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Market Impact Costs of Institutional Equity Trades

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Abstract

This paper is the first to analyze market impact and execution costs of equity trading by a pension fund. We find that, on average, these costs are nonnegligible. Average market impact costs equal 20 basis points for buys and 30 basis points for sells; average execution costs equal 27 basis points and 38 basis points, respectively. Furthermore, we show that volatility and momentum have considerable influence on market impact costs. Other important determinants of these costs are trade type (agency, single, or principal), trading venue, and industry sector. Additionally, we find that the timing of trades plays a substantial role in explaining trading costs. The moment of the day, as well as the day of the week and the period of the month significantly affect the costs of trading. Moreover, we also establish a cost-risk trade-off: the longer it takes to execute a trade, the lower the expected market impact costs but the higher the volatility of these costs.

Keywords: market impact costs, trading costs, price effects, institutional equity trading, pension funds

JEL-classification: E32, G14, G23, G28

Introduction

Institutional investors today account for a large part of international stock holdings and equity trading. For example, in 2001 they owned more than 50% of total US equities[1]. Furthermore, Schwartz and Shapiro (1992) estimated that institutional investors and their member firms accounted for about 70% of total trading volume on the New York Stock Exchange (NYSE) in 1989. Since institutional investors occupy such a predominant position in the equity trading process, the literature has paid much attention to the impact of institutional trading on stock prices. For a survey, see Keim and Madhavan (1998). The upshot of their survey is that institutional trades cause nonnegligible price pressure.

The existence of substantial price effects has important consequences for institutional investors, since they may cause additional trading costs ('market impact costs'). Trading costs occur when price effects cause execution prices to be less favorable than the benchmark price. Usually the decision to buy or sell a particular asset is based on expectations about the future performance of this asset. Buying a stock with high expected returns might result in worse performance than expected if trading costs for this particular stock are high. In such a case a stock with lower expected returns may perform better if its trading costs are lower. Therefore, knowing the trading costs on each stock up front might change the optimal portfolio holdings of an institutional investor. This makes trading costs an important factor to consider when trading decisions have to be made, since ignoring them reduces the performance of the portfolio substantially.

Trading costs are also of interest from the perspective of regulators such as the U.S. Securities and Exchange Commission. Financial markets must have proper rules to ensure efficient execution of market transactions. Regulators have coined the concept of 'best execution' as a way to provide an assessment of the reasonableness of the prices of market transactions; see Wagner and Edwards (1993) and Macey and O'Hara (1997). Although the distinction between intentional failure and poor performance is hard to make, poor performance can be assessed by means of statistical methods.

Central banks are also interested in the costs of institutional equity trading, since one of their concerns is the existence of a well-functioning financial system in which large institutional investors can find sufficient liquidity to control the risk profile of their portfolios. Institutional trades are not only motivated by investment strategies or sound risk management, but may also stem from regulatory rules. Therefore, it is important for a central bank − in charge of financial stability and possibly also pension fund supervision − to assess that the eventual procyclical effects of regulation are very limited.

This paper analyzes the market impact of the equity trades of the largest Dutch pension fund and is, as far as we know, the first paper to investigate market impact and execution costs incurred by a pension fund. The 'Algemeen Burgerlijk Pensioenfonds' (ABP) has 2.4

[1]Source: NYSE Fact Book 2001. See www.nyse.com.

million clients and an invested capital of about 156 billion Euro.[2] Its assets constitute about one third of total Dutch pension fund assets. Furthermore, ABP is not merely the largest pension fund of the Netherlands, it is also among the five largest pension funds in the world. A unique data set, containing detailed information on all worldwide equity trades of ten different funds at ABP during the first quarter of 2002, is used to identify the trade and stock-specific characteristics that determine the expected price impact of trading. Moreover, in order to gain more insight into the cost-risk relation, this paper extends the existing literature by assessing the determinants of the volatility of the price effects as well. Since the data provide a wide set of trade and stock-specific characteristics including investment style and trade timing, they allow for a comprehensive analysis of the determinants of the price impact of ABP trades. In particular, the detailed information on the timing of each trade is used to address an issue that has not yet been considered in the literature, namely the relation between market impact costs and trade timing.

We find that, on average, market impact and execution costs of the pension fund's trades are nonnegligible. Average market impact costs equal 20 basis points for buys and 30 basis points for sells; average execution costs equal 27 basis points and 38 basis points, respectively. Furthermore, we show that volatility and momentum have considerable influence on market impact costs. Other important determinants of these costs are trade type (agency, single, or principal), trading venue, and industry sector. Additionally, we find that the timing of trades plays a substantial role in explaining trading costs. The moment of the day, as well as the day of the week and the period of the month significantly affect the costs of trading. Moreover, we also establish a cost-risk trade-off: the longer it takes to execute a trade, the lower the expected market impact costs but the higher the volatility of these costs.

This paper is organized as follows. Section I provides a brief review of the literature on the price effects of institutional trading. In Section II the trading process at ABP is explained. Section III describes the data set containing information on the equity trades of the pension fund. Some sample statistics on the temporary and persistent price effects of the ABP trades are presented in Section IV. Section V assesses the determinants of both the expected price impact and the volatility of the price effects and derives a mean-variance cost relation. Finally, Section VI summarizes and concludes.

I Price effects of institutional equity trades: a literature review

Quite a number of articles have been devoted to market the impact and execution costs of institutional equity trades.

Chan and Lakonishok (1993) examine the price impact of institutional trades on the basis

[2]This is the invested capital of ABP d.d. March 31, 2004.

of transaction data of 37 large institutional money management firms during a two and a half year period (1986−1988). Correcting for market-wide stock price movements, the authors find that the average price change weighted by the dollar size of the trade (called the principal-weighted average) from the open to the close on the trade day equals 34 basis points (bp) for buys and −4 bp for sells.

Using the same data as Chan and Lakonishok (1993), a similar analysis is presented in Chan and Lakonishok (1995). In the latter paper the authors do not measure the market impact of individual trades but of trade packages. The authors define a trade package as a series of successive sells or purchases of the same stock, which ends when the money manager stays out of the market for at least five days. After adjustment for market-wide price movements, the principal-weighted average price change from the open on the first trading day of the package to the close on the last day amounts almost 100 bp for buy packages and −35 bp for sell packages.

Keim and Madhavan (1997) investigate the total execution costs (defined as the sum of commission and market impact costs) of institutional trades in relation to investment styles, using data on the equity transactions of 21 institutions during the 1991−1993 period. They distinguish fundamental value managers (who focus on assessment of fundamental value, with a long-term perspective), technical managers (who focus on short-term price movements), and index managers (who focus on mimicking the returns of a certain index). The authors show that total execution costs are significant and that value traders have lower costs than traders using strategies that require more immediacy. Keim and Madhavan (1997) also explain execution costs from trade difficulty. Trade difficulty is measured by variables such as relative trade size, which has a positive impact, and market capitalization, which has a negative effect on the execution costs. Additionally, the authors relate the execution costs to the trading venue by showing that for institutional trades in Nasdaq stocks, costs tend to be higher than for trades in comparable exchange-listed stocks. The authors find that the magnitude of the average total execution costs varies between 49 bp and 123 bp for buys and between 55 bp and 143 bp for sells. On average, commission contributes about 40% to total execution costs.

Chan and Lakonishok (1997) also analyze the effect of the trading venue on execution costs. The authors compare the total execution costs on the NYSE and the Nasdaq for institutional investors, using transaction data from 33 large institutional money management firms during a two and a half year period (1989−1991). Median total execution costs on the Nasdaq are 99 bp versus 54 bp on the NYSE. Moreover, the authors show that − after controlling for firm size, relative trade size, and the money management firm's identity − the execution costs are lower on the Nasdaq for trades in smaller firms and lower on the NYSE for trades in larger firms.

Wagner and Edwards (1993) analyze a sample of institutional trades during the second quarter of 1992 and investigate price effects. They establish average market impact costs of 18 bp.

Domowitz, Glen, and Madhavan (2001) investigate execution costs across 42 countries in the period September 1996 until December 1998. The authors document wide variation in execution costs, even after correcting for factors affecting costs such as market capitalization and volatility. Average execution costs vary from 30 bp in France up to 138 bp in Korea.

Chiyachtantana et al. (2004) investigate the price effects of institutional trading in international stocks from 37 countries in the period from 1997-1998 and 2001. They find that price impact varies across international stocks based on firm-specific determinants, country-specific factors, and order submission strategies. On an overall basis, average price effects vary between 31 and 45 bp.

Several studies analyze the market impact of trades using more general transactions data on block trades that are typically initiated by institutional investors, and often on the so-called upstairs market. On the upstairs market, large institutional block trades are processed through a search-brokerage mechanism. That is, an intermediary or broker first identifies counter parties to trade, after which the order is sent to the downstairs market for final execution. By contrast, smaller trade are routed directly to the downstairs market, where market makers, floor traders, and limit orders provide liquidity on demand.

