-0.29)	**2.52**	(3.72)	0.51	(0.62)
Dimson (1979)	318	-0.06	(-0.07)	**2.43**	(3.53)	0.24	(0.29)
Scholes and Williams (1977)	318	-0.25	(-0.32)	**2.44**	(3.58)	0.20	(0.24)
Fama and French (1993)	318	-0.31	(-0.41)	**2.52**	(3.72)	0.63	(0.77)
Carhart (1997)	318	-0.25	(-0.34)	**2.62**	(3.86)	0.62	(0.75)
		Subsamples (year)					
1998	28	1.59	(0.85)	1.25	(0.57)	1.47	(0.89)
1999	85	-0.68	(-0.56)	**2.79**	(2.66)	2.35	(1.53)
2000	93	-1.97	(-1.63)	1.36	(1.30)	0.42	(0.25)
2001	112	1.03	(0.66)	**3.86**	(2.72)	-0.80	(-0.56)
		Announced repurchase limit (%)					
<0%- 5%]	42	-2.93	(-1.85)	3.37	(1.30)	-0.81	(-0.46)
<5%-10%]	276	0.16	(0.19)	**2.50**	(3.70)	0.84	(0.92)

FIGURE 4.1 Cumulative average abnormal return
The figure shows the CAR relative to a Carhart (1997) model across all 318 announcements that occurred in the period 1999 through 2001. The CAR is the accumulated average abnormal returns starting 60 days prior to the announcement of the repurchase plan and ending 60 days after the announcement.



To examine in more detail what factors are important with respect to the size of the announcement effect, we run the following regression with the cumulative abnormal return across the event window for each announcement, $\widehat{CAR}_i(\tau_1, \tau_2)$, as the dependent variable,

$$\begin{aligned}\widehat{CAR}_i(\tau_1, \tau_2) = \alpha + \beta_1 \widehat{CAR}_{i,\tau_1-k} + \beta_2 \overline{SPR}_{i,\tau_1-k} + \beta_3 MCAP_{i,\tau_1-1} \\ + \beta_4 BM_{i,\tau_1-1} + \beta_5 PERC_{i,\tau} + DIV_{i,\tau_1-360} + QuickRatio_{i,\tau} + \epsilon_i\end{aligned} \tag{4.9}$$

where α is the intercept term, CAR_{i,τ_1-k} is the cumulative abnormal return over the k days prior to the event window, $\overline{SPR}_{i,\tau_1-k}$ is the average relative spread[34] across the k days prior to the event window, $MCAP_{i,\tau_1-1}$ is the natural log of the firms market capitalization on the last date before the event window, BM_{i,τ_1-1} is the book to market value on the last date before the event window, $PERC_{i,\tau}$ is the size of the repurchase plan, DIV_{τ_1-360} is a dummy variable indicating whether a firm has paid any cash dividends during the previous year and $QuickRatio_{i,\tau}$ is the most recently reported quick ratio[35] before the firm announces a repurchase plan.

Panel A in table 4.4 shows the results from the cross sectional regression when τ_1=-2, τ_2=2 and k=20, and panel B shows the correlations between the variables. As can be seen from panel B, the average pre-event spread ($\overline{SPR}_{i,\tau_1-k}$) is strongly negatively correlated with market capitalization ($MCAP_{i,\tau_1-1}$). This is because large firms generally are more liquid and has lower spreads. In addition, as noted by Vermaelen (1981), small firms may have a greater degree of asymmetric information since they are less closely followed by analysts and the popular press. Thus, both the spread and market capitalization variables capture to a large degree these same characteristics. The second highest correlation is between the book to market (BM_{i,τ_1}) variable and the pre-event (20 days) cumulative abnormal return, which has a significant positive correlation of 0.26. To reduce the multicolinearity problem when including all these variables in the regression, we orthogonalize both the market capitalization against the relative spread measure as well as the book to market variable against the pre announcement CAR (CAR_{i,τ_1-k}).[36] Panel C in the table shows some descriptive statistics for the independent variables. Note that the $MCAP_{i,\tau_1-1}$ is in natural logs and that the $\widehat{CAR}_{i,\tau_1-k}$ is not in percentage terms.

We estimate two models. Model 1 include all variables, and in model 2 the variables related to firm liquidity are omitted. The first thing to note is that the greater

[34] The relative spread for a security for a day, τ, is calculated as $SPR_\tau = (ask_\tau - bid_\tau)/[(ask_\tau + bid_\tau)/2]$, where ask_τ and bid_τ is the best ask and bid quotes at the close of day τ.

[35] The quick ratio is calculated as the sum of cash and deposits, total short-term financial investments and total short-term receivables divided by total short-term debt

[36] When estimating the regressions with the original (nonorthogonalized) variables the results are quantitatively similar.

(lower) the cumulative excess performance ($\widehat{\mathsf{CAR}}_{i,\tau_1-k}$) during the 20 days prior to the announcement, the lower (greater) is the price impact at the announcement date. Although we did not find support for a negative drift in cumulative abnormal returns before the announcement on average in table 4.3, this indicates that some firms may announce a repurchase plan as a response to a price decline. From an undervaluation viewpoint, this suggests that the market perceives it as more likely that the firm is undervalued the worse the pre-event performance has been, and put more weight on the signal the worse the prior performance of the stock. This finding is similar to what is found in Comment and Jarrell (1991) and Chan et al. (2003) who argue that the credibility of the signal (proxied by the announcement effect) increases with the underperformance of the firm relative to the general market in the period prior to the announcement of the repurchase program. Furthermore, firms with larger spreads ($\mathsf{SPR}_{i,\tau_1-k}$) experience a greater price impact at the announcement date than firms with smaller spreads. If the spread proxy for market liquidity, this result is expected in the sense that the market price moves more for a less liquid stock. If the announcement results in an excess demand for the stock, at the announcement, the supply side of the order book will be exhausted more easily for a less liquid stock than a more liquid stock. In addition, since the spread may also proxy for asymmetric information, the announcement of a repurchase plan may have a stronger signalling value for a security where there is a higher uncertainty about firm value and potentially more private information is revealed through the announcement. With respect to the market capitalization variable (MCAP) we find that larger firms experience a lower abnormal price impact than smaller firms. As mentioned earlier, the reason for this may be that smaller firms are generally less liquid and that an announcement is more valuable to the market for small firms if there is larger information asymmetries in smaller firms.

Further, we also find that value stocks, with a high book-to-market value, experience a stronger price impact than growth stocks. One interpretation for this is that value firms are more likely to be undervalued relative to growth firms, and that the announcement of a repurchase plan may confirm the markets perception of undervaluation. With respect to the size of the repurchase plan, it does not explain any variation in the announcement effect. Initially, one would expect that a larger repurchase plan would be a stronger signal about undervaluation. However, as discussed earlier, a large fraction of the announcements are for the maximum allowed size of 10%. Thus, there may be too little variation in this variable to account for any variation in the CAR. Wether the firm has paid any dividend the previous year is not related to the announcement effect. With respect to the dividend variable, one could initially expect this to be negative if firms that has paid dividends the previous year is expected to continue paying dividends in the future (dividend smoothing). If firms are expected to continue using excess cash to pay dividends, this lowers the probability that they will repurchase, and the potential

TABLE 4.4
Cross-sectional CAR regression

Panel A in shows the results from the cross sectional regression of $\mathsf{CAR}_i(\tau_1, \tau_2)$ on various variables. Model 1 is estimated as,

$$\widehat{\mathsf{CAR}}_i(\tau_1, \tau_2) = \alpha + \beta_1 \widehat{\mathsf{CAR}}_{i,\tau_1 - k} + \beta_2 \overline{\mathsf{SPR}}_{i,\tau_1 - k} + \beta_3 \mathsf{MCAP}_{i,\tau_1 - 1} + \beta_4 \mathsf{BM}_{i,\tau_1 - 1} + \beta_5 \mathsf{PERC}_{i,\tau} + \beta_6 \mathsf{DIV}_{i,\tau_1 - 360} + \beta_7 \mathsf{QuickRatio}_{i,\tau} + \epsilon_i \tag{4.10}$$

where i denotes the announcements, α is the intercept, $\widehat{\mathsf{CAR}}_{i,\tau_1-k}$ is the cumulative abnormal return over the k days prior to the event window, $\overline{\mathsf{SPR}}_{i,\tau_1-k}$ is the average spread across the k days prior to the event window, $\mathsf{MCAP}_{i,\tau_1-1}$ is the natural log market capitalization on the last date before the event window, BM_{i,τ_1-1} is the book to market value on the last date before the event window, $\mathsf{PERC}_{i,\tau}$ is the size of the repurchase plan and $\mathsf{DIV}_{\tau_1-360}$ is a dummy indicating whether a firm has paid any dividends during the last year and $\mathsf{QuickRatio}_{i,\tau}$ is the most recent quick ratio before the announcement. In the regression τ_1=-2, τ_2=2 and k=20. Note that the market capitalization is orthogonalized against the spread measure, and the book-to-market variable is orthogonalized against the $\widehat{\mathsf{CAR}}_{i,\tau_1-k}$ variable. Panel B shows the Pearson's correlations coefficients between the variables used in the regressions in panel A. The correlations for MCAP and SPR are before they are orthogonalized. Numbers in bold refer to correlations significantly different from zero at the 5% level. Panel C shows some descriptive statistics for the variables.

Panel A: Cross sectional CAR regression

	Model 1				Model 2			
Variable	Est.	std.err.	p-val.	Part.R^2	Est.	std.err.	p-val.	Part.R^2
Constant	0.041	0.034	0.228	-	0.026	0.036	0.463	-
$\widehat{\mathsf{CAR}}_{\tau_1-k}$	-0.165	0.046	<0.001	0.027	-0.151	0.049	0.002	0.027
$\overline{\mathsf{SPR}}_{\tau_1-k}$	0.338	0.067	<0.001	0.060	-	-	-	-
MCAP_{τ_1-1}	-0.013	0.005	0.008	0.016	-	-	-	-
BM_{τ_1-1}	0.023	0.006	<0.001	0.051	0.028	0.006	<0.001	0.051
PERC_i	-0.179	0.350	0.609	0.000	0.054	0.364	0.882	0.000
$\mathsf{DIV}_{i,\tau_1-360}$	-0.031	0.017	0.067	0.008	-0.035	0.018	0.045	0.012
Quick ratio$_\tau$	-0.007	0.002	0.002	0.026	-	-	-	-
$\mathsf{adj.R}^2$	0.171				0.078			
N	318				318			

Panel B: Variable correlations

	$\widehat{\mathsf{CAR}}_{\tau_1-k}$	$\overline{\mathsf{SPR}}_{\tau_1-k}$	MCAP_{τ_1-1}	BM_{τ_1-1}	$\mathsf{PERC}_{i,\tau}$	$\mathsf{DIV}_{\tau_1-240}$
$\overline{\mathsf{SPR}}_{\tau_1-k}$	0.06					
MCAP_{τ_1-1}	-0.05	**-0.52**				
BM_{τ_1-1}	**0.26**	**0.13**	-0.07			
$\mathsf{PERC} - i, \tau$	0.07	**0.12**	**-0.15**	-0.08		
$\mathsf{DIV}_{\tau_1-360}$	0.00	-0.01	0.08	**0.12**	-0.07	
Quick ratio$_{i,\tau}$	0.01	0.08	-0.13	-0.03	0.08	-0.02

Panel C: Variable statistics

Variable	Mean	std.dev	min	max
$\widehat{\mathsf{CAR}}_{\tau_1-k}$	-0.003	0.132	-0.43	0.33
MCAP_{τ_1-1} (log)	20.602	1.512	16.13	25.12
BM_{τ_1-1}	1.328	1.111	0.24	8.54
PERC_i	0.095	0.018	0.01	0.10
$\overline{\mathsf{SPR}}_{\tau_1-k}$	0.064	0.093	0.01	0.81
$\mathsf{DIV}_{i,\tau_1-360}$	0.164	0.370	0	1
Quick ratio$_\tau$	2.078	2.668	0.26	31.79

positive effects related to repurchases discussed in section 4.2 are less likely to occur. Finally, the most recent quick ratio before the announcement, is negatively related to the announcement effect. Initially, one would expect this variable to be positive in the sense that liquid firms may be expected to actually execute repurchases such that the signal is more credible when firms are liquid. On the other hand, the announcement may to a greater extent be expected by the market in these cases.

4.6.2 Long-term performance of firms announcing a repurchase plan

In this section we examine the long term performance of firms announcing a repurchase plan. The main hypothesis to be investigated is the underreaction hypothesis of Ikenberry et al. (1995) who argue that, if a repurchase announcement is a positive signal, this signal should be, in an efficient market, incorporated into prices completely and in an unbiased fashion when the firm announces the repurchase plan. In the previous section we found a significant positive announcement effect of about 2.5%. In panel A of table 4.5 we report the results from evaluating the long term abnormal performance of a calendar time portfolio of announcing firms. The portfolio is rebalanced every month. All stocks that announce a repurchase plan during a month are added to the portfolio the first day of the following month. At the beginning of each month, all firms receive equal weights in the portfolio. We also examine in panel B of table 4.5 the performance of our portfolio with respect to various fixed holding periods from 1 to 4 years in addition to a buy-and-hold strategy ("whole sample") where the stock remains in the portfolio for the rest of the period. When a stock has been in the portfolio for the duration of the respective holding period, it is removed from the portfolio until it announces a new repurchase plan. To reduce the idiosyncratic risk of the portfolio, we require there to be at least 10 firms that has announced a repurchase plan before we start the portfolio.[37]

Panel A in table 4.5 shows that for a buy-and-hold portfolio, with no limit on the holding period, the portfolio significantly outperforms the market by about 0.9% per month, or 11% per year, when we adjust for the Fama and French (1993) and Carhart (1997) risk factors. This is in line with results in Ikenberry et al. (1995, 2000) who finds an abnormal performance of 12.1% in the US and 7% per year in Canada respectively. Relative to the CAPM, the excess performance is almost 2% per month, or almost 27% per year, illustrating the importance of adjusting the portfolio performance for additional risk factors in addition to the market risk. When restricting the holding period in panel B, we find, for the Fama/French and Carhart models, that there is a significant excess performance when the holding period is longer than 1 year. With respect to a CAPM specification, the portfolio outperforms regardless of the chosen

[37] When we use the entire sample period, this result in our portfolio starting in October 1998, when 10 firms had announced a repurchase plan.

holding period.

One important point with respect to evaluating the long term abnormal performance in this type of study is that the expected return model may be misspecified. As shown by Kothari and Warner (1997), in a random sample of 200 firms, about 35% of the firms, independent of the benchmark model used, show an abnormal positive and negative abnormal performance over a 36 month period. Although they do not examine these issues in the context of calendar time portfolios (only with respect to the long run performance through event time), they argue that a calendar time approach may involve similar issues. In this study we do not attempt to adjust for such biases, but instead examine several model specifications for expected returns. An alternative approach could be to create a matching portfolio of non announcing firms. However, since there are relatively few listed companies at the OSE,[38] implementing a matching procedure in a satisfactory way may be difficult. As noted by Kothari and Warner (1997), it is not necessarily enough to match on size and book to market, but also other firm characteristics as well.

To examine the robustness of the results in table 4.5 we also estimate the excess returns when we start the portfolio construction in different years throughout the sample period (1999, 2000 and 2001) and vary the holding period from 1 to 4 years. The results from this analysis, relative to a Carhart (1997) specification is reported in table 4.5. We also note that the results when we start the portfolio construction in 1999 are very similar to the results in table 4.5. The reason for this that we do not start the portfolio construction in 1998 before at least 10 firms have announced a repurchase plan, which is in October 1998. Thus, the portfolio construction only starts 3 months later for the portfolio starting in 1999. In addition, since the time series becomes longer the earlier we start our portfolio, the data used in later years are subsets of the data we use when starting the portfolio in earlier years. However, the main point of the analysis is to check to what degree the results change when we change the starting point of the sample. The results are similar to those in panel B in table 4.5. There is no significant excess performance for the announcement portfolio for holding periods of one year. However, for holding periods of two years or longer, there is a significant abnormal performance regardless of the year when we start the portfolio construction.

To summarize the analysis so far, both the results in table 4.5 and 4.6 support the underreaction hypothesis of Ikenberry et al. (1995, 2000). The reaction to the announcement of repurchase plans found in table 4.3 seem to be incomplete relative to the true value of the signal conveyed through the announcement proxied by the long term excess performance following the announcement. The subsequent abnormal performance for announcing firms may be related to information surprises through e.g. public announcements or unexpected earnings reports that occur after the announcement of

[38]In the end of 1999, 2000 and 2001 there were respectively 215, 214 and 212 listed firms at the OSE.

TABLE 4.5
Long term performance of the announcement portfolio

The table shows the excess performance of a calendar time portfolio of firms announcing a repurchase plan. The excess return on the portfolio is both measured relative to a one-factor CAPM model (*i*), a three factor Fama and French (1993) model (*ii*) and a four factor Carhart (1997) model (*iii*),

$$(i) \quad R_{p,t} - R_{f,t} = \alpha + \beta_m (R_{m,t} - R_{f,t}) + \varepsilon_t$$
$$(ii) \quad R_{p,t} - R_{f,t} = \alpha + \beta_m (R_{m,t} - R_{f,t}) + \beta_{hml} R_{hml,t} + \beta_{smb} R_{smb,t} + \varepsilon_t$$
$$(iii) \quad R_{p,t} - R_{f,t} = \alpha + \beta_m (R_{m,t} - R_{f,t}) + \beta_{hml} R_{hml,t} + \beta_{smb} R_{smb,t} + \beta_{mom} R_{mom,t} + \varepsilon_t$$

where $R_{p,t}$ is the return on the equally weighted portfolio of announcing firms, R_t^f is our proxy for the risk free rate, R_τ^m, R_τ^{hml}, R_τ^{smb} and R_τ^{mom} are the returns on the market-, the book to market-, the size- and the momentum factors respectively, and the β's are the factor exposures. The factor returns are calculated similarly as in eq. 4.3 and α measures the average daily abnormal performance of the portfolio relative to the excess return on the factor portfolios. The portfolio is rebalanced at the beginning of every month, and firms that announced a repurchase plan during the previous month is included in the portfolio. Panel A shows the results for our buy-and-hold portfolio when stocks are not sold (the stocks in the portfolio are hold through the entire sample from when they enter), and Panel B shows the results when we vary the holding period from 1 months to the entire sample period. In both panel A and panel B the average daily excess return, α, is reported in percent.

Panel A: Buy-hold portfolio performance (no limit on holding period)

	CAPM	t-value	Fama/ French	t-value	Carhart	t-value
α (%)	0.10	4.71	0.04	2.29	0.04	2.30
β_m	0.58	33.79	0.72	38.88	0.72	37.94
β_{smb}	-	-	0.27	13.51	0.27	13.38
β_{hml}	-	-	0.06	3.74	0.05	2.90
β_{mom}	-	-	-	-	-0.02	-0.98
adj.R^2	0.523		0.602		0.602	
N	1041		1041		1041	

Panel B: Various holding periods

Holding period	CAPM		Fama/French		Carhart	
	α(%)	t-value	α(%)	t-value	α(%)	t-value
1 year	0.064	2.18	0.008	0.28	0.008	0.27
2 years	0.087	4.49	0.036	1.98	0.036	1.99
3 years	0.100	4.61	0.046	2.28	0.047	2.29
4 years	0.099	4.73	0.045	2.31	0.045	2.32
Whole sample	0.098	4.71	0.044	2.29	0.045	2.30

the repurchase plan. However, we cannot exclude the possibility that the excess performance may be due to miss-specification of the expected returns model as discussed in Kothari and Warner (1997) among others. We try to reduce the misspecification by using several model specifications for expected returns. Including the size, book to market and momentum factors, reduces the excess performance estimate relative to a CAPM specification. However, for horizons longer than one year, there is still evidence that the portfolio of announcing firms experience an excess performance after having accounted for the portfolios exposure to these risk factors.

Table 4.6

Long term performance of announcement portfolio - varying starting year

The table shows the excess performance of a calendar time portfolio of firms announcing a repurchase plan for various starting years and holding periods. The excess return on the portfolio is measured relative to a four factor Carhart (1997) model,

$$R_{pt} - R_t^f = \alpha + \beta_m (R_t^m - R_t^f) + \beta^h R_t^{hml} + \beta^s R_t^{smb} + \beta^{mom} R_t^{mom} + \varepsilon_t$$

where R_{pt} is the return on the equally weighted portfolio of announcing firms, R_t^f is our proxy for the risk free rate, R_τ^m, R_τ^{hml}, R_τ^{smb} and R_τ^{mom} are the returns on the market-, the book to market-, the size- and the momentum factors respectively, and the β's are the factor exposures. The factor returns are calculated similarly as in eq. 4.3 and α measures the average daily abnormal performance of the portfolio after having adjusted for the Carhart risk factors. The portfolio is rebalanced at the beginning of every month, and firms that announced a repurchase plan during the previous month is included in the portfolio. The results when starting the portfolio construction in 1998 and 1999 are quite similar. This is mainly because we do not start the portfolio in 1998 before enough firms (10 firms) have announced a repurchase plan which is in October 1998.

	Year when starting portfolio construction					
	1999		2000		2001	
Holding period	α(%)	t-value	α(%)	t-value	α(%)	t-value
1 year	0.009	0.31	0.008	0.23	0.02	0.46
2 years	**0.038**	2.11	**0.044**	2.09	**0.07**	2.59
3 years	**0.049**	2.40	**0.059**	2.38	-	-
4 years	**0.048**	2.44	-	-	-	-

4.6.3 Long term performance conditional on repurchase activity

In the previous section we found support for the underreaction hypothesis in the Norwegian market. In this section we examine more closely the nature of the excess performance. Moreover, we study whether the fact that a firm actually execute a repurchase or not is important for the subsequent performance.

This is motivated by the fact that a repurchase announcement itself is not a commitment to actually repurchase shares. Furthermore, the announcement does not impose any costs on the managers in the announcing firms if the announcement is false.[39] Thus, as discussed in Fried (2002) and Comment and Jarrell (1991), the credibility of the signal may be questionable. On the other hand, when a firm actually executes a repurchase, this may be perceived as a stronger signal about undervaluation since it involves real transactions. Especially, if the manager or other insiders owns a stake in the company, since if they repurchase when the firm is overvalued, the managers will increase their ownership in an overvalued firm (assuming that they retain their shares). Thus, when the market observes that the firm executes a repurchase it may be interpreted as a signal (or confirmation of the initial signal) that the the firm is actually undervalued.

Given that undervaluation is the main motivation for why firms repurchase shares, the actual repurchase executions should be a positive signal to the market about firm value. Moreover, one would expect the firm to execute repurchases until the firm is no longer undervalued. If this is the case we expect the market to react positively to the actual repurchases, and increase prices closer to the true value. Furthermore, if the firms repurchase activity increases the price closer to the true value, reducing the mispricing, this should also reduce the subsequent long run excess performance for these firms.[40]

Announcements that do not result in subsequent repurchases, may be because of several reasons. First of all, the firm may simply not be mispriced after the announcement. If these firms are more able to credibly signal that they are undervalued through the announcement of a repurchase plan, and the market fully reacts to the information conveyed by the announcement, one would *not* expect these firms to repurchase any shares after the announcement (at least not for undervaluation reasons). If this is the case, we would expect announcements that do not result in subsequent repurchases to experience a greater announcement effect than announcements that result in subsequent repurchases. To check this, we examine, in table 4.7, whether announcements that do not result in subsequent repurchases experience a stronger announcement effect than announcements that result in repurchases. The results suggest that the announcement effect (as well as the pre- and post-announcement CAR) is similar for the two groups. Thus, there is no evidence that announcements which result in subsequent repurchases experience a greater underreaction than announcements that do not result in repurchases. Rather, the market reaction in the two cases are remarkably similar.

Another reason for why firms do not execute any repurchases may be because of liquidity reasons. This can be due to low profitability or that they do not have any excess cash available for repurchasing shares. Thus, from an undervaluation perspective, the managers may want to repurchase shares due to undervaluation, but are unable to do so.[41] An additional reason for why firms do not repurchase shares during the course

[39] As proposed by Fried (2002), if managers act opportunistically they may also announce a repurchase plan when the firm is not undervalued to boost the stock price when selling.

[40] As discussed in section 4.2, firms also repurchase shares for many other reasons than undervaluation. However, our main discussion will be centered around the undervaluation hypothesis.

[41] The managers could also issue debt to finance the repurchases, but this may be costly if the firm

Table 4.7
Announcement CAR given subsequent repurchase activity

The table shows the abnormal returns (in percent) for different periods around the announcement of repurchase programs that resulted in actual repurchases versus announcements that did not result in subsequent repurchases. The table also show the p-value from a test that the means between the two groups are equal.

		Days relative to announcement date (τ_1 to τ_2)		
	n	-60 to -3	-2 to +2	+3 to +60
Announcement, no repurchase	133	-0.05%	2.39%	0.89%
Announcement, repurchase	185	-0.40%	2.78%	0.43%
Test for difference in means (p-value)		0.54	0.75	0.62

of a repurchase program is discussed in Ikenberry et al. (2000). Findings in Ikenberry et al. (2000) indicates that managers are sensitive to price movements. Thus, if the price increases, such that the stock potentially becomes overvalued, the manager may choose not to execute repurchases.

Our main hypothesis is that if managers execute repurchases to exploit undervaluation, and the market efficiently reacts to the signal conveyed through the actual repurchases, the repurchase activity should mitigate the mispricing. Moreover, the price should increase towards the "true" value if the actual repurchases signal undervaluation. This should further reduce the subsequent excess returns closer to expected levels for a portfolio of these firms. In other words, we should observe a lower subsequent abnormal performance for repurchasing firms if the initial repurchases are successful in reducing the mispricing. In addition, we should also see a positive, and permanent price impact from the actual repurchases if the market respond favorably to the information that the firm has executed repurchases (this will be examined more closely in section 4.6.4).

Relative to what we expect to see for the group of non-repurchasing firms, this is not clear. As discussed earlier, these firms may both choose to repurchase because they are not mispriced which imply that these firms should perform as expected. Alternatively, these firms may experience a price increase after the announcement such that the managers choose not to repurchase any shares (Ikenberry et al., 2000), in which case we expect these firms to show an abnormal performance if the price increase is related to new information. Also, if these firms are undervalued after the announcement, but are unable to execute repurchases due to e.g. liquidity constraints, we would also expect these firms to show an long run abnormal performance if prices are adjusted in response to favorable information arrivals in later periods. On the other hand, if these firms choose not to repurchase because they are overvalued, we would expect these firms to underperform in the long run.

already have a high leverage ratio or that the undervaluation is to small to justify an issue of debt.

To examine these questions in more detail, we construct a portfolio through calendar time in the similar fashion as we did when we examined the long term performance of announcing firms in the previous section. However, instead of only selecting our portfolio stocks conditional on whether the firm has announced a repurchase plan, we now also condition our stock selection on whether a firm has executed its first repurchase as well. More specifically, we create two portfolios, assigning firms based on whether they have repurchased shares in the previous period or not. In the first portfolio (P1) we include a firm the first day of the month following the month when it announced a repurchase plan (similar to the portfolio created in the previous section). Next, if a firm in P1 executes a repurchase, we remove the firm from P1 the following day and include it in a second portfolio (P2) the first day of the following month after it for the first time has executed a repurchase.[42] Thus, P1 will at any point in time only contain firms that have announced a repurchase plan, but not yet repurchased, while P2 contains firms that have executed at least one repurchase following an announcement. The combined portfolio of the firms in P1 and P2, is the portfolio that was analyzed in section 4.6.2, such that P1 and P2 represent a decomposition of the announcement portfolio.[43] The fraction of firms actually repurchasing and the fraction of outstanding shares actually repurchased among Norwegian firms is reported in table 4.1. Thus, at the end of the sample period in the scenario with no limit on the holding period, and we start the portfolio construction at the beginning of the sample, we will be left with 63 firms in P1 and 100 firms in P2 at the end of the sample period.

In table 4.8 we estimate the performance of the two portfolios relative to the CAPM, Fama and French (1993) three factor model and the Carhart (1997) four factor model. On average the portfolio of firms that has not repurchased, P1, consists of 45 firms while the portfolio firms that execute at least one repurchase, P2, contains on average 69 firms. For diversification reasons, we do not start our portfolio construction before both portfolios each contain at least 10 firms, which is in May 1999. Estimating Jensen's alpha with respect to the CAPM, both portfolios show a significant abnormal performance of 2% (P1) and 1.6% (P2) per month. However, relative to the Fama/French and Carhart specifications, the results indicate that P2 does not experience an abnormal performance while P1 experience a significant abnormal performance of about 1.2% per month. In other words, the portfolio tracking the portfolio of repurchasing firms (after they have executed their first repurchases) perform as expected while the portfolio of firms that announces, but do not repurchase, experience an excess performance.

This result may indicate that actual repurchases provide useful information to the

[42] Firms may execute several repurchases before it is included in P2. However, the potential price effect of these repurchases will not be included in either P1 or P2. Only the effect of the first repurchase will be included in the return of P1.

[43] One difference however, is that since firms are removed the day after they repurchase and not included in P2 before the first day of the next month, there is a window where a repurchasing firm is excluded from both portfolios.

Table 4.8
Long term performance conditional on repurchase activity

The table shows the excess performance of two calendar time portfolios. P1 is the portfolio with announcing firms that do not execute any repurchases, only announces. P2 is a portfolio of repurchasing firms where a firm is included in the portfolio the month after it has executed its first repurchase. The firm is excluded from P1 one day after it has repurchased for the first time. Thus, at any point in time, P1 consists of firms that has announced a repurchase plan, but has not executed any repurchases, while P2 consists of firms that has executed at least one repurchase. The excess returns on the two portfolios are estimated relative to a one-factor CAPM model (*i*), a three factor Fama and French (1993) (*ii*) and a four factor Carhart (1997) model (*iii*),

$$(i) \quad R_{p,t} - R_{f,t} = \alpha + \beta_m (R_{m,t} - R_{f,t}) + \varepsilon_t$$
$$(ii) \quad R_{p,t} - R_{f,t} = \alpha + \beta_m (R_{m,t} - R_{f,t}) + \beta_{hml} R_{hml,t} + \beta_{smb} R_{smb,t} + \varepsilon_t$$
$$(iii) \quad R_{p,t} - R_{f,t} = \alpha + \beta_m (R_{m,t} - R_{f,t}) + \beta_{hml} R_{hml,t} + \beta_{smb} R_{smb,t} + \beta_{mom} R_{mom,t} + \varepsilon_t$$

where $R_{p,t}$ is the return on the equally weighted portfolio of announcing firms, R_t^f is our proxy for the risk free rate, R_τ^m, R_τ^{hml}, R_τ^{smb} and R_τ^{mom} are the returns on the market-, the book to market-, the size- and the momentum factors respectively, and the β's are the factor exposures. The factor returns are calculated similarly as in eq. 4.3 and α measures the average daily abnormal performance of the portfolio relative to the excess return on the factor portfolios. The table shows the results for buy-and-hold portfolios for which stocks are not sold (the stocks in the portfolio are held through the entire sample from when they enter the portfolio). The estimated average daily excess return, α, is reported in percent, and numbers in bold denote an α estimate significant at the 5% level.

	CAPM		**Fama/French**		**Carhart**	
	P1 (norep)	P2 (rep)	P1 (norep)	P2 (rep)	P1 (norep)	P2 (rep)
α (%)	**0.10**	**0.10**	**0.06**	0.03	**0.06**	0.03
p-value	0.00	0.00	0.03	0.20	0.03	0.20
β_m	0.58	0.56	0.68	0.72	0.67	0.73
β_{smb}			0.20	0.31	0.20	0.32
β_{hml}			0.05	0.04	0.01	0.06
β_{mom}					-0.08	0.03
adj.R^2	0.39	0.37	0.42	0.45	0.43	0.45
Avg. firms	45	69	45	69	45	69

market which may be related to the confirmation of the initial announcement signal, permanently increasing the price such that mispricing is mitigated, and subsequent returns are reduced to expected levels. However, we cannot exclude the possibility that these firms do not repurchase shares for undervaluation reasons. In addition, the result may also indicate that managers repurchase shares when their underperforms, such that the average performance of this portfolio is lower than the portfolio where managers do not execute any repurchases. We will examine the abnormal price impact of the actual repurchases in the next section to investigate whether it is likely that the actual repurchases mitigate mispricing.

Our results are also consistent with earlier findings. Stephens and Weisbach (1998) find, using quarterly repurchase data for Canada, that repurchases during one quarter appear to be negatively related to unadjusted returns in the previous (and contemporaneous) quarter. This suggests that managers respond to previous price changes when determining whether to repurchase or not. In addition, they find that subsequent returns is lower in the quarters after the firm has repurchased. This finding is also confirmed in, Ikenberry et al. (2000), using monthly repurchase data from Canada. In addition, Ikenberry et al. (2000) find that stock performance in the year following the announcement of a repurchase plan decreases with the repurchase activity. They argue that this is because managers time their repurchases to times when the firm is perceived by the manager of the firm as being undervalued, such that these firms experience a lower excess performance on average.

This points to an issue that is not examined in the paper. The decision to repurchase is likely to be related to events occurring after the announcement of the repurchase program, such that the repurchases (or non repurchases) observed ex post were not necessarily intended ex ante. This is an important and interesting issue since announcing firms are likely to "self select" into being repurchasers or non-repurchasers. Furthermore, this may explain the finding that repurchasing firms has a lower abnormal performance than non repurchasing firms. It may be that firms choose not to repurchase because the price of their stock has increased reflected by the abnormal performance of P1, while non-repurchasers choose to repurchase because their stock has performed poorly. An interesting extension would be to examine this self selection in more detail to study what are the important decision variables that induce announcing firms to execute repurchases or not.[44]

Since the results in table 4.8 are for the whole sample period for a buy-an-hold strategy, we also check the robustness of our results by creating portfolios starting in different years as well as with various holding periods. The results from this analysis is reported in table 4.9. With respect to the different starting years, the results are

[44] In the introduction of the thesis, in section 1.1.2, this is proposed as a future research topic or as an improvement of the current paper.

Table 4.9

Long term performance conditional on repurchase activity - varying starting year and holding period

The table shows the excess performance of two calendar time portfolios for varying starting years and holding periods. P1 is the portfolio with announcing firms that do not execute any repurchases, only announces. P2 is a portfolio of repurchasing firms where a firm is included in the portfolio the month after it has executed its first repurchase. Thus, at any point in time, P1 consists of firms that has announced a repurchase plan, but has not executed any repurchases, while P2 consists of firms that has executed at least one repurchase. The excess returns on the two portfolios are both measured relative to a four factor Carhart (1997) model,

$$R_{pt} - R_t^f = \alpha + \beta_m(R_{m,t} - R_t^f) + \beta_{hml}R_{hml,t} + \beta_{smb}R_{smb,t} + \beta_{mom}R_{mom,t} + \varepsilon_t$$

where R_{pt} is the return on the equally weighted portfolio of announcing firms, R_t^f is our proxy for the risk free rate, R_τ^m, R_τ^{hml}, R_τ^{smb} and R_τ^{mom} are the returns on the market-, the book to market-, the size- and the momentum factors respectively, and the β's are the factor exposures. The factor returns are calculated similarly as in eq. 4.3 and α measures the average daily abnormal performance of the portfolio relative to the excess return on the factor portfolios. The average daily excess return, α, is reported in percent, numbers in parentheses are p-values for the α estimates, and numbers in bold represent a significance at the 5% level.

Year when starting portfolio construction

Max. holding period	1999		2000		2001	
	α(P1)	α(P2)	α(P1)	α(P2)	α(P1)	α(P2)
1 year	0.045	0.013	0.069	-0.007	**0.134**	0.028
	(0.191)	(0.727)	(0.128)	(0.86)	(0.039)	(0.655)
2 years	**0.066**	0.012	**0.089**	-0.006	**0.121**	0.017
	(0.046)	(0.658)	(0.033)	(0.832)	(0.034)	(0.665)
3 years	**0.063**	0.028	**0.083**	0.016	.	.
	(0.036)	(0.231)	(0.027)	(0.533)	.	.
4 years	**0.061**	0.029	.	.	.	.
	(0.025)	(0.308)	.	.	.	.

qualitatively the same as in table 4.8, but quantitatively stronger in the later part of the sample. When we also vary the holding period, we find that the abnormal performance for P1 is significant for holding periods longer than one year. This is similar to the results when we examined the performance for all firms in table 4.5.

So far we have not discussed in detail what may contribute to the abnormal performance of P1. As discussed in the beginning of this section, the abnormal performance of this portfolio may be due to several reasons. However, one issue that may affect the excess performance of P1 is that a stock is removed after it has repurchased shares for the first time after the announcement. If there is an strong abnormal price impact related to the first repurchase execution, this may affect the performance of P1.

To examine to what degree this contributes to the abnormal performance of P1, we re-estimate the models in table 4.8, but exclude each firm from P1 five days before it execute its first repurchase. Thus, the excess returns related to the initial repurchases

TABLE 4.10

Long term performance conditional on repurchase activity - removing initial repurchase in P1

The table shows the excess performance of two calendar time portfolios. P1 is the portfolio with announcing firms that do not execute any repurchases, only announces. To examine whether the the effect of the initial repurchase contribute to the excess performance of P1, we exclude a firm five days before it executes its first repurchase. P2 remains identical as in the previous analysis where firms are included in the first day of the month after it has executed its first repurchase. Thus, at any point in time, P1 consists of firms that has announced a repurchase plan, but has not executed any repurchases, while P2 consists of firms that has executed at least one repurchase. The excess returns on the two portfolios are both measured relative to a one-factor CAPM model (*i*), a three factor Fama and French (1993) (*ii*) and a four factor Carhart (1997) model (*iii*),

$$\begin{aligned}
(i) \quad & R_{p,t} - R_{f,t} = \alpha + \beta_m (R_{m,t} - R_{f,t}) + \varepsilon_t \\
(ii) \quad & R_{p,t} - R_{f,t} = \alpha + \beta_m (R_{m,t} - R_{f,t}) + \beta_{hml} R_{hml,t} + \beta_{smb} R_{smb,t} + \varepsilon_t \\
(iii) \quad & R_{p,t} - R_{f,t} = \alpha + \beta_m (R_{m,t} - R_{f,t}) + \beta_{hml} R_{hml,t} + \beta_{smb} R_{smb,t} + \beta_{mom} R_{mom,t} + \varepsilon_t
\end{aligned}$$

where $R_{p,t}$ is the return on the equally weighted portfolio of announcing firms, R_t^f is our proxy for the risk free rate, R_τ^m, R_τ^{hml}, R_τ^{smb} and R_τ^{mom} are the returns on the market-, the book to market-, the size- and the momentum factors respectively, and the β's are the factor exposures. The factor returns are calculated similarly as in eq. 4.3 and α measures the average daily abnormal performance of the portfolio relative to the excess return on the factor portfolios. The table shows the results for buy-and-hold portfolios for which stocks are not sold (the stocks in the portfolio are held through the entire sample from when they enter the portfolio). The estimated average daily excess return, α, is reported in percent, and numbers in bold denote an α estimate significant at the 5% level.

	CAPM		**Fama/French**		**Carhart**	
	P1 (norepo)	P2 (repo)	P1 (norepo)	P2 (repo)	P1 (norepo)	P2 (repo)
α (%)	**0.09**	**0.10**	**0.06**	0.03	**0.06**	0.03
p-value	0.00	0.00	0.04	0.24	0.04	0.20
β_m	0.58	0.56	0.68	0.72	0.66	0.73
β_{smb}			0.20	0.31	0.19	0.32
β_{hml}			0.05	0.04	0.01	0.06
β_{mom}					-0.08	0.03
adj.R^2	0.39	0.37	0.42	0.45	0.42	0.45
Avg. firms	45	69	45	69	45	69

should then not be included in the performance of P1. The results from this analysis is reported in table 4.10, and it does not change the results greatly relative to the results in table 4.8. However, the estimated alpha for P1 decreases slightly, as well as its p-value, but the alpha is still significant at the 5% level for P1. Thus, the initial repurchase seem to have an impact on the performance of P1, but it does not explain the overall abnormal performance of P1.

An alternative reason for why firms choose not to repurchase shares may be that the stock price increases such that the manager choose not to repurchase any shares (Ikenberry et al., 2000). This may clearly be a potential reason for why P1 experience a long term abnormal performance. However, another explanation for why these firms do not execute any repurchases may be that the firms do not have any cash available to repurchase shares. Thus, if these firms experience an underreaction when they announce the repurchase plan, such that they are undervalued after the announcement, it may be that they are unable to signal to the market that they are mispriced through actual repurchases due to liquidity constraints. Moreover, given that the market underreacts to the signal conveyed through the initial announcement, and the firm is undervalued after the announcement, the lack of repurchase activity keeps the price at a low level, resulting in abnormal returns when the market is faced with positive information surprises in later periods.

To examine more closely whether low liquidity is a likely reason for why firms do not repurchase, we examine measures of liquidity from accounting data. The liquidity measures we use are the most recently reported quick ratios and current ratios prior to the announcements of the repurchase plans. The current ratio is calculated as the total short-term assets divided by total short-term debt, and the quick ratio is calculated as the sum of cash and deposits, total short-term financial investments and total short-term receivables divided by total short-term debt. In table 4.11 we examine the difference in liquidity between the firms in the two groups. The "no repurchase" group contains firms that do not repurchase shares during the sample (the firms in portfolio P1 in the above analysis). The first column of the table also contain the average liquidity measure for all firms listed at the OSE.[45] The results suggests that non-repurchasing firms are on average significantly less liquid than repurchasing firms. Although this varies somewhat across the years, the overall difference in liquidity between non-repurchasing and repurchasing firms support a hypothesis that at least some announcing firms do not execute repurchases due to lack of liquidity. Furthermore, it also substantiates our story that since these firms are constrained from repurchasing, and more credibly signal undervaluation, they experience a long-term abnormal drift due to e.g. information surprises in later periods.

To summarize, the results in this section indicates that the long term abnormal performance experienced by firms that announce a repurchase plan, mainly is due to firms that do not repurchase shares (P1). These results does not provide an explanation for the underreaction hypothesis proposed by Ikenberry et al. (1995). However, it offers an alternative interpretation in that the market rationally underreacts at the announcement date due to the low credibility of the signal. If a firm actually executes a repurchase, this may be a stronger signal of undervaluation, such that the market price is increased and the subsequent performance is reduced to expected levels. With respect to why the firms that do not repurchase experience a long term abnormal performance, we propose several explanations. This may be because these firms experience a price increase after the announcement reflected in the excess performance for this group, such that the manger chooses not to execute any repurchases. An additional interpretation,

[45] Before averaging across all the firms, we filter away the extreme observations in the upper 99% percentile. This removes 6 observations (within different years) with the largest having a quick ratio of more than 1000.

Table 4.11
Liquidity difference

The table shows the average liquidity of firms announcing a repurchase plan conditional on whether they execute repurchases for the duration of the repurchase plan or not. Results are supplied for the whole sample (All years) as well as for announcements occurring within separate years. The first column report the average across all firms at the OSE. The proxies used to measure liquidity are the "current ratio" calculated as total short-term assets divided by total short-term debt, and the "quick ratio" calculated as the sum of cash and deposits, total short-term financial investments and total short-term receivables divided by total short-term debt. The liquidity measure is the most recently reported by the firm before it announces the repurchase plan. We perform t-tests for differences in means between firms that announce a repurchase plan but do not repurchase (1) and firms that execute repurchases (2). The first test is a one sided test with the null that non-repurchasing firms has a higher or equal liquidity to firms that repurchase. The second test is a two sided test with the null hypothesis that the two means are equal. The p-values are adjusted conditional on whether the variance of the two distributions are significantly different at the 5% level or not.

	All OSE firms	No repurchase (1)			Repurchase (2)			Test for difference in means	
	Mean	Mean	Std.err	N	Mean	Std.err	N	(2) <= (1) p-value	(1) = (2) p-value
					Quick ratio				
All years	2.32	1.66	0.14	63	2.47	0.24	100	<0.01	<0.01
1998	2.48	1.97	0.38	13	1.91	0.31	15	0.54	0.91
1999	2.31	1.55	0.22	44	2.23	0.31	41	0.04	0.08
2000	2.36	1.41	0.18	25	2.88	0.43	65	<0.01	<0.01
2001	2.14	1.84	0.31	49	2.37	0.49	60	0.18	0.37
					Current ratio				
All years	2.65	1.98	0.14	63	2.72	0.23	100	<0.01	0.01
1998	2.96	2.31	0.35	13	2.10	0.29	15	0.68	0.63
1999	2.62	1.86	0.21	44	2.56	0.21	41	0.03	0.05
2000	2.63	1.74	0.22	25	3.13	0.42	65	<0.01	<0.01
2001	2.36	2.16	0.33	49	2.58	0.49	60	0.24	0.47

may be that these firms are unable to signal undervaluation, such that they on average experience a positive drift when positive information about the firms are announced in later periods.

4.6.4 The timing and price impact of the actual repurchases

In the previous sections we found evidence that the market on average underreacted to the announcement of a repurchase plan, suggesting that the information in the initial signal was slowly incorporated into prices over time. In addition, we found that the apparent underreaction seemed to be mainly related to firms that announced a repurchase plan, but did not execute any repurchases during the course of the plan.

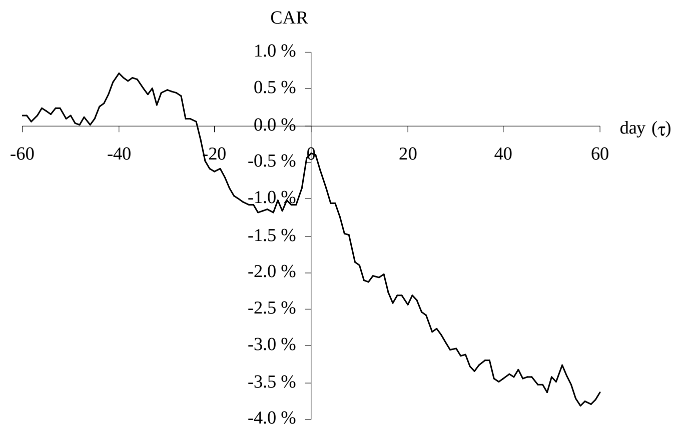
In this section we look closer at the short term effect in the days surrounding the actual repurchases. Moreover, we examine whether and to what degree the actual repurchases are interpreted by the market as informative to the value of the firm. If the repurchase is interpreted as a valuable positive signal, we should observe on average a positive abnormal return on the repurchase date, and that there is no reversal in the CAR after the repurchase. This would be in line with our interpretation of the results in the previous section that the repurchases mitigate mispricing. Alternatively, an effect from the repurchase may also be related to trading activity of the firm, in which case we would expect to see only a temporary effect.

Initially, in the extreme case where undervaluation is the only motive for why a firm announces a repurchase plan, undervaluation should also be the main motivation for why firms actually execute repurchases. However, as discussed in Ikenberry et al. (2000), the manager may also repurchase because he perceives the firm to be undervalued after large price declines. Relative to the initial announcement, the actual repurchases reflect real transactions and may be more credible signals to the market than the announcement of the plan when there is no commitment to repurchase. Furthermore, when a firm announces a repurchase plan, this may not be related to the firm being undervalued at the time, but rather to give the managers the flexibility to exploit windows of opportunity some point in the future. Thus, examining the price impact of the actual repurchases may give us more information about whether undervaluation is a potential explanation for why firms repurchase shares and how the market react to the actual repurchase. If managers successfully identify when the firm is undervalued, one would expect their timing to coincide with a preceding negative drift in abnormal returns. Results in Ikenberry et al. (2000) suggest that this is the case, but are unable to examine the pattern in excess return around the repurchase date since they only have monthly repurchase aggregates. However, their results indicate that firms repurchase more in periods when the stock price falls.

To examine the effect of actual share repurchases, we apply a similar event study methodology to the one used in section 4.6.1, and use the actual repurchase announce-

FIGURE 4.2 CAR around actual repurchases - unfiltered

The figure shows the CAR from 50 days before the actual repurchase until 50 days after the repurchase. In the figure we average across all 1375 event dates.

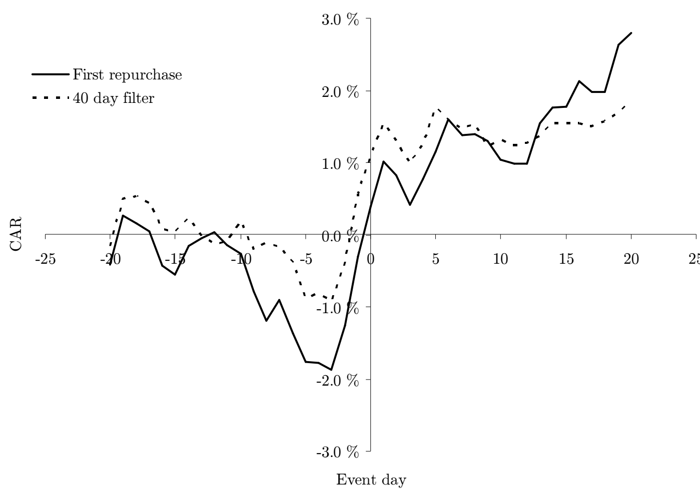


ment date as the event. This date is either the same day as the repurchase or before the trading session starts the next day. One main problem with analyzing the actual repurchases is that there are about 1375 repurchase events over a 4 year period. Since firms often repurchase shares on several days in a row, this clustering of events is problematic in several respects. First of all, if a firm execute several repurchases in sequence, the event dates will be overlapping and dependent. This results in the post and pre-event excess returns being averaged across overlapping periods. Thus, if firms repurchase when there is a negative drift in excess returns, the average negative excess return will be exaggerated. Figure 4.2 shows the average cumulative abnormal returns from 50 days before to 50 days after the repurchase when we ignore these problems and use all 1375 repurchase events. Although the numbers used in the figure are subject to several problems related to the clustering of events, and that firms that repurchase more gain a larger weight, it illustrates that repurchases are executed in periods when the stock experience a downward drift in abnormal performance. In addition, there seem to be a temporary increase in the stock price around the repurchases date. Thus, the normal performance of the repurchase portfolio (P2) in the previous section, may be because these firms perform worse on average than non-repurchasing firms in (P1).