By analyzing data on upstairs block trades traded at the NYSE, the NASDAQ, and the AMEX from July 1985 until December 1992, Keim and Madhavan (1996) show that the average price effect of NYSE-traded stocks belonging to the bottom half of market capitalization equals 145−451 bp for buys and 434−1,024 bp for sells.

Madhavan and Cheng (1997) examine data on block transactions in Dow Jones stocks executed on both the upstairs and downstairs NYSE market. They show that the upstairs market provides significantly better execution of transactions than the NYSE floor market, although economically speaking, the differences are small. The authors establish average market impact costs of 18 bp (upstairs) and 19 bp (downstairs) for buys. For sells they find average price effects between 15 bp (upstairs) and 16 bp (downstairs).

Using transaction data on upstairs and downstairs trades on the Toronto Stock Exchange in June 1997, Smith, Turnbull, and White (2001) show that the adverse selection costs of trades on the upstairs market are significantly lower than on the downstairs market. Furthermore, they show that the price impact of trades depends on the trade type (agency or principal). The authors establish an average implementation price effect of 22 bp (downstairs), 25 bp (upstairs), 27 bp (upstairs, agency), and 22 bp (upstairs, principal).

II Trading at ABP

This paper analyzes equity trading at ABP during the first quarter of 2002. In this period there were ten internal funds in ABP's equity group, apart from the externally managed funds.

Quantitative approach

Three funds follow a systematic quantitative approach for Japan, the US and Europe. The approach is to make bets on individual stocks while keeping the overall portfolio sector neutral. The horizon of the fund varies from one to six months. Trading is usually done on the basis of information available up to the previous day. Variables in the model-based process are company specific characteristics such as book to price ratios and analysts' forecasts, but also short term and longer term technical indicators, capturing short term mean reversion and long term momentum. New signals are generated at the beginning of every month. For all three funds the portfolio managers feel an urgency to trade quickly on the new signals although a careful analysis of the forecasting signals of these models reveals a deterioration of its forecasting power after six months.

Fundamental approach

At the time of writing there were seven fundamental funds. Three groups of portfolio managers each run a European fund and a US fund. One group runs a similar Canadian fund. These funds have a fundamental macroeconomic approach to sector rotation. Here the approach is to make bets on sectors while being neutral on stocks. These funds typically held this view for a longer term horizon, from six months or more. The portfolio managers do not have the urge to trade immediately, though most of the trades are executed within one day. There are no views on individual companies, so the trades only comprise sector bets. Usually groups of companies are bought and sold tracking a certain sector very closely. Obviously the groups cross trade with each other before going to the market.

All funds have a mandate with a maximum tracking error of 2% per annum with respect to a certain benchmark and a certain outperformance target. All funds are essentially enhanced index funds. Each of them also have a long-only constraint. The benchmarks of these mandates are for the US the S&P500, for Europe, the MSCI Europe, for Japan, the MSCI Japan and for Canada the TSE300.[3] Most of the trades that take place are for rebalancing purposes to keep portfolios in line with the original allocation. There are also moderate shifts due to changing tilts towards individual stocks for the quantitative portfolio and sectors for the fundamental approach.

Before turning to the trading process at ABP, we make notice of three types of trades. A so-called agency trade is a trade between the pension fund and a counter party, where the broker acts solely as an intermediate party. Hence, an agency trade involves two clients of the brokerage firm, one of them being the pension fund. A principal trade is a transaction between the pension fund and the broker, in which case the broker buys or sells stocks from or to the pension fund at a predetermined price. Hence, a principal trade involves the brokerage firm and the pension fund. Single trades apply to difficult trades that are traded separately, not necessarily with packages of other stocks.

[3]This is currently the S&P/TSX Composite

For all the trades the trading process during the first quarter 2002 was as follows. A portfolio manager forms his or her portfolio. Subsequently, he or she approaches a trader at ABP. Together they discuss the proposed trade. In most cases the trader will leave out some parts of the trades (say 10%) for reasons of perceived cost reduction and execute these elsewhere in the market. Next, the trader approaches at most two of the large brokerage firms for the remaining trades and reveals some of the characteristics of the trade (volume, US or Europe, quantitative or fundamental, sector decomposition and a judgment on the complexity of the trade). The choice of brokerage firms is based on experience of the trader. Only the largest brokers can make competitive offers, though sometimes a smaller one has an edge in some market segments, for example Japan. Based on the characteristics of the trade the broker makes an offer for a principal trade. The offer of the broker is compared over brokers and with the trader's own systems and experience. If the offer is acceptable a principal trade is executed. Otherwise the trade is executed as an agency trade.

III Data and definitions

The data sample consists of 3,728 worldwide equity trades at ABP, executed during the first three months of the year 2002 and with a total transaction value of 5.7 billion Euro. Of these trades, 1,963 are buys and 1,765 are sells. The total market value of buys and sells is about the same: 2.9 billion Euro for buys and 2.8 billion Euro for sells. In the first quarter of 2002, ABP holds about 50 billion Euro (equivalent to 35% of total invested capital) in equity. The internally managed portfolios in our sample had a value of 20 billion Euro and, hence, constitute approximately 28% of the total invested capital.

Unfortunately, the database only provides the direction of the trade as seen from the perspective of the pension fund and does not tell whether a buy by the pension fund is also classified as a buy on the stock market. A buy by ABP is not necessarily a buy on the stock market, since the sign of a trade is determined by the direction of the order that removes volume from the order book. Moreover, since the data do not provide information on the prevailing bid and ask quotes either, we can not use the Lee and Ready (1991) rule to assess the trade sign. However, the primary goal of this paper is to assess the market impact of a trade when the pension fund sells (or buys) a large amount of stocks. Therefore, it is natural to condition on the direction of the trade as seen from the perspective of the pension fund. Clearly, the true sign of the trade could have additional explanatory power, but we are able to do our analysis without this information.

For each transaction the data provide the execution price and a benchmark price in Euro. The benchmark price is the price of the stock just before the trade was passed to the broker. Moreover, the data also tell when the trade was submitted to the broker and when it was executed. The data also provide the amount of commission that was paid, which is used to compute the fee rate. Additionally, the data include detailed information on several trade and stock-specific characteristics including the investment style of the fund and the timing of trades, which will be discussed below.[4]

The data set has been constructed on the basis of the post trade analysis, provided by ABP Investments. The remaining data were taken from Factset and Reuters.

Possible determinants of the price impact

With respect to trade-specific characteristics, the data set contains information on the country where the stock was traded, trading volume, and the type of trade (agency, single, or principal). Country dummies on a regional level have been constructed to distinguish between Europe, United States, Canada, and Japan. Two relative measures of trading volume are considered: relative to total shares outstanding and relative to daily trading volume. With respect to the type of trade, there are three possibilities: agency, single, or principal. The largest part of the data consists of agency trades (2,178 observations). The remaining trades are either principal (1,439 observations) or single (111 observations).

With respect to stock-specific characteristics we distinguish market capitalization, volatility, momentum, value and growth stocks, and sector dummies. Market capitalization is computed as the dollar value of all shares outstanding, using the amount of shares outstanding three months prior to the trade (to avoid the look-ahead bias). Volatility is computed over the last thirty trading days prior to the trade. The period of 30 days is chosen to ensure that recent price fluctuations are incorporated in the measure of volatility. Momentum is computed as the volume weighted average daily return on a stock over the last five trading days prior to the trade. Roughly speaking, momentum indicates whether there is a buying or a selling trend for a particular stock. A binary variable distinguishes between value and growth stocks on the basis of its membership of the MSCI Value and Growth Index.[5] Value stocks have a relatively low book-to-price ratio, while this ratio is relatively high for growth stocks. The sector dummies classify each stock into one of the following sectors: consumer discretionary, consumer staples, energy, financials, health, industry, information technology, materials, telecommunications, and utilities. These sectors correspond to the Global Industry Classification Standard, see Table I.

The data also contain information on the investment style of each of the funds under consideration. A dummy variable indicates whether a fund is quantitative or fundamental, where quantitative funds correspond to positive-feedback strategies focusing on short-term price movements and fundamental funds to negative-feedback strategies with a long-term horizon.

[4]Trades that were split up into several sub trades are considered as one single trade, if a trader at ABP decided to split up the trade. The data contain about 0.5% of such 'trade packages'. Orders split up by portfolio managers will be treated as individual trades, since it is not known whether the trader eventually split the trade in the same way the portfolio managers did.

[5]Some stocks do no belong to either of these two categories.

Finally, the data set provides information on the timing of trades. In particular, trade duration is provided and defined as the time elapsed between the moment that the trade was passed to the broker and the moment that it was truly executed. Trade duration can be interpreted as a proxy for the degree of immediacy of a trade, where immediacy refers to the urgency of a trade. Trades that are executed quickly are generally more urgent than trades that take longer to fulfill. Secondly, a dummy variable indicates whether a trade was passed to the broker before or at the opening of the market. Another dummy distinguishes trades executed on Fridays and trades executed on other days of the week. Finally, the data set contains a binary variable indicating whether a trade took place at the beginning of the month or later.

Sample properties of ABP trades

Table III reports sample statistics such as means, standard deviations, medians, and quantiles of several trade characteristics such as trade duration, various measures of absolute and relative trade size, and commission, for both buys and sells. Table II provides a description of the abbreviations of the variable names used in Table III. Average trade size for buys (sells) is more than 70,000 (84,000) shares and the average value of a trade equals almost 1.5 (1.6) million Euro. Expressed as a percentage of daily trading volume and shares outstanding, average trade size of buys equals 4.29% and 0.02%, respectively. For sells these percentages are 3.41% and 0.02%. Commission equals about 12 bp on average, for both buy and sell transactions. Average commissions documented by Wagner and Edwards (1993), Keim and Madhavan (1997), Domowitz, Glen, and Madhavan (2001), and Chiyachtantana et al. (2004) are somewhat higher (17−20 bp). Regarding the timing of trades, it takes, on average, almost 4 (4.5) hours for a buy (sell) to be executed. Slightly more than 25% of the trades is executed before or at the pre-open of the market. About 12% (16%) of the buy (sell) transactions is executed on Fridays. About 86% (80%) of the buys (sells) is executed at the beginning of the month.

Table IV provides information on the nature of the stocks that have been traded by the pension fund. Again we refer to Table II for a description of the abbreviations of the variable names used in Table IV. For both buys and sells, a majority of the trades consists of value stocks (47.1% for buys and 50.1% for sells). The main part of both buys and sells is traded by quantitative funds. The buy transactions took place mostly in Europe, while most sell transactions were executed in the United States. The three largest industry sectors for buys are consumer discretionary, financials, and information technology. For sells the three largest sectors are consumer discretionary, industrials, and information technology (see Table I). Furthermore, a majority of both buy and sell transactions consists of agency and single trades.[6]

[6] Agency and single trades have been aggregated, since there are too few single trades to treat them as a

IV Measuring the market impact of ABP trades

This section presents a further exploration of the data described in Section III in order to assess the impact of the ABP trades on prices. We start with a definition of market impact.

Market impact

To measure the market impact of trading, a benchmark price has to be chosen. We emphasize that there are several ways to do this; see Collins and Fabozzi (1991) and Chan and Lakonishok (1995) for a discussion. With a same-day benchmark, the benchmark is the volume-weighted average price calculated over all transactions in the stock on the trade day. With a pre-execution benchmark the opening price on the same day or the closing price on the previous day is used. Finally, with a post-execution benchmark the closing price of the trading day or the opening price on the next day is taken as reference price, ensuring that the temporary price impact has disappeared form the benchmark. This paper opts for the pre-execution benchmark, which is in line with e.g. Wagner and Edwards (1993). More precisely, we take as the benchmark the price at the moment that the order was passed to the broker. For each trade our data set provides this price.

Moreover, we proceed as in Chan and Lakonishok (1995, 1997) and correct the price effects for market-wide price movements during the trade. We use the MSCI World industry group indices as a proxy for these market movements. This means that we approximate the market movement during a trade of, for instance, ABN-AMRO stocks by the movement of the MSCI World Banks index.

Thus, for a buy transaction in stock i at day t we measure market impact costs (MIC) as follows:

$$MIC_{it}^{B} = \log(P_{it}^{exe}/P_{it}^{pt}) - \log(M_{it}^{exe}/M_{it}^{pt}), \quad (1)$$

where P_{it}^{exe} and P_{it}^{pt} denote the execution and pre-trade price of stock i at day t, respectively. M_{it}^{exe} and M_{it}^{pt} denote the value of the MSCI industry group index corresponding to stock i at the time of the execution of the trade and at the pre-trade time, respectively. In a similar way, the market impact of sells is defined as

$$MIC_{it}^{S} = \log(P_{it}^{pt}/P_{it}^{exe}) - \log(M_{it}^{pt}/M_{it}^{exe}). \quad (2)$$

For both buys and sells, positive market impact implies that a trade has been executed against a worse price than at the moment of trade initiation.

distinct class. It is natural to aggregate agency and single trades, since these are the trades that the broker acts as an agency for.

Sample properties of price effects

The first and second column of Table V report sample means, standard deviations, medians and quantiles of market impact for buys and sells with and without correction for market-wide price movements.[7] The sample statistics in Table V are calculated on a principal-weighted basis (cf. Chan and Lakonishok (1993)). The principal-weighted statistics are obtained by weighting each observation by the Euro value of the trade, so that smaller trades contribute less to, for instance, the average market impact than larger ones.

Table V shows that the average market impact costs of buys (corrected for market-wide price movements) equal 19.6 bp. Average market impact of sells is even larger at 29.7 bp. Our finding that sells have larger price effects than buys is not in line with the results of Chan and Lakonishok (1993) and Keim and Madhavan (1997) and earlier studies on individual transactions by Kraus and Stoll (1972), Holthausen, Leftwich, and Mayers (1987, 1990)). These studies establish higher price effects for buys than for sells. Chan and Lakonishok (1993) and Saar (2001) explain this by arguing that institutional selling is more often based on liquidity motives than is buying and that therefore, sells would contain less information than buys. However, Chiyachantana et al. (2004) show that price effects of sells (buys) tend to be larger than those of buys (sells) in bearish (bullish) markets. Since the market was in a bearish phase in the first quarter of 2002, this could explain our findings.

To give a more complete picture of total trading costs, Table V also report execution costs, which are defined as the sum of market impact costs and commission. Execution costs equal 27.4 bp for buys and 37.5 bp for sells, on average. Generally speaking, trading costs consist of explicit and implicit costs. The explicit part consists of fixed costs, such as commissions, taxes, and fees. Implicit costs are more variable and consists of the market impact costs, the bid-ask spread, delay costs and opportunity costs. Opportunity costs basically represent the cost of not transacting and measure the theoretical performance of the buys and sells you did not execute. If the risk of non-execution is significant, these costs may be considerable. There are two important reasons for unexecuted orders. Either the trader cannot locate the

[7] Since we only have closing prices of the MSCI industry group indices, we approximate the market-wide price movements in expressions (1) as

$$\frac{\text{dur}_{it}}{8} \log\left(M_{it}^{pdc}/M_{it}^{close}\right),$$

where M_{it}^{pdc} and M_{it}^{close} denote the previous day closing price and the closing price of the MSCI industry group index of stock i at day t and dur_{it} represents the number of hours it took to complete the trade in stock i at day t. Hence, we assume that there are eight hours in a trading day. Under this assumption we can say that, given the fact that an index rose by 100 bp on a certain day, the expected price change of that index during a one-hour period is 12.5 bp. If, for example, it took four hours to complete a trade, we will correct the price effect for market movements by subtracting fifty percent of the price change in the index during the day of the trade. A further assumption we will have to make is that overnight price movements, which are also included in the index return over the one-day period, are negligible. For the market-wide price movements of sells in expression (2) we use the same approximation.

shares to complete the order, or the price has moved out of the range of prices the portfolio manager is willing to pay. Delay costs reflect the risk of adverse price movements that can occur when trading is postponed. These costs are the counterpoint to market impact costs. As time increases, impact should decrease. However, as time increases, so does price variability. Waiting too long with trading can therefore increase delay costs considerably. Hence, total trading costs would not only consist of market impact costs, but also of commission, opportunity costs, and delay costs.[8] However, in our data sample opportunity costs are negligible, since all trades on the 'trading list' where truly executed. This is in line with Keim and Madhavan (1997), who found high rates of completion in institutional trades (about 95%). Moreover, notice that the correction for market-wide price movements can be interpreted as a proxy for the so-called delay costs. Since we subtract delay costs, we do not take these costs into account. At this point we follow Bodurtha and Quinn (1990), who argue that losses or gains that could arise from market movements can be neutralized through effective hedging practices. Concluding, this paper ignores opportunity costs, but corrects for delay costs and calculates execution costs as the sum of market impact costs (corrected for market-wide price movements) and commission.

The literature distinguishes temporary and persistent price effects. Total market impact is computed as the sum of these two effects. As explained by Kraus and Stoll (1972), temporary price movements are caused by short-term liquidity effects (i.e. price concessions to stimulate buyers or sellers to provide liquidity), inventory effects (temporary price effects due to inventory imbalances), or imperfect substitution (price concessions to induce buyers and sellers to absorb the additional shares). The permanent impact of a trade on prices reflects the change in the perception of the market due to the information contained in a trade. Roughly speaking, a buy transaction tells the market that the stock may be underpriced, and a sell reveals that a stock may be overvalued. Market participants observe the information contained in trades and adjust their perceptions accordingly, leading to price revisions. Technically speaking, temporary price impact is defined as the log return from a post-trade moment to the trade (i.e. $\log(P_{trade}/P_{post})$), whereas the persistent price impact is measured as the log return from a pre-trade moment to a post-trade moment ($\log(P_{post}/P_{pre})$). In this way, the temporary price impact measures the price movement that is needed to provide enough liquidity to absorb the trade and the permanent price impact represents the price change due to the information contained in the trade. Temporary and persistent price effects are corrected for market-wide price movements, cf. equations (1) and (2).