To reduce the bias related to the clustering of repurchases discussed above, we calculate short term excess returns for two main cases. First, for each firm, we restrict repurchases to be 40 days apart to be included in the sample. Although this reduces the bias related to overlapping, the excess returns both before and after the repurchase contain potential abnormal price movements related to repurchases that are not included in the sample, but are still reflected in the returns. We also examine excess returns surrounding only the first repurchase executed by a firm, leaving us with 100 repurchase events. The results from this analysis is illustrated in figure 4.3. In both cases, there seem to be a negative drift in CAR prior to the repurchase and a price impact on the event date. However, pre event CAR is not significant at any conventional levels. The most important thing to note is that the price impact is permanent, in the sense that there is no reversal in CAR at least 20 days after the repurchase. If the impact was mainly a liquidity effect, we would expect to see a reversal in the day after the actual repurchase. Thus, the abnormal permanent price impact is in line with the market interpreting the repurchase as a positive signal and/or a confirmation of the initial announcement of the repurchase plan. This support our interpretation of the results in the section 4.6.3, in the sense that repurchases permanently increase prices, and mitigate the undervaluation.

FIGURE 4.3 CAR around actual repurchases - filtered

The figure shows the CAR from 20 days before the firm announces that it has repurchased until 20 days after the announcement, when we restrict repurchases not to be within 40 trading days of each other (40 day filter) and when we only look at the first repurchase executed by a firm (first repurchase).



One concern with the argument in section 4.6.3 is that many of the firms that have executed their first repurchase, execute several repurchases. In fact 81% of the firms execute two repurchases, and 26% of the firms execute 10 repurchases. Thus, if each repurchase has an impact on excess returns, we would expect to see an abnormal performance related to these subsequent repurchases which should create a positive drift in the repurchase portfolio (P2). On the other hand, it may be that most of the signalling value of the repurchase activity is related to the first repurchase conducted by a firm, since it conveys to the market that the firm is committed to actually repurchasing shares. If so, most of the price correction occurs before the stock is included in the second portfolio (P2), such that the subsequent performance is not affected by the continuing repurchase activity. To examine this in more detail we estimate the CAR for the three day period surrounding the actual repurchase, from τ_1=-1 (when the firm actually execute the repurchase), through τ_2=1 (one day after the firm has announced that it has repurchased). We do this for each n'th repurchase event. In table 4.12 "Repurchase number" denotes the sequence number of the repurchase. Thus, 100 firms executed one repurchase, 81 firms execute a second repurchase etc. For each subsequent repurchase event we report the percentage CAR for the event window, the standard deviation of the CARs related to the event and the associated t-value. As opposed to the event study in section 4.6.1 where we estimated the variance for the excess returns prior to the event, we use the event window standard deviation when we examine the abnormal returns related to actual repurchases. This estimator of the variance takes into account the possibility that the event itself increases the risk of the firm, as suggested in Campbell et al. (1997). In addition, the two last columns of the table shows the average fraction that firms repurchase during the n'th repurchase, both with respect to the total number of shares they repurchase in the program as well as as a percentage of outstanding shares. The results in the table indicate that the first repurchase executed by firms has the greatest price impact of about 0.88% which is highly significant. This may suggests that the first repurchase contains the most value to the market. After the first repurchase there seem to be a decrease in the effect from the subsequent repurchases.

It is also interesting to note that firms on average repurchase about 38% of their total repurchase amount during their first repurchase. This is also evident when looking at the repurchase volume as a fraction of outstanding shares, with about 1.1% of the firm shares bought back during the initial repurchase. Thus, the largest impact from the initial repurchase may be due to a liquidity effect. On the other hand, a larger average volume may also be perceived as a stronger signal in the market. From figure 4.3 there is no evidence of reversal, but rather that the CAR is relatively stable in the 20 days following the repurchase.

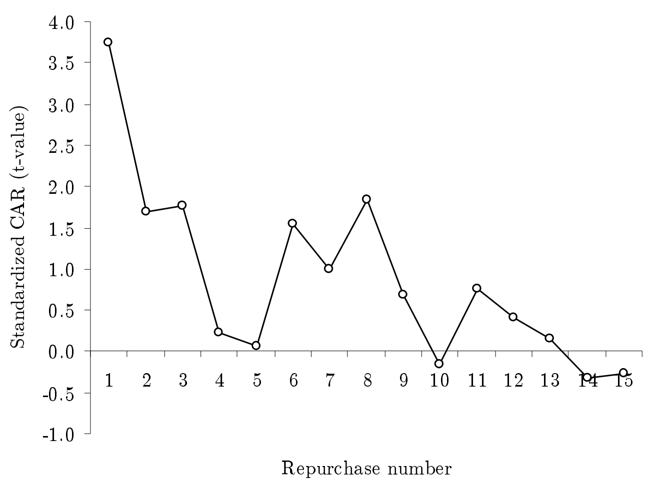
Overall it seems like the actual repurchases are greeted by the market as a positive signal, and that the first repurchase executed by firms is perceived as the most valuable signal.

TABLE 4.12
CAR for subsequent repurchase events

The table shows the average cumulative abnormal return from τ_1=-1 to τ_2=1 for the 15 first repurchases executed by firms. The first column ("Repurchase number") denotes whether it is the first, second, third etc. repurchase executed by the sample firms. Thus, we see from the table that 100 firms executed one repurchase, 81 firms executed a second repurchase, 66 firms executed a third repurchase and so on. %CAR(τ_1, τ_2), is the average CAR around the n'th repurchase executed by firms. The table also report the t-value from a test that the CAR is equal to zero, the average fraction of the total volume repurchased by firms in the n'th repurchase and the average% of outstanding shares repurchase by firms in the n'th repurchase.

Repurchase number	Firms	%CAR (τ_1, τ_2)	std.dev	t-value	avg.fraction of rep.vol	avg.fraction of outs. shares
1	100	0.877	0.023	3.83	38.1%	1.1%
2	81	0.388	0.021	1.69	16.1%	0.6%
3	66	0.398	0.018	1.77	13.1%	0.7%
4	65	0.045	0.017	0.22	11.6%	0.5%
5	54	0.012	0.015	0.06	8.7%	0.6%
6	51	0.449	0.021	1.55	8.0%	0.6%
7	41	0.298	0.019	1.00	6.6%	0.6%
8	38	0.599	0.020	1.84	6.9%	0.7%
9	33	0.218	0.018	0.68	3.1%	0.2%
10	26	-0.051	0.017	-0.16	3.9%	0.3%
11	22	0.365	0.023	0.75	2.8%	0.3%
12	22	0.186	0.021	0.42	3.8%	0.4%
13	18	0.154	0.043	0.15	3.8%	0.8%
14	16	-0.116	0.014	-0.33	6.0%	0.7%
15	15	-0.129	0.019	-0.26	4.4%	0.4%

FIGURE 4.4 CAR for subsequent repurchase events
The figures plots the standardized CAR (t-values) calculated in table 4.12 for the 15 first repurchases by firms.



4.7 Conclusion

This paper examines a sample of announcements of repurchase plans and actual repurchases by Norwegian firms in the period 1998 through 2001. In addition to providing evidence on open market share repurchases in a market where repurchases recently has been allowed, we believe that repurchases in Norway are particularly interesting to study because of the legal requirement that firms report their repurchase activity on a daily basis. By exploiting these unique data, we improve the understanding of repurchases, and how the market reacts to the actual repurchase executions.

Even during this short period, repurchases has become an important tool for Norwegian firms. With respect to the actual repurchase activity of Norwegian firms, we find that about 60% of the firms that announces a repurchase plan execute at least one repurchase during the repurchase period authorized by the shareholders. In addition, the cash distributed through repurchases as a fraction of dividends was 25% in 1999 and 44% in 2000 and 2001. Furthermore, these firms repurchased on average 2.9% of their outstanding shares during the repurchase period.

We find support for the underreaction hypothesis investigated in Ikenberry et al. (1995) also in Norwegian data. The excess performance around the announcement of a repurchase plan is on average about 2.5%, while a calender time portfolio of the same firms experience a significant long term excess performance of about 0.9% per month, or about 11% a year, relative to a Fama and French (1993) three factor model specification. Thus, although the market puts a positive value on the signal conveyed through the announcement, this indicate that it is not completely and immediately incorporated into prices.

In the long run, when creating two portfolios of firms that have announced a repurchase plan and condition the portfolio construction on whether the firm actually execute any repurchases, we find that the portfolio consisting only of announcing firms that has not yet repurchased show a significant excess performance of about 1.2% per month. The portfolio of firms that actually execute repurchases does not experience a significant abnormal performance. We interpret this as the market assessing the actual repurchases as a valuable signal, increasing the stock price and aligning the subsequent long term returns to expected levels.

For the firms that do not repurchase, we argue that their excess performance may be related to several issues. First, it may be that these firms do not repurchase simply because their stock price increases after the announcement such that the manager no longer assess the firm as being undervalued. However, an additional explanation may be that these firms are restricted from repurchasing due to liquidity reasons. And by being unable to signal undervaluation to the market through real transactions, their stock price experience excess performance as the information is conveyed through positive information surprises in later periods. Consistent with this interpretation we find that firms that do not execute any repurchases are less liquid than firms that actually execute repurchases.

When examining in more detail the timing and price impact around the actual repurchase executions, we find that there is a negative drift in excess returns during the 20 days prior to the actual repurchase. This suggests that managers execute repurchases in periods when the stock underperforms relative to several model specifications for expected returns. When examining the market impact of the repurchases itself, we find that there is a significant excess return on the day when the firm execute the repurchase. In the period after the repurchase, there is no reversal in excess returns suggesting that market puts a positive value on the signal that the firm has actually repurchased shares.

Overall, our findings offer additional evidence for the underreaction hypothesis. Overall, the market seem to underreact to the initial announcement. However, the abnormal performance of announcing firms is to a large degree driven by firms that are unable to execute repurchases. If these firms are still undervalued after the announcement, and unable to signal undervaluation due to liquidity constraints, the price remains too. This result indicate that requiring repurchasing firms to announce their repurchases immediately may help improve price discovery.

4.A Robustness check for announcement effect

To check that the results in table 4.3 in section 4.6.1 are affected by extreme observations, firms with CARs below the 5th percentile and above the 95th percentile are removed from the sample. Table 4.A1 shows the results from this analysis. Truncating the sample reduces the average announcement CAR to about 1.9% for the Carhart specification.

TABLE 4.A1

Abnormal returns around announcements of repurchase plans - a robustness check

The table shows the abnormal return (in percent) around announcements of repurchase plans when the 5% lowest and 5% highest CARs are removed from the sample. The abnormal return is measured relative to a one factor market model (unadjusted and adjusted for biases induced by infrequent trading as proposed in Dimson (1979) and Scholes and Williams (1977)), Fama and French (1993) three factor model and the Carhart (1997) four factor model, with the value weighted OSE general index as the market portfolio. The sub-sample regressions and the repurchase% regressions are cumulative excess returns relative to the Carhart four factor model. Numbers in bold represent numbers significantly different from zero at the 1% level, and numbers in parenthesis are the associated t-values.

		Days relative to announcement date					
	n	-20 to -3		-2 to +2		+3 to +20	
				Whole sample regressions			
Unadjusted market model	286	-0.56	(-1.20)	**1.845**	(4.39)	0.51	(0.62)
Dimson(1979)	286	-0.32	(-0.67)	**1.806**	(4.21)	0.00	(0.01)
Scholes/Williams(1977)	286	-0.51	(-1.08)	**1.807**	(4.23)	-0.12	(-0.21)
Fama/French 3 factor model	286	-0.74	(-1.54)	**1.814**	(4.28)	0.16	(0.29)
Carhart 4 factor model	286	-0.60	(-1.27)	**1.901**	(4.44)	0.14	(0.26)
				Subsample regression (year)			
1998	25	1.61	(1.18)	1.360	(0.74)	1.12	(0.86)
1999	77	-0.59	(-0.69)	**2.198**	(2.82)	1.46	(1.19)
2000	83	-1.55	(-1.62)	1.042	(1.30)	-0.17	(-0.17)
2001	101	-0.37	(-0.47)	**2.515**	(3.62)	-0.87	(-0.96)
				Max.repudchase %			
<0%-5%]	23	**-4.27**	(-2.08)	4.235	(1.00)	-1.80	(-0.67)
<5%-10%]	263	-0.33	(-0.69)	**1.893**	(4.48)	0.24	(0.41)

4.B Additional data for the sale of treasury stock

The paper only examines the gross repurchase activity by firms. However, the dataset also contains the sale of repurchased shares (treasury stock). Table 4.B1 shows aggregate statistics for both repurchases as well as for the sale of treasury stock ("reverse repurchases"). The reduction in treasury stock may be due to e.g. sales of shares in the open market, as payment in various transactions, management/employee option exercises, stock bonuses, stock dividends or that the treasury stock is retired. As can be seen from the table, there are almost six times as many repurchase executions as sales, and the number of repurchased shares are more than twice of what was sold. However, the size of the repurchases are on average about 1/3 of the amount that was sold. This indicate that firms aggregate treasury stock through many smaller repurchases, and reduce treasury stock in much larger volumes.

TABLE 4.B1
Aggregate statistics for repurchases and sale of treasury stock

The table shows aggregate statistics for both stock repurchases as well as for "reverse" repurchases (sale of treasury stock). The table shows the number of transactions, the total number of shares traded and the average size of the transactions for repurchases and sales during the period from 1999 to 2002. The last part of the table shows the fraction of buys to sales.

	Number of transactions	Shares (mill.)	Size of transactions (1000 shares)
Repurchases			
Whole period	1719	247.2	143.8
1999	205	35.3	172.2
2000	463	64.6	139.5
2001	659	107.4	163.0
2002	392	40.6	103.5
Sales			
Whole period	293	109.4	373.5
1999	19	2.8	145.0
2000	68	26.2	385.0
2001	105	40.6	386.9
2002	101	39.9	394.9
Fraction of buys/sales			
Whole period	5.87	2.26	0.38
1999	10.79	12.82	1.19
2000	6.81	2.47	0.36
2001	6.28	2.64	0.42
2002	3.88	1.02	0.26

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Chapter 5

Ownership Structure and Open Market Share Repurchases

Written with Bernt Arne Ødegaard

Abstract

This paper provides an examination of the ownership structure in Norwegian firms that initiated repurchase programs during the period 1999 through 2001, as well as for groups of these firms conditional on whether they actually executed repurchases or not. By using detailed information on various ownership variables that can be related to corporate governance mechanisms, the paper also examines whether the propensity for firms to announce a repurchase program during a given period depends on the ownership composition in these firms. Some interesting patterns are found which are consistent with models where firms with potentially the highest agency problems use repurchases to mitigate agency costs. However, a very high insider ownership in these firms also suggest that asymmetric information, shareholder expropriation and entrenchment may also be motivations for why firms initiate repurchase programs.

5.1 Introduction

An open market share repurchase is an event where the repurchasing firm indirectly distributes cash to some of its shareholders and gets in exchange a fraction of its outstanding equity.[1] Compared to dividends, which generally are pro-rata distributions at regular points in time, an open market repurchase distributes cash to shareholders in an non-proportional fashion at varying points in time. Although a repurchase, at a general level, merely is an alternative mechanism for the firm to distribute cash, it also changes the composition of assets held by the firm, the financing mix and alters the ownership proportions of the remaining shareholders. Furthermore, a repurchase is also a more flexible way for firms to distribute excess cash if they have volatile cash streams and aim at smoothing their dividends.

Although there is a large amount of research aimed at explaining the price effect of repurchase announcements and why firms choose to initiate a repurchase plan, there are few studies that explicitly examine the relationship between ownership structure and share repurchases. This despite the fact that the initiation of a repurchase plan is an important corporate event that in some cases can alter the ownership composition significantly and in the long run potentially affect the value of a firm through corporate governance mechanisms. The ownership composition in a firm may also be an important motivation for firms to initiate a repurchase plan in the first place. As suggested by Jensen (1986) a repurchase can help reduce the probability of incurring agency costs related to free cash.[2] Thus, in firms with potentially severe agency problems, repurchases may be a way for managers to convey to the market that they are committed to distribute excess cash back to the owners.[3] A repurchase may also help improve the governance of the firm through other mechanisms as well. For example, in firms where there is insufficient monitoring of management,[4] a repurchase may change the ownership composition such that the incentives to monitor management becomes greater for some shareholders if their proportional cash-flow rights and voting rights increases. As noted by Shleifer and Vishny (1986), open market share repurchases are not equivalent to dividends, because they may change the share of the firm held by the large shareholder which has greater incentives to monitor. At the same time, a repurchase may also increase the manager's ownership proportion in the firm such that there is a con-

[1] The shares owned by the company is accounted for as Treasury shares and has no cash-flow or voting rights attached to them. These shares can later be removed to decrease the shares in the company, sold back to the market, used in acquisitions, distributed to employees as a part of a bonus plan etc.

[2] Jensen (1986) defines free cash as the remaining cash within the firm after all projects with positive net present values have been funded. Other suggested mechanisms for reducing agency costs of free cash is also new debt and dividends.

[3] This reasoning assumes that the managers actually have incentives to impose a disciplinary mechanism on themselves.

[4] One example could be liquid firms with few investment opportunities, dispersed ownership and where management has a low stake in the firm.

vergence of interest between the inside and outside shareholders (Jensen and Meckling, 1976). On the other hand, a repurchase may also intensify the conflict between large shareholders and minority shareholders. For example, if large shareholders stronger incentives to becoming informed, a repurchase may be used to increase their ownership (and the remaining shareholders ownership) in an undervalued company by retaining their shares, or alternatively decrease their ownership in a overvalued company at the expense of less informed owners (Brennan and Thakor, 1990). A repurchase may also contribute to the conflict between inside- and outside owners since insiders have incentives to secure their position in the firm. By repurchasing shares from the owners with the lowest valuations (Bagwell, 1991) they increase the cost to a bidding firm. Thus, a repurchase can be used to reduce the probability of a value creating takeover occurring, which would benefit shareholders, but potentially make the manager loose control over the firms resources. Also, certain types of owners may prefer one type of payout policy to another for tax reasons. For example certain investors such as pension funds and non-profit organizations are in many countries exempt from taxes on dividends and capital gains, while other investors are not. Thus, if dividends and capital gains are taxed differently, firms may attract different types of investors through their payout policy. Grullon and Michaely (2002) suggest that one reason for the growth in repurchases in the US, is due to relative tax disadvantage of dividends. On the other hand, findings in Brav et al. (2003) indicate that taxes are, at best, of second order importance when firms choose whether to repurchase or not.

The main focus of this paper is to investigate these issues in more detail, and to examine whether firms that initiate repurchase programs[5] have any systematic patterns in ownership that may be related to theory. In this respect, the paper has several objectives. The first objective is to provide a descriptive analysis of the ownership structure of firms that announce repurchase plans, as well as for subgroups of these firms conditional on whether they actually execute repurchases or not. The second objective is to examine whether and how the ownership changes over time in firms that actually execute repurchases. The third objective is to study whether the propensity for firms to initiate a repurchase program may be motivated by ownership characteristics prior to the event.

Recent studies indicate that repurchases has become an increasingly important means for firms to distribute cash. In a study on repurchase activity in the US, Grullon and Michaely (2002) find that firms gradually have substituted repurchases for dividends during the period from 1980 through 2000, and that US firms in 2000 spent as much money on repurchases as on cash dividends.[6] This is also in line with findings in

[5] With "initiate" we mean that the firm announces a repurchase plan, which has received a supermajority vote at the general shareholder meeting. This gives the managers of the firm the opportunity to repurchase shares when they see fit over a pre-specified period. The maximum legal length of this period in Norway is 18 months, but the firm is not committed to repurchase any shares.

[6] Grullon and Michaely (2002) find that dividend payouts grew at an annual rate of 6.8% during the

Fama and French (2001) who find that the number of dividend paying firms has fallen dramatically since 1980 until today. Similarly, in Norway, there has been an increase in spending on share repurchases, although for a much shorter time period. Since Norwegian firms for the first time were allowed to repurchase shares in 1999, they have increased their spending on repurchases as a percentage of cash dividends starting at 25% in 1999 and increased this to 44% in 2000 and 2001. During the same time period, there has been a growth in aggregate dividends as well.

At a general level, a share repurchase is essentially a dividend payment, and thus an alternative way for a firm to distribute excess cash back to its shareholders. In a world where markets are perfect and complete, whether a firm distributes its cash through dividends or repurchases should be equivalent according to the propositions in Miller and Modigliani (1961). Given the firms investment policy, no rational investor has a preference for either payout policy, and through arbitrage arguments the choice of payout policy is shown to be irrelevant with respect to the value of the firm. On the other hand, empirical results suggest that the information inherent in repurchase announcements have some economical benefits to shareholders in the sense that these firms on average experience an abnormal price increase when they announce that they are planning on repurchasing shares. Among others, Vermaelen (1981), Dann (1981), Comment and Jarrell (1991), Stephens and Weisbach (1998) and Ikenberry et al. (1995, 2000), find strong support for a positive announcement effect, and that this effect is about 2%.[7] These findings are comparable to what has been found with respect to unexpected dividend initiations/increases and dividend omissions/decreases (Asquith and Mullins, 1983; Michaely et al., 1995).

The dominating theoretical explanation for both of these announcement effects rests on a signalling framework, in which there is asymmetric information between the managers and outside investors, and the announcement communicates valuable information about current earnings and the future prospects of the firm. As shown in Miller and Rock (1985), if there is asymmetric information between investors and the managers of a firm, changes in dividends can result in revaluations. Similarly for repurchases, models by Vermaelen (1981), Ofer and Thakor (1987), Constantinides and Grundy (1989), McNally (1999) and others, show that a repurchase announcement may be a valuable signal to investors about current undervaluation and the future prospects of the firm, which

period 1980 to 2000, while cash used on share repurchases grew at an annual rate of 26.1% during the same period. From 1980 to 2000 share repurchases as a percentage of dividends increased from 13.1% in 1980 to 113.1% in 2000.

[7] Comment and Jarrell (1991) and Ikenberry et al. (1995) find an announcement effect in the US of 2.3% (for the period 1985-1988) and 3.5% (1980-1990) respectively. In addition Comment and Jarrell (1991) examine Dutch auction repurchases and tender offer repurchases, which have a 11% and 8% price impact respectively. They argue that tender offer repurchases have the strongest signalling ability of the three. For Canada, Li and McNally (2002) find a announcement effect of 0.9% (for the period 1995-1999). Lasfer (2000) find the effect to be 1.64% in the UK, 1% for continental Europe, 0.78% in France and 0.63% for Italy over the period 1985 to 1998.

should command a higher stock price. In addition to the signalling hypothesis, other suggested reasons for why firms repurchase shares include, capital structure adjustments (Vermaelen, 1981; Opler and Titman, 1996), disgorgement of excess cash (Jensen, 1986; Stephens and Weisbach, 1998; Jagannathan et al., 2000), substitution for cash dividends (Grullon and Michaely, 2002), takeover defense (Denis, 1990; Bagwell, 1991; Dittmar, 2000), shareholder expropriation (Brennan and Thakor, 1990), to counter the dilution effects of employee and management options (Fenn and Liang, 1997), personal taxes (Masulis, 1980; Lie and Lie, 1999; Grullon and Michaely, 2002) and manipulating EPS figures (Bens et al., 2002).

With respect to the topic in this paper, the amount of research that examine the relationship between ownership structure and share repurchases is much more scarce. However, some exceptions include Ginglinger and L'Her (2002) who examine the relationship between ownership structure and the announcement effect for French firms, Howe et al. (2003) who examine the relation between insider ownership and the announcement effect of various cash distributions in the US, including tender offer repurchases, and Li and McNally (2002) who examine the insider holdings of repurchasing firms. The results in Ginglinger and L'Her (2002) suggests that the announcement effect of controlled firms is stronger than for widely held firms, that the presence of foreign institutional investors yield a more positive reaction and that family controlled firms experience a negative price effect when a repurchase program is announced. They also find that firms with a low likelihood of takeover and low risk of minority shareholder expropriation experience a stronger positive announcement effect, and that the effect is highly unfavorable when the market participants interpret the repurchase as a takeover defense.[8] Howe et al. (2003) find that there is a positive relationship between the excess return around various cash distribution events[9] and the insider ownership for a sample of US firms. Their overall conclusion is that when managers owns a larger stake in the firm, their wealth depends stronger on the success of corporate decisions and strategy such that the signals conveyed through payout announcements becomes more valuable/credible in firms where the inside ownership is large. Li and McNally (2002) also study the insider holdings of repurchasing firms and find that insiders have a larger stake in firms that initiate repurchase plans, and that these firms experience a greater announcement effect. Their main argument for this is that insiders use repurchases to signal that they are committed to distribute excess cash back to the shareholders. In addition, Denis (1990) examines the price effect of defensive changes in corporate payout policy and how the ownership changes in firms that remain independent after the takeover contest. The results indicate that these firms experience large structural changes after the takeover

[8] Ginglinger and L'Her (2002) proxy potential target firms as firms where the largest shareholder owns 20% of the voting rights and the float is higher than 50%.

[9] The cash distributions they examine are dividend increases and decreases, dividend initiations and tender offer repurchases.

attempt in which there are large changes in capital- and ownership structure in addition to a high turnover rate among top management. Finally, Grinstein and Michaely (2001) examine the effect of institutional ownership on the choice of payout policy among firms. Their main finding is that institutions increase their ownership in firms that repurchase, but that they do not actively affect firms payout policy or cause firms to increase their overall payout.

There are also earlier studies on the ownership structure of Norwegian firms that are important to mention. Bøhren and Ødegaard (2000, 2004) provide a detailed description of the ownership structure of Norwegian firms listed on the Oslo Stock exchange for the period 1989-1997. In addition, using the same dataset, Bøhren and Ødegaard (2001) examine whether ownership structure matters for economic performance. Their main findings are that insider ownership enhances firm value while ownership concentration is negatively related to firm value.[10] They also point to Norway being an atypical case relative to the ownership structure in other countries in Europe due to very high state ownership as well as relatively high foreign ownership (about 30%). In addition, the ownership by personal investors is found to be the smallest compared to any European country, and the largest shareholder owns much less while the second and third largest owner has a relatively high stake indicating that the power structure is very flat.

The analysis in this paper uses similar ownership data as used in Bøhren and Ødegaard (2000, 2001, 2004), but for a more recent period and with monthly share-holdings of all shareholders in all public Norwegian firms listed on the Oslo Stock Exchange (OSE). The paper combines this dataset with a sample of repurchase announcements and actual repurchases conducted by Norwegian firms for the period 1999 through 2001.[11] There are several things to note about the dataset. First of all, there are few papers that examine the actual repurchase activity of announcing firms. One reason for this is that a large amount of studies on open market repurchases has been for US data. Due to the loose disclosure rules in the US, where firms are not required to disclose the actual repurchase executions, this has made it difficult to obtain detailed data on actual repurchases in the US.[12] By combining the repurchase dataset with a detailed ownership database containing the monthly equity holdings of all shareholders in all listed Norwegian firms, we are able to study in detail the ownership characteristics of these firms. In addition, we are able to examine to what degree the composition changes during the repurchase program and whether ownership characteristics affect firms propensity to

[10] While their results are robust in single-equation models, the relationships are rendered insignificant when they apply simultaneous equations models taking into account the causalities between governance and performance.

[11] The repurchase sample starts in 1999 because Norwegian firms were not allowed to repurchase shares earlier. However, firms were allowed to announce repurchase plans prior to 1999.

[12] One exception is Stephens and Weisbach (1998) who estimate the actual repurchase activity by US firms based on the change in outstanding shares. In addition, during the last few years, studies on actual repurchase activity outside the US has emerged for markets where firms are subject to stricter disclosure rules, such as Canada.

initiate such programs.

To summarize our main findings, we find that firms that announce at least one repurchase program during our sample period, have a significantly lower ownership concentration (both when concentration is measured as the aggregate ownership of the five largest owners and by the Herfindahl index) than firms that do not announce a repurchase plan. With respect to the number of owners, announcing firms have about twice as many owners as non-announcing firms, while the average size of these firms are similar. This is in line with a story in which firms with dispersed ownership has a stronger incentive to disgorge cash to mitigate agency costs related to free cash. On the other hand, our results also suggest that insiders own on average a significantly higher fraction (20%) in announcing firms than in non-announcing firms (8%), and that this difference is most pronounced in firms that actually repurchase shares. This, however, is not consistent with a monitoring story for repurchases, since agency theory predicts that the insider and outsider interests are better aligned in these firms. Moreover, there would be a lesser need for additional mechanisms to avoid agency costs of free cash in these firms.

This finding would instead be more in line with models where insiders have incentives to initiate a repurchase program either to maximize the future value of their personal wealth (Isagawa, 2000), expropriate outside shareholders or to entrench themselves. Moreover, Isagawa (2000) argue that if managers have stock options or ownership in the firm, the managers objective function depends on the stock price as he gets a monetary compensation based on the future value of the firm. By repurchasing, this reflects that the manager has no profitable projects to invest in, and that his private benefits from increasing the value of the firm outweighs the personal benefit from investing in negative net present value projects, which would depress the stock price in the long run and reduce his wealth. Thus, Isagawa (2000) propose an explanation for the announcement effect which resolves the credibility issues, in addition to offering a prediction that repurchasing firms have a high insider ownership. Our finding may also be consistent with an mispricing story where there in asymmetric information between the inside- and the outside shareholders as suggested in models by Barclay and Smith (1988) as well as Brennan and Thakor (1990) when large shareholders are better informed than smaller shareholders. From this point of view, the insiders may use repurchases to transfer wealth from selling shareholders to themselves (and remaining shareholders) by retaining their shares when the firm repurchase. Our results also indicate that the dividend payments of announcing firms are lower than for non-announcing firms, which is consistent with a hypothesis where firms substitute repurchases for dividends (Grullon and Michaely, 2002). When examining the changes in ownership variables during the periods when firms repurchase shares the results confirm that the concentration increases. However, although there is an increase in the insider ownership, it is not significant. With respect to the different ownertypes, the results further indicate that the ownership by institutions and individuals falls, while the state ownership increases. Interestingly, this is opposite from what Grinstein and Michaely (2001) find for institutional investors in the US. Grinstein and Michaely (2001) argue their results are inconsistent with models in which firms use dividends to attract institutional investors. Our results may indicate an opposite effect for Norway.

In the second part of the paper, we estimate binary models for the probability of observing a firm announcing a repurchase plan during each sample year given the ownership characteristic at the beginning of the year. The results from these estimations reflect to a great degree the findings in the descriptive part of the analysis, but provide some additional results. With respect to the insider ownership, we find that the propensity to initiate a repurchase program increases with insider ownership. This is in line with findings in Li and McNally (2002) for Canada. In addition, while ownership concentration seem to be unimportant, a large controlling shareholder reduces the propensity for firms to initiate a repurchase program. This is the opposite of what is the prediction in the model by Brennan and Thakor (1990). One implication from their model is that large shareholders will prefer repurchases to dividends, while small shareholders will prefer dividends. Our findings instead suggests that a controlling shareholder opposes the initiation of a repurchase program. Alternatively, it may also reflect a lower need for additional mechanisms to mitigate agency costs of free cash when there is a large shareholder in place with sufficient incentives to monitor the management. We also examine whether the identity[13] of the largest shareholder is important, but find no systematic evidence. The estimation results also provide evidence that firms that paid dividends in the previous year have a lower propensity to initiate a repurchase plan. This is likely related to dividend smoothing, and that firms are reluctant to cutting dividends as suggested by findings in Lintner (1956) and Brav et al. (2003).

The remainder of the paper is structured as follows. In the next section we discuss theoretical and empirical results that motivate why there could be a relationship between ownership structure and firms choice of repurchasing. Then we give an overview of the repurchase methods and history of repurchases in Norway, the Norwegian tax system as well as some information about the corporate legal environment in Norway. In section 5.4 we discuss the datasets and provide some general statistics, before we in in section 5.5 and section 5.6 present and discuss our results and conclude in section 5.7.

5.2 Ownership structure and repurchases

In this section, we try to motivate why there could be a relationship between ownership structure and the choice by firms to initiate a repurchase program. Although the main

[13]We have information on five types of owners. These are “state” owners, “foreigners”, “financial”, “non-financial” and “individuals”.

purpose of the paper is to provide a descriptive analysis of repurchasing firms, it is necessary to have a theoretical framework in which we can interpret the results and guide the analysis as well to motivate various variables used when we estimate a model for the propensity for firms to announce a repurchase plan. However, as discussed in Bøhren and Ødegaard (2000, 2001) corporate governance has still an underdeveloped theoretical foundation. This also affect the present paper in the sense that there are few models directly relating firms choice of repurchases to ownership structure and corporate governance. In other words, there are few models with clear predictions with respect to what patterns we should expect to see. Due to the lack of a testable theory, the discussion of the results will to a large degree be partial. However, some models provide implicit theoretical prediction for the relationship between ownership structure, corporate governance mechanisms and stock repurchases which we will discuss below. At a general level, it is useful to distinguish between agency- and signalling models used in the literature to explain why firms repurchase shares and experience a positive announcement effect. In the agency models, the principal (shareholder) wants to ensure that the agent (manager) do not waste internal resources to benefit themselves. In these models, repurchases may be used as a mechanism to discipline the manager and reduce the cash available to him. The agency explanations however require that the shareholders can force the manager to actually repurchase or that the manager has incentives to do so. Also, if large shareholders or insiders own a large stake in the firm, it may be difficult to initiate a repurchase plan in the first place, since it in most cases requires a supermajority vote which can be blocked by a large shareholder. In addition, to ensure that the manager actually execute repurchases when there are no profitable investment opportunities may require excessive monitoring. As discussed by Jensen and Meckling (1976), it is generally impossible for the principal to costlessly ensure that the agent will act optimally from the principals viewpoint. Thus, even though a repurchase is a cash distribution mechanism that initially could help reduce agency costs, it may not be very effective unless the manager has incentives to disgorge free cash. In the signalling models, the manager may use repurchases to signal that they are committed to not wasting cash, or to convey information to the market about their private information. However, as will be discussed below, the credibility of the signal is not always clear, since the costs to the manager for signalling falsely may be questionable. This is especially important with respect to open market share repurchases.

Free cash flow

Agency theory predicts that non-owner managers will tend to divert parts of the firm's free cash flow to value-destroying projects that provide private benefits to themselves.[14]

[14] As discussed by Shleifer and Vishny (1997) such diversion by insiders may be theft, dilution of outside investors through share issues to insiders, salary increases, below market value share issues to

More specifically, as discussed by Jensen and Meckling (1976), if there is low or zero insider ownership, and consequently a separation of ownership from control, there may be a need for monitoring by outside shareholders to avoid that management uses internal resources in a fashion that does not maximize firm value.[15] However, active monitoring by outside owners may not occur if there are no outside owners with strong incentives to monitor the management.

In those cases payout policy is a mechanism that may help to mitigate agency costs related to cash. As suggested by Easterbrook (1984) and Jensen (1986) a firm may use cash distributions to reduce the agency cost of free cash by reducing the amount of cash available to the manager. Agency theory predicts that both debt financing, repurchases and dividend payments are mechanisms that help mitigating agency costs. With debt financing, the cash flow of the firm must be used to pay creditors which potentially could force a bankruptcy if not paid. Dividend payments are also a way for the firm to distribute excess cash that could potentially be miss-allocated by management. The use of repurchases is potentially less costly to the firm than using dividends for distributing non-sustainable excess cash. As proposed by Lintner (1956), managers prefer to increase dividends regularly and avoid cutting dividends if possible.[16] Substantiating the finding in Lintner (1956), 94% of the company executives interviewed in Brav et al. (2003), state that they strongly try to avoid dividend cuts, and 65% answered that they would raise external funds before they would cut dividends. This suggest that managers view dividend cuts as costly. One reason for this is that dividend decreases generally are punished by the market as found in Denis et al. (1994) among others.[17] Thus, firms may be reluctant to increasing dividends if the cash-flow is non-sustainable. In addition, studies suggests that firms aim at a target ratio and tries to smooth dividends. Thus, an unexpected dividend increase may be a stronger signal about permanent future earnings, while a repurchase announcement may convey to the market that management is committed to not wasting temporary cash on private benefits and value destroying activities.

With respect to the relationship between repurchases and ownership structure, a firm with plenty of cash, few investment opportunities, low insider ownership and dispersed outside ownership may benefit from using repurchases in distributing excess cash to mitigate agency costs. This in the sense that a repurchase announcement could be a signal to the market from the primary insiders that they are committed to not wasting

insiders etc.

[15] A crucial assumption with respect to outside monitoring is that outside shareholders are competent and that their monitoring in fact improve the quality of managerial decisions.

[16] These arguments predict that dividend increases will be made by firms with higher and more stable cash flows, that dividend increases will be related to permanent but not necessarily to temporary components of cash flow, and that dividend decreases will be less frequent than increases and accompanied by very poor performance.

[17] Some proposed explanations for this has been signalling, overinvestment and dividend clienteles.

excess cash. Overall, from an agency perspective, if repurchases are motivated by poor monitoring, we would expect to see more dispersed ownership and lower ownership concentration in firms that announce repurchase plans. In addition, one would also expect to see a lower insider ownership in these firms, since high insider ownership initially would reduce the need for monitoring. On the other hand, for the managers to support the initiation of a repurchase program as a self-imposed disciplinary mechanism, the manager must have incentives to do so. In a model by Isagawa (2000), the initiation of a repurchase program is argued to be credible despite the fact that the announcement of a repurchase plan is not a commitment to actually repurchase shares. The model by Isagawa (2000) assumes that the managers objective function depends on the stock price, as he gets a monetary compensation based on the future price of the firm (the manager may have stock options or own a part of the firm), in addition that he has a private benefit from growing the size of the firm. By announcing a repurchase plan, this reflects that the manager has no profitable investment opportunities, and that the cost to him for wasting internal cash is greater than returning cash to the shareholders and increasing the value of the firm. Thus, the announcement of a repurchase plan reveals information about the managers private benefits when there are no profitable investment opportunities available to the firm. Li and McNally (2002) find support for this model in that insiders have a larger stake in firms that announce repurchase plans.

Empirical results in Fenn and Liang (2001), suggest that there is a negative relationship between management stock ownership and the amount of cash distribution. They find that firms in which managers has a low ownership stake, few investment opportunities (or high free cash flow) pays out more cash. These are firms that potentially have the highest agency problem. However, although higher insider ownership is one mechanism that align managers interests with shareholders, it is also argued that greater ownership by institutional owners or other large shareholders may improve outside monitoring of the management (Shleifer and Vishny, 1986). Grinstein and Michaely (2001) investigate the relationship between firms payout policy and institutional ownership in the US, for the period 1980 through 1996, and find evidence that firms attract institutions through their payout policy. More specifically, their results suggests that institutions increase their holdings in firms that repurchase more shares, and decrease their holdings in firms that pay more dividends. In addition, when examining the causality between institutional ownership and payout policy, their results indicate that institutions do not actively change dividend policy or repurchase policy.

The signalling/undervaluation hypothesis

The traditional signalling hypothesis with respect to repurchases proposed by Vermaelen (1981, 1984) and Dann (1981), among others, is motivated by asymmetric information between the managers of a firm and the market. If the managers of the firm has superior information about the future prospect of the firm, and know that the firm is undervalued, they can initiate a repurchase plan to convey this information. Due to the new information about future earnings, implied by the announcement, a positive price impact on the announcement day is expected, as prices adjusts to the new information. Since the undervaluation hypothesis supposes that the managers of the firm has superior information about the true value of the firm, and that the managers successfully announce repurchase plans when the firm is truly undervalued, one would also expect the insiders of the firm to have a higher ownership fraction in these firms if they are able to trade in the firms shares.[18]

However, there is a problematic issue related to the signalling hypothesis and the incentives of the managers of a firm discussed in Fried (2002). The signalling hypothesis implies that managers signal only when the firm is undervalued, and thereby sacrifice their own wealth on behalf of the shareholders.[19] The proposition in Fried (2002) is that it is more likely that managers act opportunistically, and announce repurchase plans to maximize their own wealth. One prediction of the model is that managers announce a repurchase plan both when the firm is undervalued as well as when it is overvalued. The main intuition behind this is that when the firm is undervalued, the manager uses the announcement of a plan, as well as actual repurchases, to transfer wealth to themselves and the remaining shareholders. On the other hand, when the manager want to sell a large part of her shares due to overvaluation, the repurchase announcement can be used to temporarily boost the stock price. Another argument against the signalling hypothesis is that for the signal conveyed through the announcement of a repurchase plan to be credible, there should be an explicit commitment by the managers of the firm.[20] However, for open market share repurchases, it is rarely the case that insiders of a firm explicitly states that they are going to retain their shares for the course of the repurchase plan. Fried (2002) argue that managers could more credibly signal undervaluation by committing to retaining their shares over a period of time.

Thus, in the managerial opportunism case of Fried (2002), the prediction with respect to the level of insider ownership relative to non-announcing firms is not clear since the managers may choose to announce a repurchase plan both when the firm is undervalued and overvalued. With respect to the signaling hypothesis, however, one would expect insider ownership to be greater in announcing firms if the managers in these firms exploit their private information.[21]

[18]Primary insiders are generally constrained from trading in company shares around major information disclosures. However, a repurchase announcement is not generally considered as an information release where the firm announce fundamental information. In these cases, it is up to the firm to define a “blackout” period for the insiders in which they are not allowed to trade company shares.

[19]The main argument for this is that the announcement reduces the managers financial flexibility as well as limits the potential profits that they can reap from the information.

[20]At least, there should be an implicit commitment in the sense that the initial signal is backed by actual repurchases at a later point in time.

[21]An behavioral interpretation could be that insiders have a higher ownership in announcing firms

Management stock options

Fenn and Liang (2001) find evidence that managers substitute repurchases for dividends to increase the value of their stock options. More specifically, they find a strong negative relationship between dividend payouts and management stock options and a positive relationship between repurchase activity and stock options. Their main interpretation of this finding is that managers will have incentives to reduce dividends and increase repurchases (or retain more cash) because the value of the managers stock options are negatively related to expected future dividend payments. However, as noted by Fenn and Liang (2001), there are alternative explanations for a positive relationship between share repurchases and stock options. One explanation could be that options increase the managers incentives to maximize the value of the firm, and therefore also increase profits that is distributed to the shareholders. Another explanation may be that firms use repurchases to counter the dilution effects of employee and management options, such that the increased repurchase activity in firms with large amounts of management options is a direct result of option exercises.

With respect to how stock options relate to the ownership structure of repurchasing firms, one might expect there to be higher insider ownership in repurchasing firms if repurchases are substituted for dividends to maximize stock option values. However the prediction is not clear in the sense that risk averse managers with already a stake in the firm, through stock ownership as well as labor income, may want to reduce their ownership fraction when they are granted more options for diversification reasons.

Expropriation of minority shareholders

So far our discussion has centered around the the potential conflict between the management in a firm and the outside shareholders. However, as argued by Shleifer and Vishny (1997), if large controlling shareholders participate in, or is closely connected to, the firms management,[22] or have enough power to influence the decision process within the firm, there may also be a conflict between controlling shareholders and minority shareholders. For example, large shareholders may use the resources of a firm to benefit themselves on the expense of minority shareholder. If large shareholders are better informed than smaller shareholders, repurchases may be used by controlling shareholders to increase their ownership further (by retaining their shares) on behalf of smaller shareholders when they have favorable information about the firm. When a firm executes repurchases in the market, the sellers are current shareholders who, unknowingly, are trading with the firm in the open market. Thus, the cash distribution

because these managers are over-optimistic with respect to their own abilities in generating value as well as to the firms future prospects.

[22] Gomes and Novaes (2002) shows that the conflict between controlling shareholders and minority shareholders may increase when the controlling shareholders also participate in the management of the firm.

is essentially involuntary[23] in the sense that the sellers may not have wanted to sell any shares at the current price if they had known that the firm was the buyer. If there is asymmetric information between the managers of the firm and the market place, and the managers are able to correctly time their repurchases accordingly, the selling shareholders execute trades against an informed investor and sell shares at a price below fair value. Thus, if large controlling shareholders has superior information about firm value either through their potentially closer connection to the management or through their greater incentives to collect information, they are also more likely to retain their shares relative to small shareholders when the firm actually execute repurchases due to mispricing. Brennan and Thakor (1990) develop a theory for firms choice among several ways of paying out cash to shareholders in which there is a wealth distribution from small uninformed shareholders to large, better informed, shareholders. Their model assumes that the collection of information by investors is costly, and that stock prices does not reflect all information. Since large shareholders have greater incentives to becoming informed, small shareholders may face the risk of being expropriated by large shareholders. Thus, small uninformed shareholders has a co-ordination problem and are unable to keep their ownership fraction constant in the event when a firm repurchases shares. Moreover, they tend to be left with a greater ownership fraction in overvalued firms (when insiders or larger shareholders sell), and a lower ownership fraction in undervalued firms (when the firm and better informed investors buy). The center of their argument is that non-proportionate share repurchases forces shareholders to collect information and incur the gathering costs or alternatively run the risk of expropriation by better informed investors. As a result of this, large shareholders prefer cash to be paid out through repurchases instead of dividends, while small, potentially less informed, investors prefer dividends since these are paid pro-rata and do not bear such adverse selection costs.

The model of Brennan and Thakor (1990) is also related to the hypothesis of Barclay and Smith (1988) who argue that there is a implicit cost associated with repurchases.[24] Their main hypothesis is that a repurchase plan increases the adverse selection component of the spread in the market, which again may increase the cost of capital for the firm. If this effect is large enough, firms would prefer to use dividends instead of repurchases. In line with their hypothesis, they find that the spread increases after the firm has announced a repurchase plan, and decreases to its pre-announcement level after the repurchase plan is completed. In other words, the increased bid-ask spread captures the increased probability of trading with an informed investor (the firm or the insiders

[23] As opposed to a tender offer repurchase where the selling shareholders know beforehand that they are selling shares back to the firm. In addition, tender offer repurchases are generally executed at a premium to the market price, while own market share repurchases are executed at the prevailing market price.

[24] Their motivation was initially to explain why firms use dividends instead of repurchases to pay out cash despite the relative tax advantage of capital gains to dividends in the US.

of the firm).

Takeover defense and entrenchment

Another motivation for management to support the initiation of a repurchase plan, as well as actually execute repurchases, is to reduce the probability of takeovers. This because a hostile takeover, if successful, could result in the manager being replaced and loose control over the firms resources. In a hostile takeover, the acquiring firm makes an offer to the shareholders of the firm. Thus, if the firms ownership is dispersed it is more likely that the bidding firm will be able to successfully take control. Repurchases is one[25] effective measure for managers to reduce the probability that a takeover will be successful. Stulz (1988), argues that a stock repurchase increases the proportion of shares held by the manager and stockholders supporting him, such that it becomes more difficult to obtain enough shares to take control of the firm. Bagwell (1991) propose a model with heterogenous valuations among current shareholders and an upward sloping supply curve for the company shares. Thus, by repurchasing shares at the current market price, the shareholders with the lowest valuations are removed, such that a more expensive group of shareholders are left, implying that the cost of acquiring shares is increased. Also, Bagnoli and Lipman (1989) develop a model where they assume asymmetric information between the managers and the market. By signalling the quality of their firm through repurchases, this convinces the current shareholders that the value of the company is higher such that a takeover becomes more costly. However, as shown in Denis (1990), when a repurchase announcement is interpreted as a takeover defense, the announcement effect is highly unfavorable.

Thus, while managers have incentives to oppose takeovers, firms with characteristics that make them likely takeover candidates is expected to be more likely to announce repurchase plans and execute repurchases. The characteristics of a takeover candidate may depend on many factors, but generally, undervalued firms, with low managerial ownership and low ownership concentration (dispersed ownership) may be more likely takeover candidates. Thus, managers in firms with these characteristics may have stronger incentives to entrench themselves and use repurchases to increase their ownership as well as to remove shareholders with the lowest valuations.

5.3 Regulatory and institutional aspects

5.3.1 Repurchase methods

There are mainly three methods for firms to repurchase their own shares; through tender offers, open market transactions or via privately negotiated transactions, also referred

[25] Among other things, managers can also adapt anti-takeover amendments, "poison pills", increase their ownership proportion etc. to oppose takeover attempts.

to as Dutch auction repurchases. The two first methods are used to a larger extent than the latter, and in the US, open market transactions are observed more frequently than tender offers. In fact, 90% of the cases between 1985 and 1993 were open market transactions as discussed in Ikenberry et al. (1995) and Stephens and Weisbach (1998). However, the size of an open market share repurchase is in general of much smaller magnitude than a tender offer repurchase. In a tender offer, the reacquiring firm offers to repurchase its shares at a specific price, usually at a premium to the market price (fixed price tender offers). In an open market repurchase, on the other hand, the purchase is executed through brokers in the open market at normal commissions rates, and no premium is paid.[26] Thus, open market repurchases is the same as a sequence of tender offer repurchases, where the bid price is the tender price. Since tender offers are generally larger in magnitude than an open market repurchases, the alternative of trading the shares directly in the market through open market repurchases, would potentially incur a price impact cost to the firm that would exceed the premium offered through the tender price, making tender offers more attractive for large distributions.