Temporary and persistent price effects (corrected for market-wide price movements) are obtained by taking the moment the trade was passed to the broker as the pre-trade moment and the closure of the market at the day after the trade as the post-trade moment. Table VI shows that, on a principal-weighted average basis, the temporary and persistent price effect of

[8] We note that our definition of market impact costs already contains part of the bid-ask spread.

buys equal 7.2 bp and 12.4 bp, respectively. For sells, these price effects equal −14.5 bp and −16.5 bp.[9] Figures 1 and 2 show the average temporary, persistent, and total price effects for buys and sells, respectively.

To provide an indication of the standard errors of our estimates of average total, temporary, and persistent price effects Tables V and Table VI report the standard deviation of the average price effects. However, note that these are obtained under the assumption that observations are mutually uncorrelated. Therefore, true standard errors may be different.

V Determinants of market impact

The impact of trades on prices will generally depend on various trade and stock-specific characteristics, including investment style and the timing of trades. This section will assess the determinants of the expected market impact costs. Moreover, to get an idea of the market impact *risk* associated with the trades under consideration, we will also analyze the *volatility* of market impact costs. The volatility of market impact costs is directly related to the probability that the price effect is large. Furthermore, the joint analysis of expected market impact costs and the volatility of these costs provides a mean-variance relation that provides insight into the trade-off between costs and risk.

Although it is common practice in the existing literature to analyze buys and sells separately, we do a joint analysis. Statistical testing for differences between buys and sells is easier in a joint framework, motivating our approach.

We assume that the market impact costs of a trade (corrected for market-wide price movements) in stock i at day t have the form

$$MIC_{it} = (\alpha_s' + \alpha_b' d_{it}) X_{it} + \nu_{it}, \tag{3}$$

where the ν_{it}'s are jointly and serially uncorrelated disturbances, orthogonal to the regressors in equation (3) and satisfying

$$\mathbb{E}(\nu_{it}) = 0, \mathbb{V}\text{ar}\,(\nu_{it}) = \exp((\gamma_s' + \gamma_b' d_{it}) Z_{it}). \tag{4}$$

Here X contains the regressors that affect the conditional mean of the market impact costs and Z the regressors that influence the conditional volatility of these costs. Moreover, $\alpha_s, \alpha_b, \gamma_s, \gamma_b$ are unknown vectors of coefficients to be estimated. Finally, d_{it} is a binary variable that is 0 when stock i at day t is a sell transaction and 1 when this trade is a buy.

[9] We compute the sample statistics of the temporary and persistent price effects for a slightly smaller sample than we used to obtain the sample statistics of the market impact. This is because, for some trades, we did not have enough data on the prices around the time of the trade. Eventually, we have computed the average temporary and persistent price effects on the basis of 1,933 buy trades and 1,738 sell trades. As a consequence, the sum of both temporary and persistent price effects (i.e. the total price effect) is not exactly equal to the previously computed market impact.

Note that the regression model in equation (3) is formulated in such a way that $\alpha_s' X_{it}$ represents the conditional expected market impact costs of a sell transaction, while $(\alpha_s' + \alpha_b')X_{it}$ denotes the conditional expected market impact of a buy trade. Similarly, $\exp(\gamma_s' Z_{it})^{1/2}$ and $\exp((\gamma_s' + \gamma_b')Z_{it})^{1/2}$ denote the conditional volatility of sell and buy transactions, respectively. The pairs $(MIC_{it}, \exp(\gamma_s' Z_{it})^{1/2})$ and $(MIC_{it}, \exp((\gamma_s' + \gamma_b')Z_{it})^{1/2})$ determine the mean-variance relation for sells and buys, respectively. The null hypothesis that the determinants of the conditional expected market impact costs are the same for buys and sells is formulated as $\alpha_b = 0$. For the conditional volatility the same hypothesis is given by $\gamma_b = 0$.

Conditional expectation of market impact costs

The regression model given in equation (3) is estimated in two steps.[10] We start with the estimation of the conditional expected market impact costs. Subsequently, we turn to the estimation of the conditional variance.

We estimate conditional mean regression in equation (3) by means of OLS, using White (1980)'s heteroskedasticity consistent covariance matrix. The regressors X used in the initial estimation of equation (3) are given in Table VII. A specification search from general to specific based on the Akaike information criterion leads to the final specification given in the left-hand-side of Table VIII.[11] This part of the table also displays the estimation results, including estimated coefficients and standard errors. We notice that the left-hand-side of Table VIII reports the coefficients $\alpha_s + \alpha_b$ of the conditional mean equation (3).

In the following, the discussion of the estimation results is confined to significant coefficients only. We start with the estimation results for buy transactions. Intuitively, when the price of a stock has recently moved upwards, it is more likely that buy order will have increased impact while a sell order will have a reduced impact on prices. We would therefore expect the impact of momentum on the market impact of buy transactions to be positive, since high momentum indicates a buying trend. The significantly positive coefficient of momentum confirms this intuition. The coefficient corresponding to relative trade size is significantly positive; i.e. market impact is higher the larger the relative trade size. This can be explained as follows. Since higher trading volume reflects a higher degree of trade difficulty (see Keim and Madhavan (1997)), the liquidity costs of larger buy trades are also higher. As a consequence, larger buy trades have higher temporary price impact. Moreover, according to Easley and O'Hara (1987) large buy trades convey more information. As a consequence, the permanent price impact of a trade depends positively on the size of the trade. Empirical evidence for the positive relation between trading volume and price effects has been established by Spierdijk,

[10] Given our large sample size, the loss of efficiency relative to joint estimation will be no problem. Moreover, the two-step approach has the advantage that no assumptions have to me made regarding the distribution of the regression disturbances, apart from the usual regularity conditions.

[11] We mention that all regression specification are very robust, in the sense that other specifications lead to estimated coefficients of about the same size and magnitude.

Nijman, and Van Soest (2003) and Keim and Madhavan (1997).

The dummy variable for agency/single and principal trades has a significantly positive coefficient and a value of 38.4. This means that, ceteris paribus, the market impact is 38.4 bp higher for agency and single trades than for principal trades. This outcome is consistent with the empirical results established by Smith, Turnbull, and White (2001). They explain the higher market impact of agency trades by noticing that brokerage firms are interested in maintaining their reputation capital. Therefore, the visibility of their price impacts and the importance of the broker-client relationships prevents them from cream-skimming their clients. This would imply that the price impact of agency and single trades is typically higher than that of principal trades. We notice that part of the difference in market impact between agency/single and principal trades disappears when commission is taken into account. When we run the same regression with market impact *including* commission as dependent variable, the dummy variable for agency/single and principal trades remains significant, but its coefficient drops to 18.1. This is due to the fact that commission also depends on the type of trade. For agency trades fee rates equal 2−8 bp, for single trades 10 bp, while principal trades carry fee rates above 10 bp.

It should also be noted that the regression analysis in this section is on an *ex post* basis; that is, based on observations after the trade has been executed. This is an important distinction to make, since, on an *ex ante* basis, the phenomenon of selectivity bias will be encountered (which would require a different estimation technique). To see this, note that it is up to the pension fund itself to decide whether it wants to trade on an agency, single, or principal basis. This is where the selectivity bias comes in, caused by the fact that the pension fund's choice for either a principal, agency, or single trade will affect the expected market impact of the trade, which, in turn, is one of the determinants of the initial choice for a principal, agency, or single trade. Since the focus of this paper is on the price effects of trades that have actually taken place (seen from the perspective of the regulator), we are interested in the market impact on an ex post basis. As a consequence, the coefficient of the agency/single dummy does *not* indicate the difference in market impact relative to the trade having been a principal trade. The coefficient only reflects the difference in market impact between the realized agency/single and principal trades. In a model that takes into account selectivity bias (see, for instance, Lee, Maddala, and Trost (1979) and Chang and Madhavan (1997)), the pension fund would in fact be able to estimate the effect on the market impact of choosing an agency/single trade instead of a principal trade and vice versa.

Country dummies capture country-related effects on market impact that are unrelated to the remaining regressors, such as differences in market liquidity, market efficiency, and institutional settings. Since the coefficient of the country dummy for the Japan is significantly positive, buy trades in Japan have higher market impact than similar trades in Canada, the United States, and Europe. Trades in the United States have significantly less impact on prices than comparable trades in the other countries. The important role of the trading venue in explaining market impact costs coincides with the findings of Domowitz, Glen, and Madhavan (2001) and Chiyachtantana et al. (2004), who document wide variation in equity trading costs across countries. Similarly, sector dummies reflect sector-specific effects on the market impact unrelated to the other regressors. Trades in stocks belonging to the energy sector have significantly higher market impact than buy trades in comparable stocks in other sectors. Trades in the financial services sector have significantly lower market impact than similar trades in the remaining sectors.

Regarding the variables related to the timing of trades, the results show that the period of the month affects market impact costs. Many institutional investors rebalance their portfolios at the beginning of the month. Since it is likely that these investors wish to trade the same stocks, it might be more difficult to trade at the beginning of the month. Indeed, the results show that trades cause significantly higher price impact at the beginning of each month, rather than half-way or at the end of it. Moreover, market impact costs are also influenced by the day of the week at which a stock is traded. We find that market impact costs are significantly lower on Fridays. This is consistent with Foster and Vishwanathan (1990), who have a theory that explains why trading costs are higher at the beginning of the week rather than at the end of it.

The right-hand-side of Table VIII reports the coefficients α_s of the conditional mean equation (3) corresponding to sell transactions. The significantly negative coefficient of momentum confirms the intuition that the market impact of a sell is higher when there is a selling trend. Volatility has a significantly positive coefficient. Hence, when prices show more fluctuations anyhow, market impact is also higher. This can be explained by the fact that stocks with higher volatility suffer from higher (permanent) price effects, since trades are more informative when volatility is high (see Chan and Lakonishok (1997) and Smith, Turnbull, and White (2001)). Market capitalization has a significantly negative coefficient, which implies that selling large cap stocks causes less market impact than selling small cap stocks. This can be explained from the higher liquidity of large cap stocks, which makes them easier to trade. See Hasbrouck (1991a, 1991b), Keim and Madhavan (1997) and Spierdijk, Nijman, and Van Soest (2002).

The coefficient of the dummy indicating whether the sell comes from a quantitative or a fundamental fund is significantly positive, hence trades by quantitative funds cause more market impact. This can be explained by noticing that market impact costs are higher as the demand for immediacy in the investment style increases. Moreover, investors with a short-term perspective are willing to pay the price for immediacy. See Chan and Lakonishok (1993, 1995) and Keim and Madhavan (1997).

The country dummies for Europe and Japan are significantly negative. This means that − relative to sells in Canada and the United States − sells Europe and Japan lead to lower market impact. With respect to the sector dummies, Table VIII shows that trades in stocks belonging to the consumer discretionary and energy sector have significantly lower market impact. The market impact of trades in stocks in the consumer staples sectors is significantly higher than comparable trades in the other sectors.

With respect to the timing of trades, we see that trades submitted before or at the opening of the market have higher market impact costs than trades submitted during regular opening hours. This is likely to be due to the presence of informed traders who benefit from their private ('overnight') information, making these trades more expensive to execute; cf. Foster and Vishwanathan (1990, 1993). As for buy trades, trades at the beginning of the month cause higher price effects than trades half-way or at the end of the month. Moreover, sell trades on Fridays have higher expected market impact costs. This contrasts to what we found for buys and is not in line with Foster and Vishwanathan (1990, 1993). Finally, the longer it takes to execute a trade, the lower the market impact cost. Stated differently, lower immediacy results in lower market impact costs.

The market impact costs of buy and sell trades show very different behavior. Most variables have significantly different impact on the expected market impact costs of buys and sells. [12] Furthermore, a Wald-test shows that the conditional expected market impact costs for buys and sells are significantly different at each reasonable significance level. This result justifies separate estimation of market impact costs for buys and sells, as is often done in the literature. However, we continue with joint estimation in the sequel.

Conditional variance of market impact costs

The motivation for analyzing the volatility of market impact lies in the fact that this provides insight into the risk of facing higher market impact costs. In particular, the joint analysis of expected market impact costs and the volatility of these costs sheds light on the trade-off between expected market impact costs and the volatility of these costs.

In equation (3) the conditional volatility is given by $\exp(\gamma_s' Z)^{1/2}$ and $\exp((\gamma_s' + \gamma_b')Z)^{1/2}$, for sells and buys, respectively. To estimate γ_s and γ_b, we regress the realized squared residuals as obtained from the conditional mean regressions in Section V (in logarithms) on the variables contained in Z:

$$\log(e_{it}^2) = (\gamma_s' + \gamma_b' d_{it}) Z_{it} + \xi_{it}. \quad (5)$$

The regressors Z used in the initial estimation of equation (5) are given in Table VII. To arrive at the final specification, we follow the same model selection principle as before. For buys the specification search leads to the model given in the left-hand-side of Table IX. This part of the table reports the coefficients $\gamma_s + \gamma_b$ of the conditional variance equation (5). Again, the discussion of the estimation results is confined to significant coefficients.

Volatility of market impact costs is likely to be related to the magnitude of momentum instead of its sign. We therefore use absolute momentum rather than signed momentum in

[12] Only the dummies for trades in the log(tradesizertdv), usadum, finservdum, preopendum, and earlymonthdum do not have significantly different impact on buys and sells.

the conditional variance regression. The results show that market impact costs fluctuate more in periods of high absolute momentum. Since trades have more extreme price effects in such periods, this results in more volatile market impact costs. Volatility has a significantly positive impact on market impact costs as well. This means that there is more variability in market impact costs in periods when price of the corresponding stock exhibits more fluctuations.

Trades by quantitative funds show more fluctuations in market impact costs than trades by fundamental funds. The dummy for the type of trade (agency/single versus principal) is significantly positive, hence market impact costs of agency and single trades fluctuate more than the trading costs of principal trades. Again this can be explained by the fact that principal trades benefit from the broker's wish to maintain his reputation. The broker will therefore try to avoid excessive price effects of principal trades, leading to less variability in the market impact costs of this type of trades.

The significantly positive coefficients of the sector dummies for the consumer staples and IT indicate that trades in stocks belonging to these sectors cause more fluctuations in market impact than comparable trades in the other sectors.

Regarding the timing of trades, we find that trades submitted before or at the opening of the market show significantly more variability in market impact costs. Since prices at trade submission are not yet based on the information that is released in the period until the opening of the market, they are likely to be substantially different from prices at trade initiation. This explains why these trades have relatively volatile market impact costs. Trades executed at the beginning of the month show more variability in trading costs than trades executed half-way or at the end of the month. Moreover, trades that take longer to execute a trade show more fluctuations in market impact costs. When it takes more time to fulfill a trade, prices have more opportunities to fluctuate and this results in higher variability of market impact costs.

The estimation results for sells are displayed in the right-hand-side of Table IX. This part of the table reports the coefficients γ_s in the conditional variance equation (5).

As for buys, market impact costs of sell transactions show more fluctuations in periods of high absolute momentum and high volatility. Furthermore, stocks with high market capitalization show significantly less variability in market impact costs. This can be explained from the fact that large cap stocks are more liquid than small cap stocks.

The coefficient of the trade type dummy (agency, single or principal) has a significantly positive value: agency and single trades have more fluctuations in market impact than principal trades. The same result was found for the conditional variance of buys. The type of stock dummy (value or growth) is significantly positive, indicating that growth stocks cause more fluctuations in market impact. This can be explained by noticing that growth stocks are usually more volatile than value stocks.

The country dummies are significantly positive: sell transactions in Europe, Japan, and the United States cause more fluctuations in market impact than sells in Canada. The coefficients of the sector dummies for consumer discretionary, energy, IT, and materials are also significantly positive.

With respect to the timing of trades, we find that trades submitted before or at the opening of the market show more variability in market impact costs. The same result was established for buy transactions. Finally, the longer it takes to executed a trade, the more volatile the market impact costs. Note that, at this point, we find a mean-variance tradeoff: trades that take longer to execute have lower expected market impact costs, but higher volatility. On the other hand, trades that are more quickly executed have higher market impact costs and lower volatility.

Buys and sells show considerable differences in conditional variance. Most variables have a significantly different impact on the variance of buy and sell trades.[13] Moreover, a Wald-test shows that the conditional variances of the market impact costs are significantly different at each reasonable significance level.

Since we have modelled both expected market impact costs and the volatility of these costs, we can derive mean-variance relations. As noticed before, there is a mean variance trade-off: trades that take long to execute have low expected market impact costs, but high volatility. On the other hand, trades that are quickly executed have high market impact costs and low volatility. The theoretical mean-variance relation is displayed in Figure 3. For a particular sell trade, we use the the estimated conditional mean and variance equations (3) and (5) to assess the empirical mean-variance curve, see Figure 4. Ceteris paribus, the variance of the market impact costs of this particular sell decreases when the degree of immediacy (as reflected by trade duration) of the sell trade increases. At the same time expected market impact costs increase with higher immediacy.