5.3.2 The introduction of repurchases in Norway

The 1st of January, 1999, the Securities Act of June 13 1997 went into effect, and Norwegian firms were allowed to repurchase their own shares. The Act states that firms are allowed to repurchase up to 10% of the outstanding shares as long as the firm's total equity value in excess of the firm's own stockholdings is higher than 1 mill. NOK. Such limited open market repurchase programs are often referred to as "Normal Course Issuer Bids", whereas fixed price tender offers which do not have any limit to the amount of stock that can be repurchased is commonly called "Substantial Issuer Bids".

In Norway, as in the US and other countries, the most frequently observed repurchase method is open market repurchases executed as a part of a Normal Course Issuer Bid, simply because Substantial Issuer Bids are only observed in a few instances. In this paper, we only examine open market shares repurchases. Furthermore, the OSE listed firms do not have to receive approval from the exchange before initiating a repurchase program. In the U.S. the same rule applies as in Norway. However, Canadian firms (see Ikenberry et al. (2000)), must receive approval from the exchange before they can initiate a repurchase program. In Norway, as in most countries, the managers must be authorized by the stockholders to initiate a repurchase program. Such an authorization is effective for the time period stated in the plan, or at most 18 months which is the legal limit. After the repurchase period has expired, there must be a new vote before the firm can continue to repurchase shares. When a firm carries out an open market transaction

[26] At least no direct premium is paid. As argued by Barclay and Smith (1988), the announcement of a repurchase plan may lead to increased spread in the market due to an increased adverse selection component in the spread. Thus, by announcing a repurchase plan, the firm itself may experience higher implicit transactions costs in the primary market when it executes repurchases.

announcement rules apply, i.e. the firm must inform the OSE before the trading starts the following day. However, if the trade is considered as being informative, the general rule is that it must be announced to the OSE immediately.

5.3.3 The corporate environment

The main laws regulating corporations in Norway are Aksjeloven (the corporate law), Verdipapirhandelsloven (the securities law) and Børsloven (Oslo Stock Exchange regulations).[27] With respect to the board structure, all listed firms with more than 200 employees is required to have a supervisory board which elects the board. The supervisory board consists of 1/3 from the employees and 2/3 owners, and the board consists by 1/3 of the employees candidates and 2/3 consists of the owners candidates. With respect to to open market share repurchase programs, any owner can suggest that an repurchase program is put on the agenda for the ordinary stockholder meeting. In addition, an owner, or group of owners, representing at least 5% of the cash flow rights can force an extraordinary stockholder meeting. A repurchase program is defined as a change in the corporate charter, and requires a super-majority vote of 2/3 from the voting shares represented at the shareholder meeting. In addition, it requires a 2/3 vote from all shareholders (including holders of non-voting shares) to be passed. Thus, non-voting shares may be important when it comes to proposals for changing the corporate charter. There are also a set of regulations in place to protect minority shareholders. First, any shareholder has to report to the firm and the Oslo Stock Exchange when it passes through various thresholds.[28] If a stockholder passes 40% of the voting rights in a firm, he has to give a tender offer (Mandatory Bid) to the remaining shareholders, and if he owns at least 90% of the shares he is required to buy from any shareholder that wants to sell shares.

There are also insider trading rules that first of all restrict all insiders from trading on firm specific information that is important for the pricing of the stock. Furthermore, primary insiders, such as board members and the management team, are restricted from trading around various corporate events. For example, they are not allowed to trade two months before the publication of annual reports. In periods when they are allowed to trade, strict disclosure rules apply as the insider must report the transaction to the OSE within the trading starts the next day (10 am). Primary insiders are defined as members of the management team, board members and substitutes. The broader definition of all insiders also include company auditors, and the primary insiders immediate families. With respect to open market share repurchases, similar disclosure rules apply, as the firm is required to report their transactions before the market opens the next day.

[27] A detailed description of the regulatory environment in Norway can be found in Bøhren and Ødegaard (2000).

[28] These thresholds were 10%, 20%, 33%, 50%, 67% and 90% during the sample period.

5.3.4 The Norwegian tax system

Dividends distributed from a Norwegian tax resident public- or private limited company were taxed fully on the investor's hand until 1992. As a result of an extensive tax-reform in 1992, dividends became tax-exempt while the capital gains tax was set at a flat rate of 28%, both for individuals, companies and private pension funds.[29] However, shareholders in firms that retain a part of their after tax earnings, may experience that some of the capital gains when the shares are sold reflect a price increase due to the retained earnings. To eliminate the double taxation this would imply, an adjustment is made. The retained earnings per share is added to the cost basis (usually the purchase price) such that the capital gain/tax basis is reduced accordingly (RISK adjustment).[30] Thus, during the period 1992 until 2001, dividends were not taxed on the investor's hand at all, and tax on capital gains linked to retained earnings was eliminated.[31] The result of this was that there were essentially was no preference in the tax system between capital gains or regular cash distributions. However, in 2001, a personal tax on dividends was re-introduced, at a rate of 11%, while the capital gains tax and corporate tax remained at 28%. With respect to the dividend taxation, a basic deduction of NOK 10 000 was introduced. Thus, small investors in dividend paying firms were not directly affected by the tax increase. However, for larger investors the total taxation on dividends increased from 28% to 35.92%, due to the double taxation of parts of the earnings. In 2002 the personal taxation of dividends was again removed. For foreign investors, dividends distributed from a Norwegian tax resident public or private limited company to its non-resident shareholders are subject to 25% withholding tax. Tax treaties may make the withholding tax deductible in the shareholder's home country. Non-resident shareholders gain on a sale of shares in a Norwegian company is not subject to any Norwegian taxation, unless the shares form part of a permanent establishment in Norway or the seller is an individual who fulfill certain conditions that would make the gains taxable at a rate of 28%.

With respect to the relative tax treatment of dividends and repurchases in Norway, there has been a change during our sample period from 1999 through 2001. In 1999 and 2000, dividend distributions were not taxed. On the other hand repurchases where the shareholder sells shares above the tax basis is taxed at 28%. Thus, in cases where the firm uses already taxed earnings for repurchasing shares at a price above the tax basis, the shareholder that sell shares back to the firm would experience a double taxation on the excess capital gains. In 2001, when a dividend tax of 11% was introduced, the tax

[29] labor unions, non-profit organizations and public pension funds are exempt from taxation.

[30] RISK is the acronym for "Regulering av Inngangsverdien med Skattlagt Kapital". Translated, it means that there is an adjustment of the cost basis by the retained earnings after corporate tax. To be eligible to the RISK adjustment within a given year, the shareholder must have owned the shares over the turn of the year.

[31] The Norwegian tax system is a full imputation system, in which a double taxation is eliminated. In the UK, there is a partial imputation system, while the US has a classical company tax system.

differential between capital gains and dividends was reduced, favoring repurchases.[32] With respect to foreign investors, they have been subject to 25% withholding tax on dividends through the entire sample period. However, since the capital gains for foreigners is subject to the tax in the home country, the preference between dividends and repurchases may vary between foreign investors depending on the tax treatment in their home country.

5.4 Data description and general statistics

The repurchase data

The sample was formed by collecting all the announcements of open market share repurchase programs for the period 1998 through 2001. In addition, the actual repurchase executions related to these announcements reported to the Oslo Stock Exchange (OSE) from January 1999 through December 2001 were collected.[33] Panel A of table 5.1 shows statistics for repurchase plan announcements for the whole sample period as well as separate years for our repurchase sample. The second column in panel A shows the number of repurchase plans announced and the second column shows the number of separate firms that announced. Thus, through the sample there were 318 repurchase plans announced by 163 different firms. This is about 55% of the firms that were listed on the OSE during the sample period. The fourth column report the maximum number of announcements for the whole period and separate years. The firm that announced the largest number of times during the sample period announced once every year. Within each year, no firms announced more than once in 1998 and 1999, while there was at least one firm that announced twice during 2000 and 2001. The next three columns in panel A report the minimum, average and maximum amount authorized to be repurchased during the repurchase period. For the whole period, the minimum amount announced by a firm was 1% of the outstanding shares at announcement. The average amount announced was 9.5% while the maximum was 10%, which also the upper legal limit. The median announcement was for 10%, and 281 of the announcements was for 10% of the outstanding shares in the firm. Thus, the default amount announced seemed to be the maximum legal limit.[34] The last 5 columns of panel A in table 5.1 shows the number of announcing firms that actually bought shares during the repurchase period, the number of announcing firms that did not execute any repurchases, the median, mean and maximum fraction of outstanding shares repurchased during the

[32] The dividend taxation was removed again in 2002.

[33] Firms could announce a repurchase plan before 1999, but were not allowed to execute any repurchase before January 1999.

[34] Several firms does not state a limit on the shares to be repurchased. In those cases, we assume that the legal limit of 10% apply. However, firms are not required to announce the size of their programs, such that these numbers may be too high relative to their intentions.

announced repurchase periods. For the whole period there were 100 firms that actually executed at least one repurchase during the course of the program, while 63 firms did not. For the separate years, the number of repurchasing firms reflect the number of firms that announced a repurchase plan in the respective year, and repurchased shares during the announced repurchase period (with a maximum length of 18 months). Thus, of the 85 firms that announced a repurchase plan in 1999, 41 firms executed at least one repurchase, while 44 did not. For the firms that actually repurchased shares, the median amount of outstanding shares repurchased was 1.8% while the mean amount was 2.9%. The maximum amount repurchased was 22.1% which is more than twice the legal limit of 10%. The maximum legal limit is exceeded by a few firms in every year in the sample except for repurchases related to announcements in 1998. This may be due a renewal of some repurchase plans which is not captured in our announcement records. In addition, it may be because these firms have used repurchased shares as payments in transactions, bonus plans to employees or managers or simply reduced the number of outstanding shares such that their holding of treasury shares is kept below 10% at any point in time, but that the accumulated repurchases exceeds the limit. Overall, the table shows that the first years after repurchases were introduced in Norway, there has been a large increase in the number of firms announcing that they have initiated a repurchase program. Of these firms, about 60% actually executed repurchases.

Panel B of table 5.1 shows statistics for the actual repurchase activity by the firms in our sample for the whole sample period as well as for separate years. The second column in panel B report the total number of executed repurchases, while the third to sixth column report the cross-sectional distribution for the number of repurchases, column seven and eight show the average repurchase size in number of shares and Norwegian kroner (NOK), while the two last columns provide numbers for the total repurchase volume in shares and NOK. The median firm executed 10 repurchases through the sample period while the average number of repurchases across firms was almost 17. The firm that repurchased the most, executed 197 repurchases through our sample period.[35] For the separate years, the number of repurchases more than tripled from 1999 to 2001, while it decreased in 2002. On the other hand, the average number of repurchases across firms doubled through the period. One interesting thing to note about the trend in repurchases is that there was that the repurchase volume was the highest in 2001, both with respect to the number of repurchases, the total number of shares repurchased as well as the NOK value of all repurchases. One reason behind this may be that there was introduced an 11% personal tax on dividends in 2001. However, a large amount of the repurchases in 2001 was also triggered due to the large price drop in September 2001 after the terrorist attacks in the US, as about 20% of the repurchases in 2001 was

[35] The specific firm is Pan Fish ASA (PAN). The company is engaged in the farming, processing, sale and distribution of salmon and trout at a global level. It has more than 2300 employees and operations in 10 countries (numbers from 2002 annual report).

executed in September.

With respect to the size of the repurchases, the average size in number of shares increased from 1999 to 2001 and decreased in 2002, while the size in Norwegian kroner (NOK) steadily decreased through the period. This may indicate that firms that experienced a decline in their stock price repurchased more, wile firms with a high price or that experienced an increase in their price repurchased less. With respect to the two last columns in the table, we see that the number of shares in all repurchases tripled from 1999 to 2001, and fell in 2002. The same trend is evident when looking at the aggregate volume of repurchases in NOK.

The ownership data

The ownership dataset was obtained from the Norwegian Central Securities Depository (Verdipapirsentralen, VPS), and contains detailed monthly data on the ownership of firms listed at the Oslo Stock Exchange spanning the same period as our repurchase data, 1999-2001.[36] More specifically, for each month, the data contain variables describing the ownership structure of each firm with respect to the number of shares owned by each owner, the number of owners, and the type of owners (state, foreigners, financials, nonfinancials and individuals).

We also use data on insider ownership. The insider data is constructed based on the reports published by the OSE when an insider trades in company stock. The disclosure rules at the OSE state that an primary insider is required to report any transactions to the OSE within 10 am the next day. This report contains the insider's name, position, number of shares transacted and the resulting total holding which makes it possible to estimate the stake held by primary insiders. One important problem with the insider data is that insiders who leave the firm has no obligation to report this event to the OSE. Thus, when tracking the insider ownership fractions in firms, we are unable to remove insiders that are no longer insiders. Thus, the insider ownership is potentially overstated due to this. With respect to price and accounting data, we obtained this from OBI.[37] This data contain daily stock prices (at the close with best bid and ask prices) and adjustment factors (for dividends, stock splits etc.).

To give a general overview of the ownership structure for firms listed at the OSE for the period we are studying, table 5.2 report some general statistics across time and market capitalization quartiles. In part (a) of the table we report statistics for the number of listed firms, the average market capitalization, market/book, price and dividend payment (per share) for the whole sample and for separate years. With respect to the number of firms, these numbers are higher than the official "end of year" number

[36]The ownership data actually covers a longer period. For a monthly frequency, the ownership data starts in 1997 through 2002. For end of year data, the ownership data goes back to 1989.

[37]Oslo Børsinformasjon

TABLE 5.1

Announcements of repurchase plans and actual repurchase activity

Panel A of the table shows the number of repurchase plans announced by firms, the authorized repurchase amounts, and the number of firms actually repurchasing shares as well as the associated completion rates as percentage of outstanding shares repurchased. The first column report the number of announcements, the second column report the number of different firms that announced at least one repurchase plan, and the third column report the maximum announcements by one firm within the specified period. The three next columns report the minimum, mean and maximum authorizations. The last five columns report the number of firms that actually repurchase (Rep.), the number of firms that do not repurchase as well as the median, mean and maximum fraction repurchased by firms relative to their outstanding shares. Panel B shows various statistics for the repurchases executed by firms for the whole period as well as for separate years. The columns report the total number of repurchases (n) by all firms for the whole period and separate years, the cross sectional distribution of the repurchases across firms (minimum, median, mean and max repurchases), the average size of repurchases in thousand shares and Norwegian kroner (NOK) and the total share-volume and NOK volume in all repurchases. Averages are are equally weighted across firms.

Panel A: Announcements of repurchase plans

	Announ-cements	Firms	Max ann.	Authorized repurchase amount			Repurchasing firms/Completion rates				
				Min.	Mean	Max.	Rep.	Norep.	Median	Mean	Max
Whole period	318	163	4	1.0%	9.5%	10.0%	100	63	1.8%	2.9%	22.1%
1998	28	28	1	2.5%	9.1%	10.0%	15	13	1.9%	2.9%	10.0%
1999	85	85	1	1.0%	9.5%	10.0%	41	44	1.9%	3.2%	19.0%
2000	93	90	2	1.0%	9.4%	10.0%	65	25	1.8%	2.9%	16.1%
2001	112	109	2	3.3%	9.6%	10.0%	60	49	1.3%	2.7%	22.1%

Panel B: Repurchase activity

	Number of repurchases					Repurchase size		Repurchase volume	
	n	min	median	mean	max	Shares (1000)	NOK (1000)	Shares (mill.)	NOK (mill.)
Whole period	1719	1	10	16.7	197	159	7223	247	16505
1999	205	1	3	5.0	17	168	13259	35	3679
2000	463	1	5	7.7	64	186	12770	65	5320
2001	659	1	4	9.6	120	281	7480	107	5947
2002	392	1	5	10.1	50	122	3780	41	1560

reported by the OSE. This is due to new listings, de-listings, mergers and de-mergers occurring within each year.[38] Overall, the average market capitalization increased through the period from NOK 2.3 bill. to NOK 3.4 bill, while the total market capitalization of all listed firms increased from NOK 582 bill. in 1999 to NOK 677 bill. in 2001.[39] The average market-to-book value was 1.15 for all firms through the sample period. Across MCAP quartiles, the market-to-book value was 1.2 for the firms with a market capitalization below the median and 1.1 for the above median firms. Further, the average cash dividend per share was the lowest in 1999, with NOK 6.1 per share, and the highest in 2000 with NOK 7.6 per share. The total cash dividends paid by all firms for the period was NOK 40 bill., distributed across years as NOK 14 bill. in 1999, NOK 12 bill in 2000 and NOK 14 bill. in 2001.[40] Thus, despite the increased tax on dividends in 2001, this did not seem to affect the average or aggregate dividend payments by Norwegian firms.

In part (b) of table 5.2 we summarize the average ownership fraction by each of the five largest owners. In addition, the average total fraction owned by the 5 largest owners combined and the Herfindahl index is reported. The first thing to note about the table is that the average ownership fraction each of the largest owners has been relatively constant through the period, with the largest owner owning about 33% on average. In addition, the five largest owners decreased their mean ownership from 55.5% in 1999 to 54.9% in 2001, while the median ownership by the five largest owners remained unchanged. These numbers are similar to what is found in Bøhren and Ødegaard (2001) for 1997 when the average stake for the largest owner was 29%, and the total ownership by the five largest owners was 53%. However, relative to their study, the stake of the largest owner has increased by 1.8 percentage points from 1997 to 1999, wile the aggregate ownership of the five largest owners increased by 2.5 percentage points. Compared to what is common among European firms the ownership by the largest owners is very low in Norway. Bøhren and Ødegaard (2001) report that the average ownership by the largest owner for European countries in 1997 was 44%. When looking at the Herfindahl index,[41] this measure suggests that there was an increase in concentration from 1999 to 2000, and a decrease in concentration from 2000 to 2001. However, the median concentration has increased through the period. For 1997 Bøhren and Ødegaard (2001) report an average Herfindahl index of 0.15. Across market capitalizations, the most evident pattern is that the mean fraction owned by the five largest owners is the largest in firms with a market capitalization in the second and third quartile. This is also evident when looking at the Herfindahl index. With respect to the ownership of each of the largest

[38] The official number companies listed at the OSE at the end of each year was 215 (1999), 214 (2000), 212 (2001), 203 (2002).

[39] In 2002 the total market capitalization of the OSE fell to NOK 503 bill.

[40] In 2002 Norwegian firms paid out more than NOK 19 bill. in dividends.

[41] The Herfindahl index is calculated as the sum of squared ownership fractions of all owners in a firm. The Herfindahl index is highly correlated (more than 0.8) with the aggregate ownership of the five largest owners.

Table 5.2
Ownership concentration and insider ownership at the OSE

Part (a) of the table shows some general statistics for the listed firms at the Oslo Stock Exchange (OSE) across the whole sample period, separate years and market capitalization quartiles. The number of firms also contain de-listed and firms that are listed during the sample period. Thus, this number is larger than the number of listed firms at officially reported by the Oslo Stock Exchange at the end of the year. The average market capitalization, Market/Book and price are monthly averages across firms. The dividend per share is the average dividend paid by firms across the whole sample period or within each calendar year. Part (b) of the table shows the mean and median fraction owned by the five largest owners separately, the mean and median accumulated fraction owned by the five largest owners as well as the Herfindahl index. Part (c) of the table shows the mean and median fraction owned by all insiders in the firm and the primary insiders (board members and management team). Note that we only have insider data until June 2001.

		Separate years			Market capitalization quartiles			
	All years	1999	2000	2001	Q1	Q2	Q3	Q4
				(a) General statistics				
Firm/year obs.	301	271	261	245	75	75	75	75
MCAP (mill.NOK)	3112	2326	2818	3353	93	354	1106	11394
Market/Book	1.15	1.2	1.3	1.0	1.2	1.2	1.1	1.1
Price	76.0	81.6	92.3	71.2	61.2	51.0	91.4	132.0
Dividend/share	6.5	6.1	7.6	7.1	8.6	7.1	8.0	5.1
				(b) Ownership concentration				
Largest owner								
mean	0.326	0.308	0.318	0.306	0.259	0.299	0.315	0.293
stddev	0.236	0.232	0.253	0.238	0.180	0.235	0.219	0.223
median	0.243	0.226	0.230	0.240	0.236	0.222	0.212	0.213
2nd largest								
mean	0.103	0.106	0.101	0.108	0.107	0.104	0.106	0.098
stddev	0.067	0.071	0.072	0.075	0.056	0.075	0.065	0.066
median	0.090	0.091	0.085	0.094	0.097	0.094	0.094	0.080
3rd largest								
mean	0.060	0.063	0.059	0.061	0.065	0.062	0.062	0.057
stddev	0.034	0.037	0.036	0.042	0.031	0.039	0.034	0.034
median	0.053	0.055	0.052	0.053	0.059	0.057	0.056	0.048
4th largest								
mean	0.042	0.044	0.041	0.042	0.048	0.042	0.045	0.040
stddev	0.022	0.024	0.024	0.024	0.023	0.023	0.026	0.019
median	0.041	0.042	0.040	0.041	0.043	0.044	0.042	0.039
5th largest								
mean	0.032	0.034	0.032	0.032	0.036	0.033	0.033	0.032
stddev	0.016	0.018	0.018	0.017	0.016	0.018	0.018	0.014
median	0.032	0.033	0.032	0.032	0.035	0.035	0.032	0.032
Sum 5 largest								
mean	0.563	0.555	0.551	0.549	0.515	0.540	0.562	0.520
stddev	0.229	0.234	0.243	0.240	0.208	0.240	0.231	0.212
median	0.557	0.557	0.552	0.558	0.557	0.550	0.554	0.454
Herfindahl index								
mean	0.206	0.187	0.201	0.184	0.130	0.181	0.187	0.170
stddev	0.228	0.218	0.250	0.232	0.146	0.226	0.201	0.203
median	0.099	0.095	0.098	0.103	0.096	0.096	0.099	0.081
				(c) Insider ownership				
All insiders								
mean	0.136	0.144	0.149	0.146	0.153	0.171	0.155	0.139
stddev	0.253	0.264	0.273	0.269	0.279	0.287	0.262	0.266
median	0.011	0.005	0.014	0.013	0.013	0.009	0.024	0.013
Primary insiders								
mean	0.079	0.081	0.085	0.089	0.100	0.103	0.095	0.054
stddev	0.192	0.198	0.210	0.216	0.241	0.239	0.215	0.122
median	0.001	0.000	0.002	0.003	0.003	0.001	0.005	0.002

Data from all listed firms at the Oslo Stock Exchange (OSE) over the period 1999-2002. Data source: Verdipapirsentralen (VPS).

owners across market capitalizations, the average ownership is generally the highest for firms in the third size quartile. However, the median ownership is the largest in the lowest size quartile.

In part (c) of table 5.2 we report similar statistics for the fraction owned by insiders in firms listed on the OSE. Before we continue, it should be noted that we only have insider data until the first half of 2001. For the entire sample period, all insiders owned about 14% in Norwegian firms on average, while primary insiders (the management team and board members) owned on average about 8%. Comparably, Bøhren and Ødegaard (2001) report that all insiders owned on average 10% in 1997 while primary insiders owned about 3%. Thus, relative to their numbers, there has been an increase in the insider ownership at the OSE. However, some caution should be used when interpreting these numbers since the larger insider fractions in this study may be because of the data problem related to the insider holdings discussed earlier. With respect to the median insider, all insiders owned about 1.1%, while primary insiders owned about 0.1%. Thus the distribution of inside ownership is highly skewed. This is caused by a large part of the sample firms having a very low or a close to zero fraction owned by insiders of the firm, in addition to several firms having a very high insiders ownership. Furthermore, across market capitalization quartiles, the average insider ownership is the highest in the lowest size quartiles.

5.5 Descriptive analysis of ownership in repurchasing firms

In this section we combine the data on announcements of repurchase plans, actual repurchases and the ownership data to examine whether there are differences in the ownership composition in announcing versus non-announcing firms. In addition, we examine whether firms that actually repurchase shares during the repurchase period and those that do not are different from firms that do not announce a repurchase plan. To facilitate this, we split all the firms at the OSE into 4 subgroups. When looking at the whole sample period, the first group consists of all firms that *do not* announce a repurchase plan during our sample period from 1999 through 2001. The second group consists of firms that *do* announce at least one repurchase plan during our sample period. The third group consists of firms that announce a repurchase plan, but *do not* repurchase any shares during the repurchase period, and the fourth group consists of announcing firms that actually execute repurchases during the repurchase period.[42] Similarly, when looking at separate years, we split firms into groups based on whether they have announced a repurchase plan or not during the respective year. To determine whether a firm has repurchased any shares after it has announced within in a specific year, we track whether it has repurchased within the announced time limit, or within

[42] The repurchase period is the period for which the firm has announced that it may repurchase shares. The maximum legal limit is 18 months.

the legal limit of 18 months. For example, a firm that announces a repurchase plan in May of 1999 is considered a repurchasing firm (for that year) if it executes at least one repurchase before December 2000.