Finally, we notice that the results obtained in this section do not substantially change when market impact costs are replaced by execution costs.

VI Conclusions

This paper has used a unique data set to investigate market impact and execution costs of equity trading by ABP, a major pension fund in the Netherlands. We have found that, on average, these costs are nonnegligible. Average market impact costs equal 20 basis points for buys and 30 basis points for sells; average execution costs (defined as the sum of commission and market impact) equal 27 basis points and 38 basis points, respectively.

The price effects found in this paper seem relatively moderate compared to other studies. We suggest two possible explanations. Virtually all transactions in the sample were related to rebalancing activities of the pension fund. These trades are, generally speaking, uninformed. First, this implies that buys and sells are not based on recent news events. Trades motivated by

[13] The variables log(volatility), log(marketcap), log(tradesizertdv), agencysingledum, consumerdiscrdum, ITdum, telecomdum, preopendum, earlymonthdum, fridaydum, and tradedur do not have a significantly different impact on buys and sells.

the news of the day cause price movements, which are reinforced by similar trades at the same time. However, rebalancing-trades do generally not coincide with these news driven trades and are therefore likely to have smaller price effects. Second, although market participants do not observe a trader's identity and do therefore not know whether ABP or an informed trader is trading, we still expect rebalancing trades to cause less price effects than other trades. For instance, trade characteristics and trade timing may provide some information to the market on the nature of the trade and its degree of informativeness.

The relatively small size of the established price effects shows that the impact of individual pension fund trading on stock prices is limited. This suggests that the possibly procyclical effects of regulation are small and that regulation does generally not threaten financial stability.

Previous research has established important roles for trade style and variables related to trade difficulty (such as market capitalization and trade size) in explaining market impact costs. In this paper we have found that price volatility and momentum have considerable influence on the market impact costs of buys and sells. Other important determinants of these costs are trade type (agency, single, or principal), trading venue, and industry sector. Additionally, we have found that the *timing* of trades plays a substantial role in explaining trading costs. The moment of the day, as well as the day of the week and the period of the month significantly affect the costs of trading. Moreover, a cost-risk trade-off has been established : the longer it takes to execute a trade, the lower the expected market impact costs, but the higher the volatility of these costs. Trades with more demand for immediacy have higher expected market impact costs, but less uncertainty.

Finally, the methodology developed in this paper can contribute to portfolio management. The predicted cost-risk relation can be used by the pension fund in a pre-trade analysis in order to filter out less favorable trades.

References

Bodhurta S.G. and T.E. Quinn (1990), Does Patient Program Trading Really Pay?, *Financial Analysts Journal*, 46, pp. 35-42.

Chan, L.K.C. and Lakonishok, J., 1993, Institutional Trades and Intraday Stock Price Behavior, *Journal of Financial Economics*, 33, pp. 173-199.

Chan, L.K.C. and Lakonishok, J., 1995, The Behavior of Stock Prices around Institutional Trades, *Journal of Finance*, 50, pp. 1147-1174.

Chan, L.K.C. and Lakonishok, J., 1997, Institutional Equity Trading Costs: NYSE versus Nasdaq, *Journal of Finance*, 52, pp. 713-735.

Chiyachantana, C.N., Jain, P.K., Jian, C., and Wood, R.A., 2004, International Evidence on Institutional Trading Behavior and Price Impact, *Journal of Finance*, 59, pp.869-895.

Collins, B.M. and Fabozzi, F.J., 1991, A Methodology for Measuring Transaction Costs, *Financial Analysts Journal*, 47, pp. 27-36.

Domowitz, I., Glen, J., and Madhavan, A., 2001, Liquidity, Volatility, and Equity Trading Costs Across Countries and Over Time, *International Finance*, 4, pp.221-255.

Easley, D. and O'Hara, M., 1987, Price, Size and the Information in Security Markets, *Journal of Financial Economics*, 16, pp. 69-90.

Easley, D., Kiefer, N.M., O'Hara, M., and Paperman, J.B., 1996, Liquidity, Information and Infrequently Traded Stocks, *Journal of Finance*, 51, pp. 1405-1437.

Foster, D.F. and S. Viswanathan, 1990, A Theory of the Interday Variations in Volume, Variance, and Trading Costs in Securities Markets, *Review of Financial Studies*, 3, pp. 593-624.

Foster, D.F. and S. Viswanathan, 1993, Variations in Trading Volume, Return Volatility, and Trading Costs: Evidence on Recent Price Formation Models, *Journal of Finance*, 48, pp. 187-211.

Griffiths, M.D., Smith, B.F., Turnbull, D.A.S., and White, R.W., 2000, The Costs and Determinants of Order Aggressiveness, *Journal of Financial Economics*, 56, pp. 65-88.

Hasbrouck, J., 1991a, Measuring the Information Content of Stock Trades, *Journal of Finance*, 66, 1, pp. 179-207.

Hasbrouck, J., 1991b, The Summary Informativeness of Stock Trades: an Econometric Analysis, *Review of Financial Studies*, 4, pp. 571-595.

Holthausen, R., Leftwich, R., and Mayers, D., 1987, The Effect of Large Block Transactions on Security Prices: A Cross-Sectional Analysis, *Journal of Financial Economics*, 19, pp. 237-268.

Holthausen, R., Leftwich, R., and Mayers, D., 1990, Large-Block Transactions, the Speed of Response, and Temporary and Permanent Stock-Price Effects, *Journal of Financial Economics*, 26, pp. 71-95.

Keim, D.B. and Madhavan, A., 1996, The Upstairs Market for Large Block Transactions: Analysis and Measurement of Price Effects, *Review of Financial Studies*, 9, pp. 1-36.

Keim, D.B. and Madhavan, A., 1997, Transaction Costs and Investment Style: An Inter-Exchange Analysis of Institutional Equity Trades, *Journal of Financial Economics*, 46, pp. 265-292.

Keim, D.B. and Madhavan, A., 1998, The Cost of Institutional Equity Trades, *The Financial Analysts Journal*, 54, pp. 50-69.

Kraus, A., Stoll, H., 1972, Price Impacts of Block Trading on the New York Stock Exchange, *Journal of Finance*, 27, pp. 569-588.

Lee, L.-F., Maddala, G.S., and Trost, R.P., 1980, Asymptotic Covariance Matrices of Two-Stage Probit and Two-Stage Tobit Models for Simultaneous Equation Models with Selectivity, *Econometrica*, 48, pp. 491-503.

Lee, C.M.C. and Ready, M.J., 1991, Inferring Trade Direction from Intraday Data, *Journal of Finance*, 46, pp. 733-746.

Macey, J.R. and O'Hara, M., 1997, The Law and Economics of Best Execution, *Journal of Financial Intermediation*, 6, pp. 188-223.

Madhavan, A. and Cheng, M., 1997, In Search of Liquidity: Block Trades in the Upstairs and Downstairs Market, *Review of Financial Studies*, 10, pp. 175-203.

Saar, G., 2001, Price Impact Asymmetry of Block Trades: An Institutional Trading Explanation, *The Review of Financial Studies*, 14, pp. 1153-1182.

Schwartz, R. and Shapiro, J., 1992, The Challenge of Institutionalization for Equity Markets; in Anthony Saunders (ed.), *Recent Developments in Finance*, Business One Irwin, Homewood, Illinois, USA.

Smith, B.F., Turnbull, D.A., and White, R.W., 2001, Upstairs Market for Principal and Agency Trades: Analysis of Adverse Information and Price Effects, *Journal of Finance*, 56, pp. 1723-1746.

Spierdijk, L., Nijman, Th. E., and Van Soest, A.H.O., 2003, Temporary and Persistent Price Effects of Trades in Infrequently Traded Stocks, Tilburg University and CentER.

Wagner, W.H. and Edwards, M., 1993, Best Execution, *Financial Analysts Journal*, 49, pp. 65-71.

White, H., 1980, A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity, *Econometrica*, 48, pp. 817-838.

sector name	**MSCI industry groups**
Consumer Discretionary Sector	Automobiles and Components,Consumer Durables and Apparel, Hotels, Restaurants and Leisure, Media, Retail
Consumer Staples Sector	Food & Drug Retailing, Food, Beverage & Tobacco, Household & Personal Products
Energy Sector	Energy
Financials Sector	Banks, Diversified Financials, Insurance, Real Estate
Information Technology Sector	Software & Services, Technology Hardware
Industrials Sector	Capital Goods, Commercial Services & Supplies, Transportation
Health Sector	Health Care Equipment & Services, Pharmaceuticals & Biotechnology
Materials Sectors	Materials
Telecommunications Services Sector	Telecommunication Services
Utilities	Utilities

Table I: Sector names and constituent industry groups. Source: MSCI Global Industry Classification Standard.

variable	description
momentumperc	momentum computed over the last five trading days (in %)
volatility	price volatility computed over the last thirty trading days
marketcap	market capitalization (in Euro)
commission	commission (in bp)
lots	trade size (in shares)
tradesizertso	trade size relative to total shares outstanding (in %)
tradesizertdv	trade size relative to average daily volume (in %)
tradesizertdv	transaction value of trade (in Euro)
growthdum	dummy for growth (= 1) or value (= 0) stock
quantdum	dummy for trade done by quantitative (= 1) or fundamental (= 0) fund
agencysingledum	dummy for agency or single (= 1) or principal (= 0) trade
eurdum	dummy for trade in Europe
japdum	dummy for trade in Japan
usadum	dummy for trade in the United States
candum	(dummy for trade in Canada)
consdiscrdum	dummy for consumer discretionary sector
consumstdum	dummy for consumer staples sector
energydum	dummy for energy sector
findum	dummy for financial sector
healthdum	dummy for health sector
industrydum	dummy for industrials sector)
ITdum	dummy for IT sector
materdum	dummy for materials sector
telecomdum	dummy for media sector
utilitiesdum	dummy for energy sector
preopendum	dummy for trade submitted before or at opening market
fridaydum	dummy for trade submitted/executed on Friday
earlymonthdum	dummy for trade submitted at the beginning of the month
tradedur	the time elapsed between the moment that it was passed to the broker and truly executed

Table II: Descriptions of the variables and their abbreviations

BUYS

	tradesizertso (%)	tradesizertdv (%)	lots (#)	tradevalue (Euro)	commission (bp)	tradedur (hours)
mean	0.0183	4.2932	70,302	1,464,844	12	4.0
st.dev.	0.0301	8.5971	198,535	2,799,983	10	2.4
median	0.0057	1.3225	14,428	305,958	8	4.8
0.5% quantile	0.0000	0.0010	3	258	2	0.2
5% quantile	0.0001	0.0223	169	3,845	2	0.5
95% quantile	0.0723	14.5403	308,916	6,835,122	29	6.5
99.5% quantile	0.1598	56.2211	1,147,880	17,335,108	50	6.8

SELLS

	tradesizertso (%)	tradesizertdv (%)	lots (#)	tradevalue (Euro)	commission (bp)	tradedur (hours)
mean	0.0192	3.4081	84,084	1,595,552	12	4.5
st.dev.	0.0417	6.4188	250,008	2,919,979	10	2.4
median	0.0045	1.3289	17,400	343,149	8	6.0
0.5% quantile	0.0000	0.0035	14	763	2	0.5
5% quantile	0.0001	0.0223	168	5,989	2	0.5
95% quantile	0.0801	12.2532	309,631	7,995,347	29	6.5
99.5% quantile	0.2966	41.5956	1,420,613	17,079,794	29	6.8

Table III: Trade-specific characteristics of buy and sell transactions

The abbreviations of the variable names are explained in Table II.

BUYS					
	candum	japdum	eurdum	usadum	consdiscrdum
mean	8.8	15.9	41.0	34.3	20.8
st.dev.	28.4	36.6	49.2	47.5	40.6
	consumstdum	energydum	finservdum	healthdum	ictdum
mean	4.7	4.3	13.8	7.9	11.5
st.dev.	21.1	20.4	34.5	27.0	31.9
	industrydum	materdum	telecomdum	utilitiesdum	growthdum
mean	19.2	8.9	3.4	5.4	47.1
st.dev.	39.4	28.5	18.2	22.5	49.9
	valuedum	quantdum	agencysingledum	preopendum	fridaydum
mean	33.8	73.0	57.1	26.4	12.0
st.dev.	47.3	44.4	49.5	44.1	32.5
	earlymonthdum				
mean	86.2				
st.dev.	34.5				
SELLS					
	candum	japdum	eurdum	usadum	consdiscrdum
mean	3.6	27.0	27.8	41.7	20.1
st.dev.	18.6	44.4	44.8	49.3	40.1
	consumstdum	energydum	finservdum	healthdum	ITdum
mean	7.7	3.1	18.7	6.6	15.7
st.dev.	26.7	17.3	39.0	24.8	36.4
	industrydum	materdum	utilitiesdum	telecomdum	growthdum
mean	11.2	7.7	5.3	3.8	50.1
st.dev.	31.5	26.6	22.4	19.1	50.0
	valuedum	quantdum	agencysingledum	preopendum	fridaydum
mean	33.5	66.5	66.2	24.3	16.4
st.dev.	47.2	47.2	47.3	42.9	37.1
	earlymonthdum				
mean	80.1				
st.dev.	39.9				

Table IV: Characteristics of buy and sell transactions: type of portfolio, type of trade, region, sector, and trade timing

All numbers are expressed in %. The abbreviations of the variable names are explained in Table II.

BUYS	MIC (incl. MWPM)	EC (incl. MWPM)	MIC (excl. MWPM)	EC (excl. MWPM)
mean	3.9	11.6	19.6	27.4
st.dev. mean	5.3	5.4	5.7	5.7
stdev	235.6	238.4	251.3	254.3
median	0.0	0.8	0.2	1.1
0.5% quantile	−1,056.5	−1,046.8	−942.7	−922.8
5% quantile	−171.7	−155.4	−133.1	−123.1
90% quantile	174.8	207.0	241.6	265.7
95% quantile	993.6	1,024.8	1,329.5	1,341.9
SELLS	**MIC** (incl. MWPM)	**EC** (incl. MWPM)	**MIC** (excl. MWPM)	**EC** (excl. MWPM)
mean	49.8	57.6	29.7	37.5
st.dev. mean	7.3	7.3	6.5	6.5
stdev	307.6	305.7	273.0	271.1
median	0.1	2.1	0.0	0.4
0.5% quantile	−848.6	−787.7	−950.7	−857.8
5% quantile	−125.0	−97.1	−157.3	−135.2
90% quantile	432.3	442.3	357.5	374.0
95% quantile	1,904.5	1,916.9	1,426.2	1,440.0

Table V: Market impact costs (MIC) and execution costs (EC) for buys and sells (in bp)

Execution costs are defined as the sum of commission and market impact costs. Both market impact and execution costs are given with and without correction for market-wide price movements (abbreviated as MWPM). All values are on a principal-weighted basis.

BUYS	temporary	persistent
mean	7.2	12.4
stdev mean	10.5	12.1
st.dev.	461.3	532.8
median	0.0	0.4
0.5% quantile	−2,024.0	−2,028.2
5% quantile	−383.0	−398.3
90% quantile	418.5	509.6
95% quantile	2,345.1	2,463.6
SELLS	temporary	persistent
mean	−14.5	−16.5
stdev mean	9.6	11.2
st.dev.	402.0	468.0
median	0.0	−0.1
0.5% quantile	−1,799.5	−2,475.1
5% quantile	−487.1	−555.4
90% quantile	359.6	467.1
95% quantile	1,711.0	1,823.3

Table VI: Temporary and persistent price effects of buys and sells (in bp), corrected for market-wide price movements and on a principal-weighted basis

const	momentumperc	log(tradesizertdv)	growthdum	eurdum	consdiscrdum	preopendum
	log(volatility)		quantdum	japdum	consumstdum	earlymonthdum
	log(marketcap)		agencysingledum	usadum	energydum	fridaydum
					finservdum	tradedur
					healthdum	
					ITdum	
					materdum	
					telecomdum	
					utilitiesdum	

Table VII: Variables included in the initial regressions in Section V

This table lists the regressors that are taken as a starting point in the model selection procedure. For the estimation of the conditional variance we do not include momentum itself as regressor, but absolute momentum.

	BUYS		SELLS	
	coeff.	st.dev.	coeff.	st.dev.
const	−14.4	40.8	61.4	53.8
usadum	**−51.5**	23.4	−0.3	25.7
eurdum	9.5	26.2	**−123.0**	39.1
japdum	**85.3**	26.9	**−90.1**	28.3
quantdum	−27.4	16.5	**76.3**	15.8
agencysingledum	**38.4**	10.0	−21.6	15.5
momentumperc	**21.3**	4.7	**−18.6**	4.1
log(volatility)	−4.3	6.6	**17.4**	8.8
log(tradesizertdv)	**4.0**	1.1	1.2	1.9
log(marketcap)	3.9	2.1	**−10.2**	3.2
consdiscrdum	4.8	6.4	**−24.1**	7.6
consumstdum	−17.2	12.7	**44.3**	15.9
energydum	**39.7**	13.2	**−29.0**	14.2
finservdum	**−14.7**	7.0	−13.7	7.8
preopendum	17.4	11.4	**33.4**	11.8
earlymonthdum	**42.6**	17.8	**35.6**	16.9
fridaydum	**−103.8**	16.0	**74.5**	17.3
tradedur	−1.0	2.7	**−10.9**	4.6
	adj. R^2	0.17		

Table VIII: Estimation results for buys and sells (conditional expectation)

The standard errors are obtained using White (1980)'s heteroskedasticity consistent covariance matrix. Coefficients in boldface are significant at a 5% significance level.