5.5.1 Ownership concentration in repurchasing firms

Jensen and Meckling (1976) and Shleifer and Vishny (1986), among others, suggest that ownership concentration is an important mechanism for disciplining and monitoring non-owner managers. This because large outside owners potentially both have the incentives to monitor through high cash flow rights as well as the power to affect corporate decisions through their voting rights. If there are no large shareholders with these incentives, there may be insufficient monitoring of managers. In those cases, payout policy is one mechanism that can help reduce the agency problems as suggested by Jensen (1986). Although cash dividends and new debt also reduce the amount of free cash within a firm, more flexible repurchases may be especially attractive for firms with volatile cash flows that want to smooth dividends.

In this section we examine the ownership concentration of repurchasing firms to investigate whether firms with potentially higher agency problems tend to use more repurchases. Table 5.3 shows the concentration statistics across firm-groups for the whole period as well as for separate years. We do not distinguish between voting and non-voting shares in any part of the analysis, but instead calculate the statistics at the company level.[43] We calculate average statistics for the groups discussed above, where "All OSE firms" are all listed firms at the OSE. These firms are further divided into "Non-announcing firms" and "Announcing firms" depending on whether the firm has announced a repurchase plan during the sample period or not. The "Announcing firms" group is then further divided into two sub-groups depending on whether the firms have executed any repurchases during the repurchase period ("Repurchase") or not ("No repurchase"). The second column in the table report the number of firms in each group and sub-group.[44] Column three to seven show the average fraction owned by the largest (ranking 1) to the fifth largest (ranking 5) owner. The eight and ninth column report the ownership concentration measures which is the combined fraction owned by the 5 largest owners and the Herfindahl index respectively. Finally, the three last columns report the average market capitalization (in NOK mill.), the average dividend (in NOK per share) paid out by the firms, and the market to book value. We run tests for differences in means between the group of announcing firms and non-announcing firms. In addition, for the two subgroups of repurchasing and non-repurchasing firms we run a test for differences in means against the group of non-announcing firms. Thus, all tests

[43] Only 13 firms had non-voting (B-shares) shares at the end of 1999. During the sample period, many firms chose to merge these together into a single share-class.

[44] Note that the number of firms within each group is lower than in table 5.1. This is because the numbers are at company level, which reduces the number of observations with about 10.

are relative to the non-announcing group.[45]

Looking at the statistics for the whole period first, there are several things to note. The largest owner has a significantly lower stake in announcing firms (30%) than in non-announcing firms (43%). On the other hand, the second- to fifth largest owners owns a significantly larger fraction in announcing firms than in non-announcing firms. This is also reflected in the concentration measure in column eight ("Sum 5 largest"), where we see that the average fraction owned by the five largest owners is significantly lower in announcing firms than in firms that do not announce a repurchase plan. This difference is mainly due to the lower ownership by the largest owner in these firms. With respect to the Herfindahl index the difference becomes even more pronounced. When examining the group of announcing firms in more detail, we see that the differences in ownership concentration is the largest for firms that actually repurchase shares. Looking at the fraction owned by the five largest shareholders together, we see that while the firms that announce, but do not repurchase has on average a combined ownership of about 58% which is not significantly different from firms that do not announce a repurchase plan (63%). However, firms that announce and repurchase has a combined ownership of about 53%, which is significantly lower than the group of non-announcing firms. This is also evident when looking at the Herfindahl index. However, relative to that measure, both repurchasing and non repurchasing firms have a significantly lower concentration. For the separate years, the differences seem to be more pronounced in the last part of the sample, except for the ownership of the largest owner and the Herfindahl index.

These findings is in line with a story where firms with dispersed ownership have greater incentives to initiate a self-disciplinary mechanism to ensure their shareholders that they are committed to mitigate agency costs of free cash. This because the largest shareholder also has potentially lower incentives to monitor management, as well as less power to intervene, compared to non-announcing firms where the largest shareholders own a significantly higher fraction of the firm. In addition, the shareholders in these firms may also be more likely to support a proposal that the firm wants to initiate a repurchase program if it is expected to reduce agency costs.

Furthermore, the results also suggest that these differences in concentration is the strongest in firms that actually repurchase shares. This results may however also be in line with managers using repurchases to reduce the probability of a successful hostile takeover, and aim at increasing the ownership concentration over time in the hands of themselves and/or the most "manager-loyal" shareholders. In addition, as discussed

[45] The test depends on whether the population variances of the two groups are equal or not. If the variances are equal, then the t-stat is calculated as $t = (\bar{x}_a - \bar{x}_b)/\sqrt{s^2(1/n_a + 1/n_b)}$ where $\bar{x}_a$ and $\bar{x}_b$ are the means for the two groups respectively, n_a and n_b are the number of firms in each group while s^2 is the pooled standard deviation calculated as $s^2 = [(n_a - 1)s_a^2 + (n_b - 1)s_b^2]/[n_a + n_b - 2]$, where s_a^2 and s_b^2 are the standard deviation of the ownership variable for the non-announcing and announcing firms respectively. We use the SAS v.8.2 package to perform all tests. If the variances are significantly different, the standard approximation (Satterwaite) supplied in SAS is used.

TABLE 5.3

Ownership concentration for repurchasing vs. non-repurchasing firms

In the table we examine ownership variables and other characteristics across different groups of firms. We split firms into five groups. “All OSE firms” are all firms listed on the OSE. These firms are divided into two groups. The first group is “Non announcing firms” containing all firms listed at the OSE that does not announce a repurchase plan during our sample period. The second group is “Announcing firms” which consists of firms that announce a repurchase plan. This group is further divided into firms that announce, but do not repurchase any shares (“No repurchase”) and firms that announce and repurchase shares (“Repurchase”). For the separate years, “announcing firms” are firms that announce a repurchase plan that year. Repurchasing firms are firms that announce a repurchase plan that result in repurchases within the next repurchase period (max. 18 months). The table shows the average ownership fraction for the 5 largest owners, with the largest owner having rank 1. In addition, we examine the combined fraction owned by the 5 largest owners (Sum 1-5), the Herfindahl index (sum of squared ownership fractions of all owners), the average market value (MCAP) in NOK millions, the average yearly dividend (per share) paid by firms and the market to book value (market capitalization divided by the book value of equity). We test whether there are differences in means for the various variables between firms that announce a repurchase plan (“Announcing firms”) and firms that do not (“Non announcing firms”). In addition, we also test whether the means of the announcing firms that repurchase and those that do not are different from the non-announcing group. Significance at the 1%, 5% and 10% is denoted by ***, ** and * respectively.

Firm group	Firms	Largest owner ranking					Sum 5 largest	Herfindahl index	MCAP (mill.)	Dividend (pr.share)	Market to Book
		1	2	3	4	5					
				Whole sample							
All OSE firms	301	0.365	0.098	0.056	0.039	0.030	0.589	0.252	3112	6.5	1.15
Non announcing firms	152	0.429	0.091	0.049	0.033	0.025	0.628	0.327	3567	8.5	1.16
Announcing firms	149	0.301***	0.104*	0.063***	0.045***	0.035***	0.549***	0.176***	2693	5.4*	1.14
-No repurchase	54	0.342**	0.099	0.060**	0.044***	0.035***	0.581	0.220**	1880	5.1	1.15
-Repurchase	95	0.277***	0.107**	0.065***	0.045***	0.035***	0.531***	0.152***	3155	5.6	1.14
				Year 1999							
All OSE firms	271	0.319	0.104	0.062	0.044	0.034	0.562	0.200	2326	6.1	1.22
Non announcing firms	193	0.333	0.101	0.061	0.043	0.033	0.572	0.220	2030	7.7	1.23
Announcing firms	78	0.284**	0.111	0.062	0.044	0.036	0.538	0.151***	2944*	3.4**	1.19
-No repurchase	39	0.307	0.108	0.061	0.044	0.035	0.554	0.182	1648	3.0***	1.15
-Repurchase	39	0.261**	0.114	0.064	0.045	0.037	0.521	0.117***	4274	3.6***	1.23
				Year 2000							
All OSE firms	261	0.326	0.101	0.058	0.041	0.032	0.558	0.211	2818	7.6	1.26
Non announcing firms	181	0.355	0.099	0.057	0.038	0.029	0.578	0.245	2347	8.1	1.27
Announcing firms	80	0.261***	0.105	0.062	0.047***	0.036***	0.511	0.132***	3741	6.9	1.25
-No repurchase	20	0.249**	0.090	0.053	0.040	0.033	0.465**	0.121**	3310	9.3	1.25
-Repurchase	60	0.263***	0.110	0.065**	0.049***	0.037***	0.527	0.136***	3884	6.5***	1.25
				Year 2001							
All OSE firms	245	0.313	0.106	0.060	0.041	0.032	0.552	0.193	3353	7.1	0.99
Non announcing firms	145	0.348	0.099	0.053	0.037	0.028	0.565	0.238	4232	8.9	0.97
Announcing firms	100	0.262***	0.114*	0.0704***	0.048***	0.037***	0.533	0.128***	2255	4.9***	1.00
-No repurchase	47	0.274*	0.113	0.068**	0.048***	0.039***	0.544	0.138***	1863	4.2***	0.99
-Repurchase	53	0.251***	0.116	0.072***	0.047***	0.036***	0.524	0.119***	2603	5.3**	1.01

earlier, those shareholders selling their shares in the market would also be those with the lowest valuations effectively increasing the price to a bidder. This may indicate that firms where the incentives to monitor are the lowest and the probability of a successful takeover is the highest, are more likely to actually repurchase. We will also come back to this issue when we later examine the number of owners in these firms.

The finding that the 2nd-5th largest owners have a higher ownership fraction in announcing firms seem to be the case both for non-repurchasing and repurchasing firms. This indicates that announcing firms have a flatter power structure than non-announcing firms. Furthermore, dispersion in ownership among the largest shareholders is even more pronounced in firms that actually repurchase shares. In non-announcing firms, the largest shareholder has about 2 times the stake of the combined ownership of the 2nd-5th largest owners, while this ratio is 1.5 in firms that announce a repurchase plan, and closer to 1 in firms that actually repurchase shares indicating that the largest owner has a similar stake as the 2nd-5th owners combined. The difference between announcing and non-announcing firms may reflect that it is easier to obtain enough votes for initiating a repurchase plan in these firms than in non-announcing firms in the sense that it would be more difficult for a large shareholder to block a proposal of a repurchase program when his relative ownership is low. With respect to why firms that actually repurchase shares has the flattest structure, this may reflect that managers have stronger incentives to actually repurchase shares in these firms. For example, the manager may benefit from concentrating the ownership in these firms to reduce the probability of experiencing a successful takeover. Alternatively, it may also reflect that managers in fact are committed to distribute excess cash in firms with the potentially highest agency costs.

With respect to the size of the firms in the different groups, there is no significant difference in market capitalization between announcing and non-announcing firms for the whole sample or separate years. Also with respect to dividends, the difference is only significant at the 10% level for the whole sample period. For the separate years however, firms that announced repurchase plans paid significantly lower dividends both in 1999 and 2001, but not in 2000. Looking at the subgroups of announcing firms within each year, firms that actually repurchased shares paid significantly lower dividends than non-announcing firms within each year. This is what one would expect to see if firms substitute repurchases for dividends as suggested by Grullon and Michaely (2002). In addition, for announcing firms that did not repurchase, the lower dividend payments may be explained by these firms being less liquid, and thus less likely to pay either dividends or repurchase shares.[46] In addition, as discussed earlier in the paper, an 11% dividend tax was introduced in 2001. This does not seem to have an impact on the

[46] In a previous paper on repurchases in Norway, we find that announcing firms that do not repurchase shares has a significantly lower quick ratio and current ratio than firms that actually repurchase shares.

average dividend payment by firms. With respect to the market to book values, these are not significantly different for firms in any of the groups.

Overall, there seem to be systematic differences in the ownership concentration of firms that initiate a repurchase program relative to firms that do not. Repurchasing firms generally have a much lower concentration and a flatter power structure between the five largest owners. This may support several theories. One interpretation may be that these firms may suffer from insufficient monitoring such that a repurchase plan is used to mitigate agency problems related to free cash. In addition, shareholders in these firms may be more likely to vote for a repurchase program if they believe this will help mitigate agency problems when there is insufficient monitoring. However, it may be difficult to force a manager to actually repurchase shares if he prefers to keep cash within the firm. On the other hand, as suggested by Isagawa (2000), if managers have a stake in the firm, through share ownership or stock options, it may be optimal for them to disgorge excess cash through repurchases instead of investing in negative net present value projects that would decrease the value of the firm in the long run. Another interesting finding is that firms that actually repurchase shares have a much flatter power structure among the five largest owners compared to any other group. This may suggest that managers have the strongest incentives to actually execute repurchases in firms with low concentration.

5.5.2 Ownership by owner-types and number of owners in repurchasing firms

The type of owner may also have important implications for the corporate governance of a firm. As discussed in Bøhren and Ødegaard (2001), agency theory predicts that personal owners are better monitorers than non-personal owners such as other corporations or the state. This because, personal owners have direct private cash flow interests, while non-personal owners, being an agent representing the ultimate owner, do not. Thus, the incentives for monitoring management may be stronger for personal owners. On the other hand, personal owners are generally much smaller, and has less power in affecting the decisions unless they co-ordinate their interests. In addition, it may be that some types of owners that have a stronger preference for one type of payout policy due to e.g. tax reasons. As suggested in Brav et al. (2003), executives do not believe that institutional investors have a preference between dividends or repurchases, but that personal shareholders have a preference towards dividends despite the tax disadvantage to this payout method in the US. On the other hand, their study suggest that institutions often have an important influence with respect to initiating a repurchase program.

In this section we examine the ownership by different owner types both with respect to their proportional ownership as well as to the number of owners by different types. Our dataset has information on 5 main types of owners; *State* owners that represent investments by the central or local government, *foreign* owners[47] which reflect ownership by non-resident organizations or individuals, *financial* owners reflects institutional ownership such as private banks, insurance firms, pension funds and investment trusts, *Nonfinancial* owners are domestic firms, and *individuals* which are Norwegian personal investors.

In table 5.4 we calculate the average ownership fractions owned by these ownertypes for the same groups that we used in the previous section. For all firms at the OSE, the largest average owner is non-financial, which is also the result in Bøhren and Ødegaard (2001). With respect to the difference in ownership fraction between announcing and non-announcing firms, there are only two types that have a significantly different ownership in announcing firms for the whole period. These are foreigners which has a significantly lower stake in announcing firms, while non-financial owners has a significantly higher stake in announcing firms. In both cases this is mainly due to their ownership in firms that actually execute repurchases. In addition, the difference is strongest for firms announcing and repurchasing in the beginning of the sample.

Whether these differences are because certain ownertypes has a preference for or against repurchases, or that firms with these types of owners initiate repurchases is difficult to say. However, one may speculate that one reason for this might be that foreign owners are mutual funds or other foreign investors that are invested in Norway for diversification reasons. As we saw in table 5.3 for the whole sample period, announcing firms seemed to have a slightly smaller (although insignificantly different) market capitalization than non-announcing firms. If foreign investors are tracking the value weighted return on the OSE, they are also likely to be invested in the largest firms on the exchange. A potential reason for why nonfinancial owners has a greater stake in repurchasing firms may be that some firms use their repurchased shares (treasury shares) as payment in transactions with other firms. In addition, the reason may simply be that the treasury stock is captured in this measure such that the numbers also reflect that firms own their own stock.[48]

Another statistic that represent an alternative measure of concentration is the number of owners. One problem with the average ownership fraction by different owner types, examined in table 5.4, is that it may to a large degree capture the ownership by the largest owners of a type. The number of owners by different owner types may give additional information with respect to the preferences of different shareholder groups. In table 5.5 we examine the average number of owners by owner type across the different firm groups as well as the mean total number of owners. Compared to the previous table

[47] The number of foreign owners is understated because it contain both registered individuals as well as nominee accounts which may reflect several different owners.

[48] We do not examine in what degree the firms own stock contribute to the difference. Since the owners in the VPS data are anonymized and represented by a unique number, it is difficult to remove the repurchasing firms own shareholdings.

Table 5.4
Ownership by owner types for repurchasing vs. non-repurchasing firms

The table shows the average ownership fraction for 5 different types of owners. We split firms into five groups. “All OSE firms” are all firms listed on the OSE. These firms are divided into two groups. The first group is “Non announcing firms” containing all firms listed at the OSE that does not announce a repurchase plan during our sample period. The second group is “Announcing firms” which consists of firms that announce a repurchase plan. This group is further divided into firms that announce, but do not repurchase any shares (“No repurchase”) and firms that announce and repurchase shares (“Repurchase”). Tests for differences in means between the different groups of announcing firms are performed relative to the group of non-announcing firms. A significant difference at the 1%, 5% and 10% is denoted by ***, ** and * respectively.

		Ownership fraction by type				
Firm group	Firm/year	State	Foreign	Financial	Non-financial	Individual
				Whole period		
All OSE firms	301	0.043	0.210	0.165	0.373	0.206
Non announcing firms	152	0.045	0.239	0.159	0.336	0.216
Announcing firms	149	0.042	0.180**	0.172	0.411**	0.196
-No repurchase	54	0.029	0.208	0.181	0.400	0.184
-Repurchase	95	0.049	0.164***	0.166	0.418***	0.203
				Year 1999		
All OSE firms	271	0.041	0.201	0.166	0.368	0.222
Non announcing firms	193	0.038	0.217	0.165	0.339	0.235
Announcing firms	78	0.049	0.159**	0.202*	0.404**	0.187**
-No repurchase	39	0.053	0.177	0.224**	0.375	0.173**
-Repurchase	39	0.045	0.141***	0.181	0.433**	0.201
				Year 2000		
All OSE firms	261	0.041	0.202	0.166	0.370	0.223
Non announcing firms	181	0.025	0.245	0.227	0.305	0.203
Announcing firms	80	0.061	0.181	0.169	0.379	0.211
-No repurchase	20	0.036	0.204	0.159**	0.374	0.228
-Repurchase	60	0.052	0.197	0.184	0.361	0.209
				Year 2001		
All OSE firms	245	0.043	0.203	0.154	0.378	0.222
Non announcing firms	145	0.047	0.203	0.150	0.359	0.243
Announcing firms	100	0.039	0.203	0.161	0.406	0.193**
-No repurchase	47	0.049	0.231	0.170	0.370	0.182**
-Repurchase	53	0.030	0.178	0.153	0.438**	0.203

there are a few interesting things to note. First of all, firms that announce a repurchase plan seem to have a larger number of owners than firms that do not announce a plan. However, the difference is not significant when looking at the total number of owners. This is mainly because the cross sectional variation in these numbers are very large. Also when testing for differences in medians there is no significant difference between announcing and non-announcing firms.[49] However, the difference seem to be mainly due to those firms that actually execute repurchases, which on average had more than 4000 owners, while non-announcing firms had about 2400 owners.

Initially one could expect there to be a higher number of owners in repurchasing firms. First, a greater number of owners in announcing firms is expected in the sense that we found that the ownership concentration is lower in these firms. Thus, one explanation discussed before could be that dispersed ownership result in insufficient monitoring, such that firms initiate repurchases to distribute cash and mitigate the agency costs of cash. However, a high number of potentially small owners may also be a reason for why firms want to repurchase shares in the first place. For example, by reducing the number of owners, and increasing the concentration, the firm may improve the external monitoring of the firm by increasing the proportional ownership of some owners, or reduce the likelihood of a successful takeover. In addition, some firms in Norway explicitly state that they intended to repurchase shares to remove "odd-lot" owners.[50] Compared to the results when we examined the fraction owned by each owner-type, some additional patterns appear. The average number of owners of all types, except individuals, is significantly higher in announcing firms.

Overall, the number of state owners, foreigners, financial and non-financial owners is significantly higher in announcing firms. This reflects the finding that firms that announce repurchase plans have a lower concentration than non-announcing firms. Furthermore, the differences are the largest in firms that actually repurchase shares, which may be a strong motivation for why these firms repurchase shares.

5.5.3 Insider ownership in repurchasing firms

One very important owner is the insider which is potentially better informed about current earnings and the future prospects of the firm. In addition, although the general stockholder meeting has voted for initiating a repurchase plan, the manager is the one that decides if and when to execute repurchases. Agency theory predicts that a firm with a large outside shareholder may help mitigate agency costs through his incentives

[49] The median number of owners in non-announcing firms is 816, while it is 1473 for announcing firms for the whole sample period.

[50] One example of this is Storebrand (STB) which at the beginning January 1999 gave an offer to shareholders that owned less than 8 shares to sell their shares back to the company. Of the total 74000 shareholders at the time, 39000 owned less than 8 shares. Since this is a *targeted repurchase* it is left out of the analysis, since we only examine open market repurchases.

Table 5.5

Number of owners by owner type for repurchasing vs. non-repurchasing firms

The table shows the average number of owners for 5 different types of owners. We split firms into five groups. "All OSE firms" are all firms listed on the OSE. These firms are divided into two groups. The first group is "Non announcing firms" containing all firms listed at the OSE that does not announce a repurchase plan during our sample period. The second group is "Announcing firms" which consists of firms that announce a repurchase plan. This group is further divided into firms that announce, but do not repurchase any shares ("No repurchase") and firms that announce and repurchase shares ("Repurchase"). Tests for differences in means between the different groups of announcing firms are performed relative to the group of non-announcing firms. A significant difference at the 1%, 5% and 10% is denoted by ***, ** and * respectively.

		Average number of owners					
Firm group	Firms	All	State	Foreign	Financial	Non-financial	Individual
				Whole period			
All OSE firms	301	2901	4	131	43	159	2564
Non announcing firms	152	2371	3	79	32	118	2138
Announcing firms	149	3443	6**	185***	53***	201***	2998
-No repurchase	54	2136	4	143	48***	168**	1773
-Repurchase	95	4185*	7***	208***	57***	219***	3695*
				Year 1999			
All OSE firms	271	2813	4	137	44	171	2456
Non announcing firms	193	2274	3	114	37	143	1976
Announcing firms	78	4147**	6**	196*	60***	240***	3645**
-No repurchase	39	2142	4	149	53*	178	1758
-Repurchase	39	6153**	8**	243*	67***	303***	5532**
				Year 2000			
All OSE firms	261	2808	4	137	46	172	2447
Non announcing firms	181	2080	3	88	37	139	1813
Announcing firms	80	4454***	6**	250***	66***	248***	3884**
-No repurchase	20	6865***	10***	448**	87***	361***	5959***
-Repurchase	60	3650*	5*	183**	60**	210**	3192
				Year 2001			
All OSE firms	245	3328	6	156	47	175	2944
Non announcing firms	145	3320	5	114	40	157	3004
Announcing firms	100	3341	7	219**	58**	200	2858
-No repurchase	47	2441	5	173*	53	175	2035
-Repurchase	53	4139	8*	259*	62**	222*	3588

to monitor and power to intervene in the decision process. Similarly, when the manager has a stake in the firm, the agency problem may also be lower as there is a convergence of interest (Jensen and Meckling, 1976) between the inside- and outside owners. However, as discussed in section 5.2, there may also be a conflict between inside- and outside owners. First of all, the manager may not have any incentives to actually execute repurchases even though the shareholders have voted for a repurchase plan. Alternatively, the manager may have incentives to secure their position in the firm by increasing their ownership fraction (entrenchment) through repurchasing. One example would be to resist hostile takeovers that, if successful, would threaten their position in the firm and make them loose control over the firms resources. As argued by Bagwell (1991) and others, a repurchase may be used as an effective measure to to reduce the probability of takeovers. For the outside owners, this would reduce their wealth if the takeover is expected to be a valuable restructuring within the firm that could lead to a more efficient use of firm resources. As shown by Denis (1990) the price effect for a firm announcing a defensive repurchase is highly negative which suggests that defensive repurchases are associated with losses for the shareholders of the target firm.

A large part of the literature also focus argue that insiders use repurchases to convey private information to the market, and that this is a potential reason for why a positive announcement effect is observed. Ignoring the credibility issues related to announcements motivated by undervaluation, discussed in Fried (2002) among others, one would expect insiders to have a higher ownership in firms announcing a repurchase plan due to mispricing, than firms that do not. Furthermore, in models by Brennan and Thakor (1990) and Barclay and Smith (1988) the manager also use repurchases to increase his ownership in an undervalued firm and thereby transfer wealth from uninformed shareholders to himself and the remaining shareholders. The model in Isagawa (2000) more explicitly focus on the credibility issues related of open market repurchase, and argue that when the manager has stock options or own shares in the firm, it may be optimal for him to initiate a repurchase program and substitute repurchases for dividends. The prediction of these models is that firms with high insider ownership are more likely to initiate repurchases, or that the insider ownership is expected to increase in undervalued firms. In line with the predictions in Isagawa (2000), Li and McNally (2002) find that repurchasing firms in Canada have a higher insider ownership on average. In addition, Fenn and Liang (2001) find that repurchase activity is positively related to the amount of management options in Canadian firms. They argue that their results suggest that managers use repurchases to increase the value of these options by substituting repurchases for dividends.