	BUYS		SELLS	
	coeff.	st.dev.	coeff.	st.dev.
const	**5.30**	0.76	**3.56**	0.85
usadum	**−0.88**	0.36	**1.66**	0.46
eurdum	−0.26	0.49	**2.07**	0.67
japdum	0.13	0.39	**1.96**	0.45
growthdum	−0.11	0.12	**0.31**	0.13
quantdum	**0.55**	0.28	−0.27	0.25
agencysingledum	**1.09**	0.21	**1.24**	0.22
abs(momentumperc)	**0.45**	0.08	**0.21**	0.06
log(volatility)	**0.33**	0.11	**0.39**	0.12
log(tradesizertdv)	0.05	0.03	−0.02	0.03
log(marketcap)	−0.02	0.05	**−0.11**	0.05
consdiscrdum	0.20	0.13	**0.34**	0.15
consumstdum	**0.65**	0.22	−0.16	0.23
energydum	0.27	0.24	**1.01**	0.26
ITdum	**0.59**	0.19	**0.43**	0.18
materdum	−0.19	0.22	**0.79**	0.21
telecomdum	−0.40	0.38	0.54	0.33
preopendum	**0.60**	0.20	**0.76**	0.17
earlymonthdum	**−0.59**	0.28	−0.46	0.24
fridaydum	−0.07	0.27	−0.48	0.26
tradedur	**0.16**	0.06	**0.21**	0.07
	adj. R^2	0.20		

Table IX: Estimation results for buys and sells (conditional variance)

The standard errors are obtained using White (1980)'s heteroskedasticity consistent covariance matrix. Coefficients in boldface are significant at a 5% significance level.

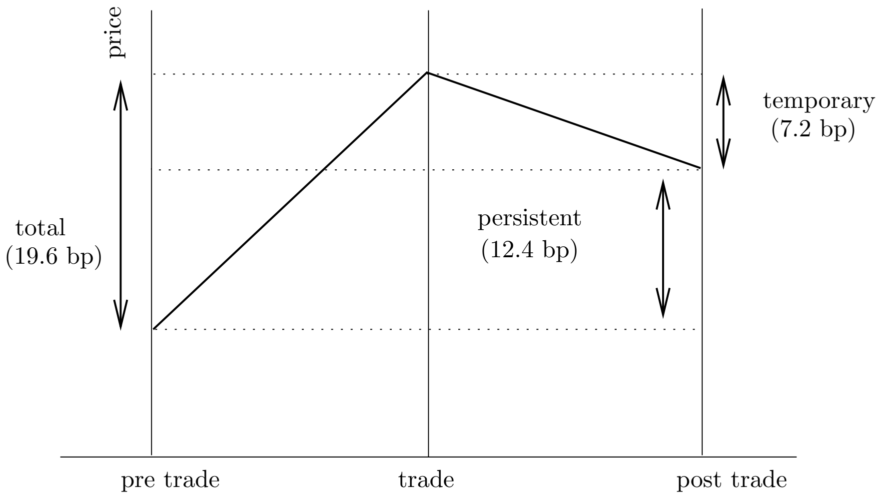

Figure 1: The average temporary, persistent, and total price effects for of buys (in bp)

This plot shows the average temporary, persistent, and total price effects of buys in bp (corrected for market-wide price movements). According to this figure, the temporary price effect (the return from the post-trade moment to the trade) is positive, as it is measured as the decline in the price after the trade. The price drops after a buy, since the liquidity effect on the price dies out. The permanent price effect (the return from the pre-trade moment to the post-trade moment) is also positive: the price at the post-trade moment is higher than at trade initiation, due to the information content of the buy. As a consequence, the total price effect − obtained as the sum of the temporary and persistent price effects − is positive as well.

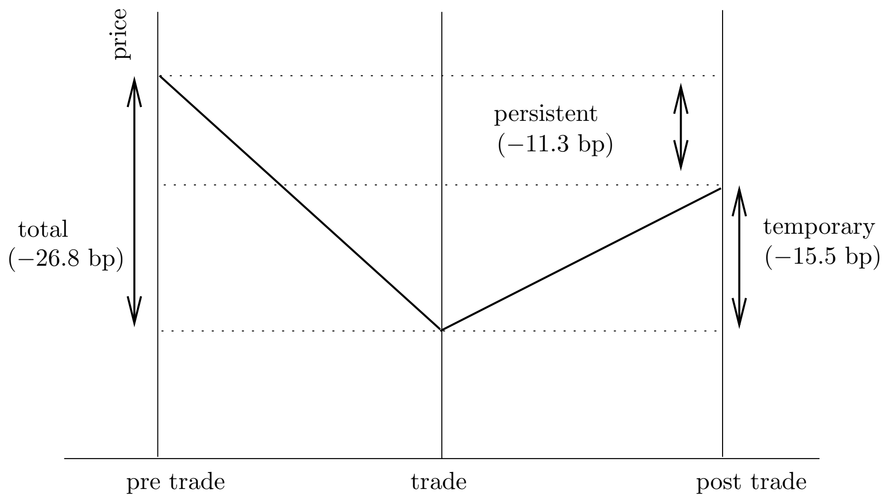

Figure 2: The average temporary, persistent, and total price effects of sells (in bp)

This plot shows the average temporary, persistent, and total price effect for sells in bp (corrected for market-wide price movements). According to this figure, the temporary price effect (the return from the post-trade moment to the trade) is negative, as it is measured as the increase in the price after the trade. Usually, the price increases after a sell, since the liquidity effect on the price dies out. The permanent price effect (the return from the pre-trade moment to the post-trade moment) is also negative: the price at the post-trade moment is lower than at trade initiation, due to the information content of the sell. As a consequence, the total price effect − obtained as the sum of the temporary and persistent price effects − is negative as well.

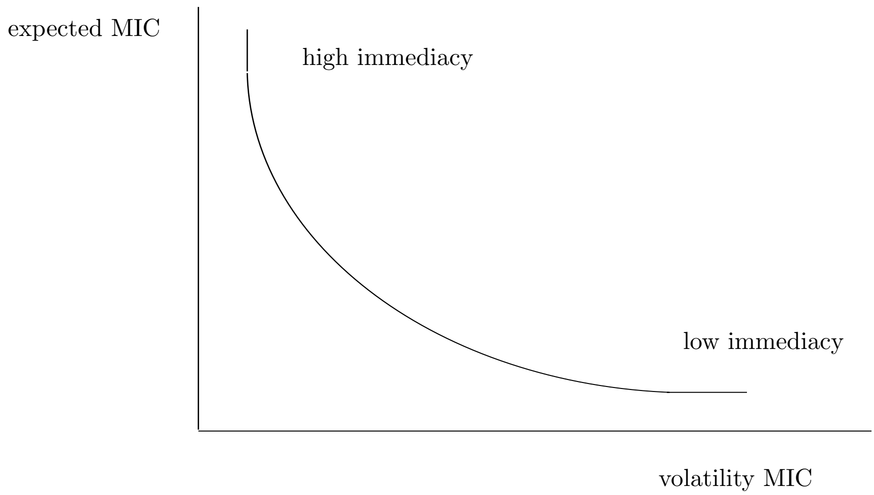

Figure 3: Theoretical mean-variance relation for market impact costs

This plot shows the theoretical mean-variance relation for market impact costs, for a given set of trade characteristics. The location of the curve in the isoquant is determined by the trade characteristics.

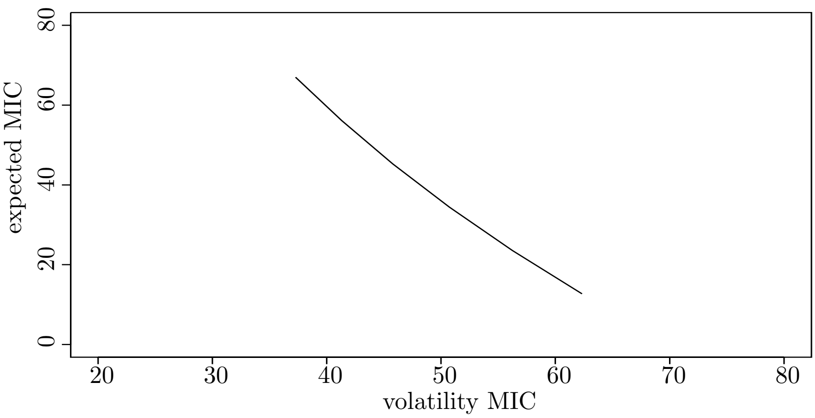

Figure 4: Empirical mean-variance relation for market impact costs

This plot shows the empirical mean-variance relation for a particular sell, based on the estimated conditional mean and variance regressions in equations (3) and (5).

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