Further, as argued by Fried (2002), managers motivation for repurchasing shares may also be related to managerial opportunism. This in the sense that managers may want to initiate an open market repurchase both when the firm is undervalued and overvalued, which is in contrast to the undervaluation hypothesis where the managers want to initiate a repurchase plan only in the cases when the firm is undervalued. Relative to the undervaluation hypothesis, the manager opportunism hypothesis does not have any clear-cut predictions with respect to the insider ownership in repurchasing firms unless these firms are systematically undervalued.

To investigate these issues further, table 5.6 provide statistics on the average insider ownership for all insiders as well as for primary insiders for the same groups of firms as before. We find a large difference in average insider ownership in firms that announce a repurchase plan relative to non-announcing firms. On average for the whole sample period, insiders in announcing firms own more than twice (20%) the fraction of insiders in non-announcing firms (8%). This difference is also systematic and significant for the separate years. However, when we examine more closely the groups of announcing firms that actually repurchase or not, some differences appear. The results suggests the firms that actually repurchase seem to have the highest total insider ownership of the two groups. This may indicate that insiders retain their shares in repurchasing firms, increasing their ownership proportion.

When looking at only the ownership by the primary insiders (managers and members of the board), the results are similar for the whole sample period. Moreover, primary own on average 11.5% in firms that initiate a repurchase program, but only 4.5% in non-announcing firms. For the subgroups of announcing firms, primary insiders have a higher ownership in firms that do not repurchase any shares, which is the opposite as the result for all insiders. The difference becomes even more apparent when looking at the separate years. We do not have a good explanation for this difference between primary insiders and all insiders. When looking at separate years, the difference in primary ownership is not significantly different for announcing firms in 2001.

Relative to the different models and hypotheses discussed earlier, this finding is consistent both with mispricing, entrenchment, expropriation and the model of Isagawa (2000). Relative to an agency story, where repurchases is used to mitigate agency costs, we would expect to see a lower insider ownership in announcing firms. Thus, combined with the findings earlier, where firms with low concentration and more dispersed ownership initiate repurchase programs, the high insider stake may suggest that mitigation of agency costs is a less important motivation for why firms repurchase. On the other hand, it might be that both are important reasons for why firms initiate repurchase programs, but that this differ among firms.

To further investigate the difference in insider ownership between announcing and non-announcing firms we examine the distribution of insider ownership in more detail. The main reason for examining this more closely is that the insider data may overestimate the true insider holdings. The construction of the insider data is based on the

TABLE 5.6
Ownership by insiders

The table shows descriptive statistics for the total and primary insider ownership across the same groups as in table 5.3. The *, ** and *** denotes a significant difference in means between the non-announcing firms and the announcing firms at the 10%, 5% and 1% levels respectively. We also test whether the mean insider ownership in the sub-groups of repurchasing/non-repurchasing firms are significantly different from the non-announcing firms. The test depends on whether the population variances of the two groups are equal or not. If the variances are equal, then the t-stat is calculated as $t = (\bar{x}_a - \bar{x}_b)/\sqrt{s^2(1/n_a + 1/n_b)}$ where $\bar{x}_a$ and $\bar{x}_b$ are the means for the two groups respectively, n_a and n_b are the number of firms in each group while s^2 is the pooled standard deviation calculated as $s^2 = [(n_a - 1)s_a^2 + (n_b - 1)s_b^2]/[n_a + n_b - 2]$, where s_a^2 and s_b^2 are the standard deviation of the ownership variable for the non-announcing and announcing firms respectively.

	Mean insider fraction			
	Whole sample	Separate years 1999	2000	2001
	All insiders			
All OSE firms	0.139	0.144	0.149	0.146
Non announcing firms	0.079	0.110	0.110	0.099
Announcing firms	0.199***	0.226***	0.234***	0.212***
-No repurchase	0.177***	0.202**	0.228*	0.109
-Repurchase	0.211***	0.249***	0.236**	0.305***
	Primary insiders			
All OSE firms	0.081	0.081	0.085	0.089
Non announcing firms	0.045	0.059	0.065	0.077
Announcing firms	0.115***	0.135***	0.131***	0.105
-No repurchase	0.131***	0.176***	0.179***	0.053
-Repurchase	0.106***	0.094	0.114*	0.151**

actual reports from the transactions reported by insiders to the OSE.[51] However, since insiders are not required to report to the OSE when leaving the firm, or his subsequent transactions, the holdings of these insiders persist in the data. One effect of this is that the insider fraction in some instances may become very high, and in some instances 100%. This is of course not possible since the firm in that case would not be listed on the OSE. Despite this bias, we do not expect there to be more extreme insider firms among the announcing firms than among the non-announcing firms except if insiders are more active in on of the groups. However, we want to examine the effect of this bias more closely. To do this, we remove all firms with more than 90% insider ownership, and recalculate the insider statistics.

The results from the truncations are reported in table 5.7. In panel A of the table, we examine the cross-sectional distribution of the total insider ownership for the whole period. If there is a systematic bias towards one of the groups removing the extreme observations should make the two distributions more similar. Doing this decreases the mean total insider fraction for the non-announcing firms from 8% to 7%, and for the announcing firms from 20% to 14%. However, the difference in means is still significant at the 1% level. Also for the separate years, there is a decrease in the mean for both groups. For 1999 the difference in insider ownership becomes insignificant, but for 2000 and 2001 it is still significant at the 1% level. When we perform the the same exercise for the primary insiders the results go in the same direction, but the change is less pronounced since there is fewer firms with extreme primary insider ownership.

Removing the insider fractions above 90% seems to reduce both averages similarly for the two groups, such that there is no systematic bias towards the announcing firms. However, an insider fraction>90% is still not uninteresting, because it captures a feature in the data in that insiders are more active in these firms. Thus, we do not remove them from the rest of the analysis, but acknowledge that there is a potential bias relative to the insider data.

5.5.4 Changes in ownership in repurchasing firms

So far, we have examined the average ownership in firms that announces a repurchase plan. We now turn to examining how the various ownership variables change during the course of the repurchase program. This is done by examining the ownership characteristics one month before firms executes their first repurchases, relative to the ownership characteristics for the same firms 12 months and 24 months afterwards. Thus, for each ownership variable we have a cross section of values before the firms execute their first repurchase and a cross section of values 12 (and 24) months after the firms initial repurchase. Note that the months vary across firms, such that the analysis is essentially similar to an event study where firms that experience an event at different points in

[51] An insider is required to report any transaction to the OSE before 10 am the following day.

TABLE 5.7
Distribution of total insider ownership

The table shows the distribution of total insider ownership across the two groups of announcing and non-announcing firms. In first part of panel A ("Full sample"), we use all firms in the sample. In the second part ("Truncated") we remove all firms that have an average insider ownership greater than 90% for both groups. We test whether the means of the cross sectional distributions are equal with *, ** and *** denoting a significant difference at the 10%, 5% and 1% levels respectively. The tests are adjusted for differences in variances between the two distributions if the variance is significantly different. In panel B we examine the distribution of insider ownership across firms that announce/do not announce within each year.

Panel A: Cross sectional distribution of insider ownership - whole period

	Firms	Insider ownership distribution						std.dev
		p25	Median	Mean	P75	p90	max	mean
Full sample								
-Non-announcing	152	0.000	0.00	0.08	0.05	0.26	1.00	0.19
-Announcing	149	0.002	0.04	0.20***	0.27	0.70	1.00	0.30
Truncated sample								
-Non-announcing	144	0.000	0.00	0.07	0.04	0.24	0.88	0.16
-Announcing	139	0.001	0.03	0.14***	0.21	0.59	0.87	0.22

Panel B: Cross sectional distribution of insider ownership - separate years

	Firms	Insider ownership distribution						std.dev
		p25	Median	Mean	P75	p90	max	mean
				Year 1999				
Full sample								
-Non-announcing	193	0.000	0.00	0.11	0.08	0.39	1.00	0.22
-Announcing	78	0.001	0.05	0.23***	0.33	0.93	1.00	0.33
Truncated sample								
-Non-announcing	182	0.000	0.00	0.09	0.06	0.34	0.88	0.17
-Announcing	69	0.001	0.03	0.13	0.17	0.43	0.87	0.20
				Year 2000				
Full sample								
-Non-announcing	181	0.000	0.00	0.11	0.06	0.41	1.00	0.24
-Announcing	80	0.003	0.06	0.23***	0.40	0.81	1.00	0.32
Truncated sample								
-Non-announcing	169	0.000	0.00	0.07	0.05	0.30	0.88	0.16
-Announcing	73	0.003	0.04	0.16***	0.24	0.51	0.85	0.23
				Year 2001				
Full sample								
-Non-announcing	145	0.000	0.00	0.10	0.05	0.26	1.00	0.24
-Announcing	100	0.003	0.06	0.21***	0.34	0.69	1.00	0.29
Truncated sample								
-Non-announcing	135	0.000	0.00	0.07	0.03	0.21	0.88	0.16
-Announcing	94	0.002	0.04	0.16***	0.29	0.51	0.88	0.22

time are aligned in event time. One concern with this is that there may have been a trend in the ownership variables through the sample period, and that the change reflect these trends. However, in table 5.2 there is not any indication that there has been a large change in the average for any of the variables across all firms at the OSE during the sample period. In addition, since different firms execute their first repurchase throughout the entire sample period, this will mitigate the effect from a trend in the ownership variables.

To examine whether there is a change in the various ownership variables before and after the initial repurchases, we run a paired test for differences in means, where the null hypothesis is that the cross sectional mean for each variable is equal before and after the initial repurchase. The results from this analysis is shown in table 5.8. The left section of the table shows the results when we examine the change over a 12 month period after the firms execute their first repurchase, while the right part of the table shows the results for changes over a 24 month period. For each variable the table shows the cross sectional mean one month before firms repurchase for the first time ("before"), and the mean 12 or 24 months after the initial repurchase ("after"), the p-value from the paired test, and an indicator for the change in the mean ("direction"). Note that the means before are different when we use a 12 month period from when we use a 24 month period. This is because we loose observations when we examine the longest period since we only have ownership data through 2002 such that firms repurchasing for the first time in 2001 drop out of the sample.

As would be expected, the repurchases increase the concentration both relative to the total fraction owned by the 5 largest owners as well as relative to the Herfindahl index. However, the change in the Herfindahl index is only significant at the 5% level when we consider the 24 month change in the index. Relative to the separate ownership fractions of the five largest owners, only the largest owner has a significant increase in the fraction, which suggests that the change in concentration is to a large degree is due to the increased ownership of the largest owner. The ownership fraction of all- and primary insiders increases, but not significantly. The fraction owned by the state increases significantly both for the 12 and 24 month periods. One reason for this may be that the state often is a long-term investor, and are more likely to retain its shares through the repurchase period, increasing its proportional ownership when the firm repurchase. On the other hand the ownership of institutional (financial) and individual investors decreases when firm repurchase shares. There may be several reasons for this. If personal investors are afraid of being expropriated (Brennan and Thakor, 1990) or has a preference for dividends they may reduce their ownership in repurchasing firms. Alternatively, since both institutional and personal investors probably are those owners that trade most frequently (as opposed to the state, foreigners and other companies) among the different owner types, they are more likely to sell their shares back to the company when it purchase shares in the open market. Interestingly, the decrease in institutional ownership is opposite of what Grinstein and Michaely (2001) find for a sample of public firms in the US. Why this difference appear is difficult to say. However, it may be argued that this is something one would expect to see. Shleifer and Vishny (1986) argue that firms pay dividends to attract institutions. In addition, many institutional investors also have restrictions with respect to investing in non-dividend paying firms. From this point of view, one would expect institutions to reduce their ownership if firms that substitute repurchases for dividends.

Finally, when we examine the change in the number of owners of the different owner types, we find that the average total number of owners declines during both periods, and that there is a decrease in the number of financial, non-financial and individual owners, while the number of foreign owners is relatively stable. In addition, the number of state owners increase during the 24 month period which reflect that these owners not only retain their shares, but that repurchasing firms may attract investors of this type.

5.6 The probability of announcement

Having examined the ownership structure characteristics of firms that use repurchases, we now examine whether the ownership structure affect the propensity for a firm to announce a repurchase plan. Thus, in this section we examine in more detail whether there are systematic relation between the ownership structure of firms and the probability of seeing a firm announcing a repurchase plan during the following period, conditional on ownership variables at a fixed point in time. To do this we estimate a binary regression model for estimating the effect of various ownership variables on the propensity for firms to announce (Ann) a repurchase program. The general model to be estimated is,

$$Prob(\text{Ann}) = F(\beta'\mathbf{x}) \tag{5.1}$$

where $\beta' x$ is the index function, with x containing the explanatory variables for each firm, β is a vector of coefficients and $F(\cdot)$ is the cumulative distribution function. The model is estimated as a binary regression model by assuming that a variable Ann$\in \{1, 0\}$, which is the event of a firm announcing a repurchase plan or not, is related to a set of explanatory variables $\mathbf{x}$.[52] We estimate models based on both a probit and logit specification by maximum likelihood.[53] However, since the results the two specifications are very similar, we report only results from the logit estimation.[54]

[52] A more detailed explanation is provided in appendix 5.A.

[53] The proc logistic, proc probit in addition to the proc mixed procedures, provided in SAS v.8.2 are used for the numerical optimizations.

[54] Also as noted in Greene (2000), the difference between a logit and probit specification is generally very small unless for very large samples.

Table 5.8
Changes in ownership in repurchasing firms

The table show the results from a paired test for differences in means for the 12 month and 24 month period after firms repurchase shares for the first time. For each period, the table shows the average for the respective variable one month before the firms execute their first repurchase ("before"), 12 (or 24) months afterwards ("after"), the p-value from the test for the mean before and after being equal, as well as a column showing the direction of the change ("direction"). The numbers in parentheses below each mean show the standard deviation of the mean for the respective variable.

	12 month period (N=90)				24 month period (N=67)			
Concentration	before	after	p-value	direction	Before	After	p-value	direction
Herfindahl index	0.138	0.166	0.09	+	**0.110**	**0.160**	0.02	+
	(0.177)	(0.236)			(0.085)	(0.194)		
5 largest owners	**0.522**	**0.545**	0.04	+	**0.509**	**0.565**	<0.01	+
	(0.205)	(0.218)			(0.174)	(0.212)		

	12 month period (N=90)				24 month period (N=67)			
Ownership fraction	before	after	p-value	direction	before	after	p-value	direction
1st largest	0.265	0.288	0.10	+	**0.242**	**0.288**	0.02	+
	(0.193)	(0.231)			(0.143)	(0.207)		
2nd largest	0.108	0.106	0.58	-	0.113	0.118	0.38	+
	(0.065)	(0.067)			(0.06)	(0.066)		
3rd largest	0.066	0.067	0.97	+	0.066	0.071	0.18	+
	(0.036)	(0.038)			(0.029)	(0.039)		
4th larges	0.047	0.048	0.50	+	0.049	0.050	0.48	+
	(0.025)	(0.027)			(0.022)	(0.024)		
5th largest	0.036	0.036	0.66	+	0.039	0.038	0.53	-
	(0.016)	(0.017)			(0.016)	(0.017)		
All insiders	0.227	0.235	0.60	+	0.228	0.235	0.71	+
	(0.336)	(0.336)			(0.328)	(0.319)		
Primary insiders	0.107	0.115	0.56	+	0.106	0.121	0.46	+
	(0.23)	(0.24)			(0.225)	(0.247)		
State	**0.043**	**0.048**	0.01	+	**0.053**	**0.060**	<0.01	+
	(0.114)	(0.118)			(0.13)	(0.137)		
Foreigners	0.167	0.176	0.49	+	0.181	0.220	0.09	+
	(0.183)	(0.208)			(0.188)	(0.251)		
Financials	**0.176**	**0.158**	0.05	-	**0.186**	**0.140**	<0.01	-
	(0.152)	(0.141)			(0.127)	(0.102)		
Non-financials	0.410	0.426	0.16	+	0.378	0.397	0.29	+
	(0.248)	(0.258)			(0.223)	(0.244)		
Individuals	**0.206**	**0.193**	0.04	-	**0.203**	**0.185**	0.05	-
	(0.172)	(0.171)			(0.161)	(0.162)		

	12 month period (N=90)				24 month period (N=67)			
Number of owners	before	after	p-value	direction	before	after	p-value	direction
All owners	4521	4219	0.35	-	5410	4892	0.25	-
	(9044)	(8543)			(10312)	(9519)		
State	7	7	0.16	+	**7**	**10**	<0.01	+
	(11)	(13)			(12)	(15)		
Foreigners	219	214	0.84	-	262	262	0.99	+
	(484)	(479)			(553)	(553)		
Financials	60	57	0.20	-	**66**	**57**	0.02	-
	(65)	(67)			(69)	(65)		
Non-financials	**242**	**215**	<0.01	-	**276**	**222**	<0.01	-
	(314)	(283)			(352)	(277)		
Individuals	3993	3725	0.37	-	4799	4341	0.26	-
	(8340)	(7849)			(9515)	(8765)		

5.6.1 Variable selection

Before we continue, we need to select variables ($\mathbf{x}$) that may be argued to be important for why firms initiate a repurchase plan. Since the set of ownership variables available to us has been examined earlier in the paper, the estimation results are likely to reflect many of the patterns found in the descriptive part. However, by estimating a model we are better able to address the relative importance of the various variables.

The first variable we include in the analysis is the *insider fraction*. As discussed earlier, agency theory predict that higher insider ownership align the interests of inside- and outside owners such that the need for external monitoring is reduced. In that case, the need for cash distribution to mitigate agency costs would be lower such that firms with high insider ownership should *not* be expected to initiate repurchase programs as often as firms with low insider ownership. Alternatively, insiders may also want to initiate a repurchase plan to maximize their future wealth, to increase the value of their options, entrench themselves, counter takeovers or to expropriate outside shareholders. To examine whether a very high insider ownership has any effect on the propensity for firms to initiate a repurchase program, we also create a dummy variable ("High insider ownership") which is equal to 1 if the insider stake is larger than 33% and zero if not.[55] If the insiders have a large stake in the firm, they may vote against the initiation of a repurchase program, effectively stopping it. Alternatively, they may also force a repurchase program through, if they have a strong preference for repurchases.

Another variable that is predicted by agency theory to be important for the quality of corporate governance is ownership *concentration*. A higher concentration is expected to improve monitoring such that the need for additional mechanisms to restrict managers to waste cash, such as repurchases, are reduced. In addition, we create a dummy variable to examine whether firms with a large controlling shareholder are more or less likely to announce a repurchase plan. The dummy variable ("Largest owner >67%") is equal to one if the largest shareholder has a super-majority (ownership fraction $> 2/3$). A very large owner may have very strong incentives to monitor the management of the firm, reducing the need for additional mechanisms to discipline management. Alternatively, a large controlling shareholder can also effectively block the proposal of a repurchase plan by voting against it.

We also have information about the type of the largest owner. Moreover, we know whether the largest owner is a state-, foreign-, financial-, nonfinancial- or individual owner. Since the identity of the largest owner may be important with respect to the incentive to monitor, we create dummies, which are interacted with the fraction owned by the largest owner to examine this. For example, it might be that personal owners are better monitorers than other owners, such as large corporations or the state, because

[55] The threshold is not related to any theoretical predictions, but merely reflect whether insiders has a super minority (1/3).

the quality of the firm affect their wealth more directly. On the other hand, it may be that institutional investors are more competent with respect to how the firm should be run and have a preference for dividend payments which would make them more inclined to vote against the proposal of a repurchase program.

Another variable which may affect the motivation for why a firm announces a repurchase plan is the *dividend* history of a firm. If firms are reluctant to reduce their dividends and engage in dividend smoothing, as suggested by Lintner (1956) and Brav et al. (2003), a firm that has paid dividends previously may be less likely to initiate a repurchase plan if it plans on maintaining its dividend rate. In addition, the size of the firm may be important since larger firms generally have more shareholders and potentially a more dispersed ownership.

In addition, we examine various model specifications to investigate whether the total number of owners, the number of owners by the different owner-types as well as their ownership proportions affect the propensity for firms to announce a repurchase plan. With respect to the discussion earlier, a high number of owners may be a motivation for firms to repurchase shares in the first place.

5.6.2 Estimation results

We estimate the models in the beginning of 1999, 2000 and 2001 with a prediction period of 12 months. Thus, for each year we use the most recent information before we estimate the models.[56] Furthermore, all firms that were not yet listed at the beginning of the estimation year is excluded from the estimation for the respective year.

Table 5.9 report the correlations between various variables in, 1999 and 2000, that we examine in the various models. The lower triangular part of the table show the correlations for January 1999 and the upper triangular part of the table shows the correlations for January 2000. For each pair of variables, the table shows the correlation with the associated p-value from a test of the correlation being equal to zero. First of all, most of the correlations are of the same magnitude and sign for the two years which is because most of the ownership variables are very persistent across time. In addition, the correlations for 2001 are similar to those shown for 1999 and 2000. As expected, several of the variables are highly correlated. First of all, the insider fraction (all insiders) has the highest correlation with the fraction owned by nonfinancial owners (although only significant for 1999) and the second largest owner.[57] Although not shown in the table, the correlation between primary insider ownership and the total insider ownership is about 0.85, and highly significant. The Herfindahl index[58] has a correlation of more than 0.8 with the concentration measure (sum of fraction owned by the five largest

[56]For 1999 we use data from December 1998, for 2000 we use data for December 1999 and so on.

[57]This points to one problem with the data. We are unable to distinguish cases where the largest owners also are primary insiders.

[58]The Herfindahl index is the sum of the squared ownership fractions of all owners in a firm.

TABLE 5.9
Variable correlations

The table shows the cross sectional correlations between various ownership variables on two dates. The lower triangular part of the matrix shows the correlations across companies in January 1999, and the upper triangular part shows the correlations in January 2000. For each pair of variables the table shows the Pearson correlation coefficient and the p-value from a test of the correlation being equal to zero. Correlations that are significantly different from zero are in bold.

	Insider fraction	Herfindahl	Concen- tration	Financial fraction	Foreigners fraction	Nonfinancial fraction	State fraction	Individuals fraction	MCAP	largest 1	largets 2	largest 3	largest 4	largest 5
Insider fraction	-	-0.04	0.12	-0.08	0.06	0.13	-0.09	-0.12	-0.03	0.00	**0.27**	0.18	0.14	0.16
	-	0.70	0.20	0.43	0.50	0.17	0.33	0.22	0.74	0.96	<.01	0.05	0.14	0.09
Herfindahl	0.11	-	**0.84**	0.07	0.12	0.22	0.13	**-0.55**	0.16	**0.98**	**-0.40**	**-0.53**	**-0.65**	**-0.69**
	0.17	-	<.01	0.45	0.19	0.02	0.17	<.01	0.12	<.01	<.01	<.01	<.01	<.01
Concentration	0.19	**0.81**	-	0.00	0.20	**0.29**	0.10	**-0.64**	0.14	**0.90**	0.07	-0.08	**-0.27**	**-0.35**
	0.02	<.01	-	0.99	0.03	<.01	0.26	<.01	0.19	<.01	0.47	0.41	<.01	<.01
Financial (fraction)	-0.01	0.01	-0.11	-	-0.22	**-0.35**	-0.05	-0.20	**0.34**	0.05	-0.16	-0.08	-0.05	-0.03
	0.88	0.93	0.15	-	0.02	<.01	0.57	0.03	<.01	0.56	0.07	0.36	0.59	0.72
Foreigners (fraction)	-0.10	0.07	0.14	-0.16	-	**-0.44**	-0.09	**-0.30**	**0.29**	0.14	0.17	0.03	-0.04	-0.08
	0.19	0.35	0.06	0.03	-	<.01	0.34	<.01	<.01	0.13	0.07	0.74	0.68	0.40
Nonfinancial (fraction)	**0.23**	0.13	**0.27**	**-0.34**	**-0.48**	-	**-0.22**	**-0.30**	-0.12	**0.25**	0.03	0.00	-0.08	-0.07
	<.01	0.08	<.01	<.01	<.01	-	<.01	<.01	0.27	<.01	0.71	0.97	0.40	0.46
State (fraction)	-0.10	**0.20**	0.15	-0.08	-0.05	**-0.27**	-	-0.17	**0.26**	0.14	-0.12	-0.10	-0.08	-0.08
	0.19	<.01	0.05	0.27	0.49	<.01	-	0.06	<.01	0.13	0.19	0.29	0.41	0.41
Individuals (fraction)	-0.08	**-0.39**	**-0.49**	**-0.20**	**-0.36**	**-0.24**	**-0.19**	-	**-0.52**	**-0.60**	0.00	0.12	**0.23**	**0.25**
	0.34	<.01	<.01	<.01	<.01	<.01	<.01	-	<.01	<.01	0.99	0.21	<.01	<.01
MCAP	0.01	0.06	0.07	0.16	**0.35**	-0.17	**0.29**	**-0.46**	-	0.18	-0.09	-0.03	-0.06	-0.04
	0.87	0.46	0.35	0.04	<.01	0.03	<.01	<.01	-	0.09	0.41	0.78	0.58	0.69
largest 1	0.14	**0.96**	**0.88**	-0.05	0.07	**0.19**	**0.21**	**-0.42**	0.06	-	**-0.33**	**-0.46**	**-0.60**	**-0.64**
	0.07	<.01	<.01	0.51	0.34	<.01	<.01	<.01	0.42	-	<.01	<.01	<.01	<.01
largest 2	**0.21**	-0.14	**0.33**	-0.16	0.12	0.18	-0.13	-0.14	0.03	-0.08	-	**0.68**	**0.55**	**0.47**
	<.01	0.08	<.01	0.04	0.11	0.02	0.10	0.07	0.75	0.29	-	<.01	<.01	<.01
largest 3	0.00	**-0.37**	0.10	-0.12	0.08	0.14	-0.10	-0.08	0.05	**-0.32**	**0.53**	-	**0.81**	**0.74**
	0.96	<.01	0.17	0.12	0.32	0.07	0.21	0.28	0.54	<.01	<.01	-	<.01	<.01
largest 4	-0.05	**-0.51**	-0.11	0.01	0.11	-0.03	-0.09	-0.02	-0.04	**-0.46**	**0.30**	**0.74**	-	**0.90**
	0.53	<.01	0.15	0.89	0.16	0.70	0.22	0.75	0.64	<.01	<.01	<.01	-	<.01
largest 5	0.00	**-0.56**	-0.22	0.08	0.09	-0.05	-0.10	-0.04	0.05	**-0.51**	**0.21**	**0.59**	**0.82**	-
	0.99	<.01	0.00	0.31	0.23	0.53	0.18	0.61	0.57	<.01	<.01	<.01	<.01	-

owners) and a correlation of 0.96 with the fraction owned by the largest shareholder in 1999, and a negative correlation with the 3rd-5th largest shareholders.

Furthermore, the ownership fraction owned by the largest owners both in aggregate and separately is not correlated with the size of the firm (MCAP). Also, relating to the previous discussion on the ownership of foreign investors, we see that their ownership fraction is significantly positively correlated with the size of the firm indicating that they are mainly investing in the largest companies to track the OSE all share index for diversification reasons. Furthermore, the fraction owned by individual owners are negatively correlated with the concentration measures, the ownership of the largest owner as well as the fraction owned by the other owner types. Another correlation that is not shown in the table, is the correlation between the dividend other variables. The dividend has the highest correlation with market capitalization, with correlation of about 0.22, which indicate that larger firms pay more dividends. However, the dividend variable is not highly correlated with any other variables.

Table 5.10 report the estimation results when we estimate the propensity for firm to announce a repurchase plan during each year given the ownership characteristics at the beginning of the year.[59]

For each year we estimate three different models with various variable combinations that are not highly correlated. In model (1) for each year, we examine the concentration (fraction owned by the 5 largest owners), the insider ownership fraction, the firm size (natural log of the market capitalization), a dummy variable for whether the firm paid dividends in the previous year. In model (2) we examine whether the identity of the largest owner is important by including the ownership fraction of the largest owner conditional on whether he is a state-, foreign-, financial-, nonfinancial- or individual owner. In addition we include the the dividend dummy and the market capitalization. In model (3) we examine the effect of a large controlling owner and high insider ownership.[60]

The results from the estimation reflect to a large degree what was found in the descriptive part of the analysis. However some new results appear. First, looking at model (1), the concentration does not seem to be important for any year with respect to whether the firm announces a repurchase plan, while the propensity for firms to announce is positively related to the insider ownership for all years. In addition, the

[59]Since we model the probability of announcement, the sign of the parameter estimates reflect the direction that the independent variable affect the probability of announcement. To evaluate the effect of a variable on the probability of announcement, one can calculate the change in the probability $\mathtt{Prob}(\mathtt{Ann}) = \exp(x'\beta)/[1+\exp(x'\beta)]$ by keeping the other variables fixed at their sample means, and vary the mean of the variable under study. The term $\exp(x'\beta)$, with all x's at the sample means is the odds ratio. For example, in model (1) for 1999, and increase in the insider ownership from 0% to 20% increases the probability of announcement by 5%.

[60]The number of firms with an insider ownership greater than 33% is 35 in 1999, 43 in 2000 and 42 in 2001. For the large shareholder dummy, 18 firms had a controlling shareholder in 1999, 34 in 2000 and 36 in 2001. These two variables has an insignificant negative correlation of -0.03 for 1999 and 2000, and 0.04 for 2001.

TABLE 5.10

The probability of announcement - 12 month interval

The table shows the results from the estimation of a logit model, $Prob(\mathsf{Ann}) = \mathsf{F}(\beta'\mathsf{x})$, with the table showing the β estimates for the independent variables for three different model specifications each year. The models are estimated at the beginning of each year, with the dependent variable equal to 1 if the firm announces a repurchase plan during the year, and equal to zero if it does not. The table shows the estimation results when we estimate the model looking 12 months forward from January each year. The independent variables are the aggregate fraction owned by the five largest owners (concentration), the fraction owned by all insiders of the firm (insider fraction), the natural log of the market capitalization, a dummy for whether the firm paid dividend the previous year (Dividend). In addition we have interactive dummies (interacted with the fraction owned by the largest owner) for whether the largest owner is a state-, foreign-, financial-, nonfinancial- or individual owner. In model (3) we also examine whether the insiders owns more than 33% of the firm (High insider ownership) and whether the largest owner has a super-majority (Largest owner >67%) in addition to the market capitalization and whether the firm has paid dividend the previous year.

	Model 1999			Model 2000			Model 2001		
Independent variable	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Intercept	-4.82**	-5.53***	-4.13**	-7.99***	-8.13***	-8.47***	-6.34***	-5.63***	-7.2***
Concentration	0.68	·	·	-0.98	·	·	0.38	·	·
Insider fraction	1.05**	·	·	1.53***	·	·	1.83***	·	·
MCAP (log)	0.23**	0.27**	0.21**	0.46***	0.44***	0.46***	0.32***	0.32***	0.38***
Dividend	-1.06***	-1.04***	-0.88***	-1.68***	-1.74***	-1.74***	-0.81**	-0.74**	-0.91***
largest state	·	2.18	·	·	0.25	·	·	0.23	·
largest foreign	·	-1.61	·	·	0.26	·	·	2.99	·
largest financial	·	6.28*	·	·	4.88	·	·	1.36	·
largest nonfinancial	·	1.69**	·	·	1.14	·	·	0.34	·
largest individual	·	4.25*	·	·	1.26	·	·	0.61	·
Largest owner >67%	·	·	-1.64*	·	·	-1.80**	·	·	-2.67**
Large insider	·	·	0.62*	·	·	0.81**	·	·	1.47***
N(Announcing)	80	80	80	84	84	84	96	96	96
N(Non announcing)	125	125	125	97	97	97	84	84	84
Pseudo R square	0.06	0.13	0.06	0.18	0.16	0.19	0.13	0.11	0.12
AIC	269	259	272	221	231	222	236	247	238
Likelihood ratio (p value)	<.001	<.001	0.02	<.001	<.001	<.001	<.01	<.01	<.01
Hosmer/Lemeshow	0.13	0.03	0.35	0.91	0.79	0.90	0.02	0.34	0.05
% concordant	64.2	68.0	63.3	74.8	73.2	75.6	69.8	68.1	70.5

results also suggest that large firms are more likely to announce, at least for 2000 and 2001. Since the correlation between concentration and firm size is very low, it does not reflect that large firms announce because they have a more dispersed ownership. Furthermore, whether the firm has paid dividends the previous year is a very important decision variable across all years and model specifications. This indicates that firms that historically has paid dividends are smoothing dividends, and reluctant to reduce dividends to facilitate a repurchase program. Relative to the identity of the largest owner, we do not find any systematic significant relationship across the years.

In model (2), we examine whether the identity of the largest owner may contribute to the announcement of a repurchase program. For 1999, the results indicate that firms where the largest owner is another firm (nonfinancial) or an institutional owner are more likely to initiate a program. However, across different years, there is no evidence that the identity of the largest owner is important.

Although, the identity of the owner is not important, the size of the owner might be. To check this, model (3) examines whether a controlling owner or a large insider is important with respect to whether a firm announces a repurchase plan. The result indicate that a large controlling shareholder reduces the probability of observing an announcement. As discussed earlier, this may be because firms with a very large shareholder are closely monitored such that additional mechanisms to discipline management are *not* needed. Alternatively, large owners are may also resist the proposal of a repurchase plan. Thus, if a large owner prefers dividends, or has a preference against repurchases, he can effectively block any proposal of a repurchase program. The dummy for high insider ownership is positive for all years, but less significant in 1999. In table 5.11 we extend the estimation period to 24 months, and estimate the models for 1999 and 2000. The results are similar, but somewhat stronger than the results in table 5.10.

We also estimate models examining whether the quick ratio as a proxy for liquidity affect the propensity for firms to announce a repurchase plan. However, it is not significant. Appendix 5.B show additional model estimations where we also investigate the total number of owners and the number of owners by different owner-types. Before interpreting these results, it is important to note that the number of owners is highly correlated with the size of the firm. In addition, the number of owners in each category is also highly correlated with eachother. Thus, in tables 5.B1 and 5.B2 in the appendix we see that the market capitalization is rendered insignificant due to the multicolinearity. Additional models, with each ownertypes ownership fraction are also estimated, but not shown in a table. The results for the ownership fractions by type of owner are not significant except for the fraction owned by individuals which is has a negative effect. For models with the separate ownerships of the five largest owners, the results are ambiguous. This because the ownership proportions of the largest 3rd-5th owners are strongly negatively correlated with the the ownership of the largest owner,

TABLE 5.11

The probability of announcement - 24 month interval

The table shows the results from the estimation of a logit model, $Prob(Ann) = F(\beta'x)$, with the table showing the β estimates for the independent variables for four different model specifications starting in 1999 and 2000. The models are estimated at the beginning of each year, with the dependent variable equal to 1 if the firm announces a repurchase plan during the year, and equal to zero if it does not. The table shows the estimation results when we estimate the model looking 24 months forward from January each year. The models are estimated in January each year. The independent variables are the total fraction owned by the five largest owners (concentration), the fraction owned by the insiders of the firm (insider fraction), the natural log of the market capitalization, a dummy for whether the firm paid dividend the previous year, the total number of owners ("number of owners") and the number of owners by various owner-types, a dummy for whether the insiders owns more than 33% of the firm (High insider ownership) and a dummy for whether the largest owner has a super-majority (Largest owner >67%).

	Model 1999			**Model 2000**		
Independent variable	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Intercept	-5.22**	-5.53***	-5.42**	-6.33***	-6.81***	-6.84***
Concentration	-0.02	·	·	-0.88	·	·
Insider fraction	1.59***	·	·	1.76***	·	·
MCAP (log)	0.30***	0.31***	0.31**	0.40***	0.41***	0.42***
Dividend	-1.12***	-0.98***	-1.12***	-1.66***	-1.66***	-1.69***
largest state	·	-0.81	·	·	-1.18	·
largest foreigner	·	-2.05	·	·	-0.93	·
largest financial	·	4.91*	·	·	4.78	·
largest nonfinancial	·	0.71**	·	·	1.45*	·
largest individual	·	2.71*	·	·	2.26	·
Largest owner >67%	·	·	-1.57**	·	·	-2.47***
High insider ownership	·	·	1.10***	·	·	0.94**
N(Announcing)	117	117	117	118	118	118
N(Non announcing)	94	94	94	74	74	74
Pseudo R square	0.09	0.10	0.10	0.16	0.16	0.19
AIC	281	287	280	231	241	229
Likelihood ratio (p value)	<.001	<.001	0.02	<.001	<.001	<.001
Hosmer/Lemeshow	0.45	0.39	0.92	0.91	0.67	0.86
% concordant	66.2	66.7	68.4	74.8	71.2	76.7

and positively correlated with eachother. However, when estimating separate models, we find that the ownership of the largest owner has a negative effect on the propensity to initiate a repurchase program, consistent with the result for the dummy variable for the controlling shareholder in table 5.10.

One thing to note about the estimations is that we do not remove firms that has previously announced a repurchase plan. Since several of the variables are highly persistent, firms that are more likely to announce every year, will be included in the model estimation every year. To study the effect of this, we also estimate models where all firms that has announced in previous years are removed from the sample. For example, when estimating the model for 2000, we remove all firms that announced before 2000. Although the results for 1999 remains the same, the results for 2000 becomes weaker while the estimation in 2001 is problematic since we are left with very few firms in both categories. However, it is not obvious that we should remove firms that has announced the previous year since it is the characteristics of these firms that we are interested in.

To summarize, the results from the model estimations above is not supportive of an agency story where firms initiate a repurchase program to mitigate agency problems. Although announcing firms have more shareholders, and a lower concentration on average, other variables seem more important in explaining the propensity for firms to initiate a repurchase program. The variables that are the most important decision variables are the previous dividend history of the firm, the insider ownership, and the existence of a large, controlling, shareholder. Another interesting finding is that the identity of the largest owner, or the identity of owners in general, is not important for the decision to initiate a repurchase program.

Although these findings may be interpreted in several ways, the results are in line with models where insiders have incentives to support a repurchase program to maximize their future wealth when they have a stake in the company (Isagawa, 2000), expropriate outside shareholders or to entrench themselves and reduce the probability of takeovers. On the other hand this interpretation is not unambiguous as the existence of a controlling shareholder decreases the probability of announcement. This is the opposite of what is the prediction in the model by Brennan and Thakor (1990). One implication from their model is that large shareholders will prefer repurchases to dividends, while small shareholders will prefer dividends. Our results instead suggest that controlling shareholders oppose repurchases or that additional mechanisms for distributing excess cash is not needed when a large shareholder is in place to monitor the management.

5.7 Conclusion

This study provide a detailed examination of the ownership in Norwegian firms that initiates repurchase programs. The main motivation is that a repurchase is an important corporate event, which has the effect of altering the ownership structure. In addition, few studies study in detail the ownership in firms that initiate repurchase programs. Since a repurchase is a flexible way for firms to distribute cash, it may be used by managers as a self imposed disciplinary mechanism which reduce cash holdings and mitigate agency costs when other corporate governance mechanisms are not in place. On the other hand, theoretical models also suggest that managers can use repurchases to pursue their own objectives. For example, if there is asymmetric information between the manager and outside shareholders, a repurchase can be used to increase his ownership in undervalued firms transferring wealth from outside owners to himself and the remaining shareholders. In addition, a repurchase may decrease the probability of value enhancing takeovers which would benefit shareholders, but threaten the position of the manager and potentially make him loose control over the firms resources.

The paper documents some interesting patterns in the ownership structure of Norwegian firms that initiate repurchase plans. Moreover, the descriptive statistics indicate that the ownership concentration in firms that announce repurchase plans is much lower than in non-announcing firms. This is to a large degree because the largest shareholder in these firms has a much lower stake in the firm. In addition, announcing firms also have a much higher number of shareholders across all owner-types. These findings are consistent with an agency theoretical explanation for why firms repurchase shares. Because owners in these firms potentially have a much lower incentives to monitor management, repurchases can be used as an additional mechanisms to mitigate agency costs (Jensen, 1986). However, the large number of shareholders may also be the main reason for firms repurchasing shares in the first place. By removing the smallest shareholders, the concentration potentially increases, such that monitoring quality improves as the remaining shareholders increases their cash-flow and voting rights.

When examining the insider ownership in announcing firms, another picture emerges. The results suggest that repurchasing firms have a much higher insider ownership than non-announcing firms. This finding is not consistent with an interpretation where firms with dispersed ownership uses repurchases to mitigate agency costs of free cash. Agency theory (Jensen and Meckling, 1976) predicts that the interests of inside- and outside shareholders converge when the insider ownership increases. Thus, from a monitoring perspective, we would expect repurchasing firms to instead have a lower insider ownership. This finding support models where firms with high insider ownership is expected to repurchase shares. These models predict that managers with a stake in the firm (through stock ownership or options) use repurchases to increase their expected future payoffs (Isagawa, 2000). In addition, the manager can use repurchases to increase his (and remaining shareholders) ownership proportion in an undervalued firm or to deter takeovers (Bagwell, 1991).

When examining how the ownership composition changes in firms that repurchase shares, we find that the concentration increases as would be expected. This increase in concentration, seem to be mainly driven by an increased ownership of the largest owner. In addition, the fraction owned by institutions and personal investors decreases. This may both be because these investors trade more actively than the other owner types such that they have a higher probability of selling shares back to the firm. Alternatively they may have a preference for dividends, making them reduce their ownership in firms that substitute dividends for repurchases.

The paper also examines whether ownership variables can be used to say something about firms propensity to initiate a repurchase program. This is done by estimating a binary model for the probability of observing a firm announcing a program during each year, given the ownership composition at the beginning of the year. The results reflect to a large degree the findings in the descriptive analysis. Moreover, the findings would be in line with models where insiders have incentives to support the initiation of a repurchase program either to maximize the future value of their wealth (Isagawa, 2000), expropriate outside shareholders or to entrench themselves.

On the other hand the finding that the existence of a controlling shareholder decreases the probability of observing the introduction of a repurchase program. There are several interpretations for this finding. One is that a controlling shareholder may oppose a repurchase program. Alternatively, additional mechanisms for distributing excess cash is not needed when a large shareholder is in place with strong incentives to monitor the management. Interestingly, this finding is the opposite of what is the prediction in the model by Brennan and Thakor (1990). In their model, large shareholders prefer repurchases to dividends, while small shareholders has a preference for dividends. With respect to the identity of the largest owner in general, we find no evidence that the type of this owner is important for the decision to initiate a repurchase program. Finally, the results also strongly suggest that firms that paid dividends in the previous year are less likely to initiate a repurchase program. This is likely related to dividend smoothing, and that firms are reluctant to cutting dividends as suggested in studies by Lintner (1956) and Brav et al. (2003).

5.A The probability of observing an announcement

At a general level, the model for the probability of announcement (Ann) can be written as,

$$Prob(\text{Ann}) = F(\beta'\mathbf{x}) \tag{.2}$$

where $\beta'x$ is the index function, with x as a matrix of explanatory variables for each firm, β is a vector of coefficients and $F(\cdot)$ is the cumulative distribution function. The model is estimated as a binary regression model by assuming that a variable Ann$\in \{1, 0\}$, which is the event of a firm announcing a repurchase plan or not, is related to a set of explanatory variables $\mathbf{x}$. A linear combination of these variables constitute an index A^* which is related to Ann in the following way,

$$A^* = \beta'\mathbf{x} + \epsilon_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_k x_{ik} + \epsilon_i \tag{.3}$$

$$\text{and} \quad \text{Ann} = 1 \text{ if } A^* > 0 \tag{.4}$$

$$\text{Ann} = 0 \text{ if } A^* \leq 0 \tag{.5}$$

where $\beta'\mathbf{x}$ is the index function, and the error term ϵ_i has a logistic or normal distribution with mean 0 and variance 1. Finally, we can write the probability that Ann$= 1$, the probability of observing the announcement of a repurchase plan during the next M months, as,

$$Prob(\text{Ann}) = Prob(A^* > 0) = Prob(\beta'\mathbf{x}) > 0 = Prob(\epsilon_i > -\beta'\mathbf{x}) \tag{.6}$$

Since both the normal and logistic distributions are symmetric, this can be expressed as,

$$Prob(\text{Ann}) = Prob(A^* > 0) = Prob(\epsilon < \beta'\mathbf{x}) = F(\beta'\mathbf{x}) \tag{.7}$$

where $F(\cdot)$ defines the cumulative distribution function for ϵ. If $F(\cdot)$ is assumed to be a logistic distribution, the model is referred to as a logistic model, and if assumed to be the normal distribution, the model is referred to as a probit model.

5.B Additional estimation results

TABLE 5.B1

The probability of announcement (number of owners) - 12 month interval

The table shows the results from the estimation of a logit model, $Prob(\mathsf{Ann}) = \mathsf{F}(\beta'x)$, with the table showing the β estimates for the independent variables for four different model specifications each year. The models are estimated at the beginning of each year, with the dependent variable equal to 1 if the firm announces a repurchase plan during the year, and equal to zero if it do not. The table shows the estimation results when we estimate the model looking 12 months forward from January each year. The models are estimated in January each year. The independent variables are the total fraction owned by the five largest owners (concentration), the fraction owned by the insiders of the firm (insider fraction), the natural log of the market capitalization, a dummy for whether the firm paid dividend the previous year, the total number of owners ("number of owners") and the number of owners by various owner-types, a dummy for whether the insiders owns more than 33% of the firm (High insider ownership) and a dummy for whether the largest owner has a super-majority (Largest owner >67%).[width=0.5]

Independent variable	Model 1999 (1)	Model 1999 (2)	Model 1999 (3)	Model 2000 (1)	Model 2000 (2)	Model 2000 (3)	Model 2001 (1)	Model 2001 (2)	Model 2001 (3)
Intercept	-4.65**	-0.84	-1.66	-8.16**	-7.77**	-7.43*	-6.35***	-4.10	-3.54
Concentration	0.96	·	0.90	-0.47	·	-1.21	0.19	·	0.63
Insider fraction	0.98*	·	0.95*	1.44***	·	1.31**	1.85***	·	1.67***
MCAP (log)	0.16	-0.04	-0.02	0.39***	0.38**	0.39**	0.36***	0.25	0.16
Dividend	-1.10***	-0.69***	-0.94***	-1.65***	-1.59***	-1.52***	-0.84***	-0.56	-0.66**
Number of owners	0.14	·	·	0.18	·	·	-0.08	·	·
State owners	·	-0.18	-0.09	·	-0.30	-0.21	·	-0.23	-0.10
Foreign owners	·	0.39**	0.32*	·	0.45**	0.48**	·	0.32*	0.20
Financial owners	·	-0.07	-0.04	·	-0.20	-0.30	·	0.09	0.24
Nonfinancial owners	·	0.60	0.61**	·	0.13	0.13	·	0.15	0.16
Individual owners	·	-0.34	-0.33	·	-0.05	-0.09	·	-0.36	-0.29
N(Announcing)	80	80	80	84	84	84	96	96	96
N(Non announcing)	125	125	125	97	97	97	84	84	84
Pseudo R square	0.07	0.09	0.10	0.19	0.19	0.21	0.13	0.11	0.14
AIC	270	272	270	221	228	224	236	247	242
Likelihood ratio (p value)	0.01	0.01	0.01	<.01	<.01	<.01	<.01	<.01	<.01
Hosmer/Lemeshow	0.47	0.99	0.35	0.78	0.76	0.53	0.02	0.34	0.03
% concordant	64.5	67.1	68.2	75.20	75.1	76.5	69.8	68.1	69.2

Table 5.B2

The probability of announcement (number of owners) - 24 month interval

The table shows the results from the estimation of a logit model, $Prob(\mathsf{Ann}) = \mathsf{F}(\beta'\mathsf{x})$, with the table showing the β estimates for the independent variables for four different model specifications starting in 1999 and 2000. The models are estimated at the beginning of each year, with the dependent variable equal to 1 if the firm announces a repurchase plan during the year, and equal to zero if it do not. The table shows the estimation results when we estimate the model looking 24 months forward from January each year. The models are estimated in January each year. The independent variables are the total fraction owned by the five largest owners (concentration), the fraction owned by the insiders of the firm (insider fraction), the natural log of the market capitalization, a dummy for whether the firm paid dividend the previous year, the total number of owners ("number of owners") and the number of owners by various owner-types, a dummy for whether the insiders owns more than 33% of the firm (High insider ownership) and a dummy for whether the largest owner has a super-majority (Largest owner >67%).

	Model 1999			**Model 2000**		
Independent variable	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Intercept	-5.05**	-1.95	-1.26	-6.47***	-5.54	-5.27
Concentration	0.54	·	-0.18	-0.48	·	-0.90
Insider fraction	1.48***	·	1.50**	1.69***	·	1.46**
MCAP (log)	0.17	0.08	0.00	0.35***	0.28*	0.30*
Dividend	-1.21***	-0.82**	-0.95***	-1.62***	-1.51***	-1.48***
Number of owners	0.31**	·	·	0.14	·	·
State owners	·	-0.14	-0.14	·	-0.42	-0.32
Foreign owners	·	0.54***	0.55***	·	0.37*	0.38*
Financial owners	·	-0.34	-0.25	·	0.03	-0.06
Nonfinancial owners	·	0.58	0.70	·	0.19	0.23
Individual owners	·	-0.35*	-0.36*	·	-0.10	-0.14
N(Announcing)	117	117	117	118	118	118
N(Non-announcing)	94	94	94	74	74	74
Pseudo R-square	0.11	0.13	0.15	0.17	0.17	0.19
AIC	278	280	272	232	239	235
Likelihood ratio (p-value)	<.001	<.01	<.01	<.01	<.01	<.01
Hosmer/Lemeshow	0.12	0.74	0.85	0.25	0.45	0.39
% concordant	68.3	70.1	73.4	74.4	74.7	75.9

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