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This paper is the first to analyze the price effects of equity trading by a pension fund. We find that, on average, these effects are non-negligible: 20 basis points for buys and 26 basis points for sells. Furthermore, we show that (relative) trade size and market capitalization, commonly found to play an important role, have only limited influence on the price impact of a trade. The most important determinants of the price effect are investment style, trade type (agency, single, or principal), momentum, stock price volatility, and trading venue.

Keywords: implementation shortfall, institutional equity trading, pension funds, transaction costs

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 institutional investors owned more than 50% of total US equities¹. Furthermore, Schwartz and Shapiro (1992) estimated that institutional investors and their member firms accounted for about 70% of the 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. 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 return might result in worse performance than expected if trading costs for his particular stock are high. In such a case a stock with a lower expected return 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. Moreover, for large institutional investors huge amounts of money are involved. Even a few basis points of savings may represent a large amount of money.

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.

Moreover, the central bank, which is responsible for financial stability, is also interested in the price impact of institutional equity trading. Institutional trades are motivated by various reasons, such as investment strategies, risk management or regulatory rules, and may possibly affect equity prices. Price effects, in turn, affect the wealth of consumers, firms and pension funds, and may influence their behavior.

This paper analyzes the price effects of the equity trades of the largest Dutch pension fund and is, as far as we know, the first paper to investigate the trading costs incurred by a pension fund. The 'Algemeen Burgerlijk Pen-

sioenfondsen' (ABP) has 2.4 million clients and an invested capital of about 150 billion Euro.² Its assets constitute about one third of the 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 world-wide 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 fluctuations in the price impact, 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, they allow for detailed analysis of the determinants of the price impact of ABP trades.

We find that, on average, the price impact of the pension fund's trades is nonnegligible: 20 basis points for buys and 26 basis points for sells. Furthermore, we show that (relative) trade size and market capitalization – variables that are often shown to be significantly related to trading costs in the existing literature – have some influence on the expected price impact and the volatility of the trading costs. However, they are considerably less important than investment style, trade type (agency, single, or principal), momentum, stock price volatility, and trading venue. This is partly in line with Chan and Lakonishok (1993, 1995), who find that the importance of (relative) trade size and market capitalization pales beside the importance of investment style. The important role of the trading venue in explaining the price impact coincides with the findings of Chan and Lakonishok (1997) and Keim and Madhavan (1997), who show that the trading venue is a crucial determinant of the price impact of trades in the USA. Our results suggest that this also holds on an international level.

This paper is organized as follows. Section I provides a brief review of the literature on the price effects of institutional trading. Section II 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 III. Section IV assesses the determinants of both the expected price impact and the volatility of the price effects. Finally, Section V summarizes and concludes.

I Price effects of institutional equity trades: a literature review

Quite a number of articles have been devoted to the price impact of institutional equity trades.

Chan and Lakonishok (1993) examine the price impact of institutional trades on the basis of transaction data of 37 large institutional money man-

agement 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 price effects 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 price impact) 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 show 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 the trading costs. The authors examine 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 trading costs of about 18 bp.

Several studies analyze the price 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 434–1024 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 trading costs of 18 bp (upstairs) and 19 bp (downstairs) for buys. For sells they find an 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 Data and definitions

The data under consideration contain the worldwide trades of ten different funds at ABP during the first quarter of 2002. Each fund corresponds to one of the regions Europe, United States, Canada, and Japan. Each fund has its own benchmark being the MSCI Europe, the S&P 500, the Toronto Stock Exchange E300 (henceforth TSE E300), and the MSCI Japan, respectively. During the period covered by the data set three funds were managed quantitatively and seven fundamentally. These quantitative funds exploited monthly to quarterly mispricings of individual stocks based on quantitative models. The fundamental funds had a semi-annual or longer-term qualitative view on the fair value of a company or sector and their portfolios were constructed to reflect these views. This implies that the quantitative funds

traded with much more urgency than the fundamental funds.

Virtually all available observations of buys and sells are related to the so-called rebalancing activities of the pension fund. Rebalancing – adjustment of the portfolio weights by selling and buying stock – takes place every month and only occasionally additional trades are executed. Price changes over time cause portfolio weights to deviate from the optimal ones, so that rebalancing becomes necessary.

The sample consists of 3,728 trades executed during the first three months of the year 2002 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: for buys it equals 2.9 billion Euro and for sells 2.8 billion Euro. 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 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. Moreover, the data include detailed information on several trade and stock-specific characteristics including the investment style of the fund, which will be discussed below.³

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 properties, the data set contains information on the country 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. Trading volume measures the size of the trade in lots.⁴ Moreover, we use two relative measures of trading volume: relative to total shares

outstanding and relative to the median of daily trading volume measured over a period of thirty days prior to the trade. We also consider the dollar value of the trade at the moment the trade decision was taken, called the 'input value' of the trade. An 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 which are traded separately, not necessarily with packages of other stocks. It is up to the pension fund itself to decide an agency, principal, or single trade. 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, median trading volume, value and growth stocks, and sector dummies. Market capitalization is computed as the dollar value of the trades 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. Median trading volume is computed as the median of daily trading volume over a period of thirty days prior to the trades. 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 trading 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.

Sample properties of ABP trades

Table II reports sample statistics (such as means, standard deviations, medians, and quantiles) of several trade characteristics such as trade duration, various measures of (relative) trade size, and commission, for both buys and sells. We see that, on average, trade durations are longer for sells than for buys. Average trade size of buy and sell transactions is different, both in absolute and relative terms. This also holds for the commission fees.

Table IV provides information on the nature of the stocks that have been traded by the pension fund. The second part of Table III provides 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

III Measuring the price impact of ABP trades

This section presents a further exploration of the data described in Section II to investigate the impact of the ABP trades on prices. We start with some definitions of price impact.

Implementation shortfall

This paper uses the so-called implementation shortfall as a measure of trading costs. Implementation shortfall, introduced by Perold (1988), is defined as the difference in performance between a hypothetical portfolio which returns are obtained by assuming that trading took place at the prices observed at the time of the trade decision (the so-called benchmark price) and a real portfolio based on trades that actually took place.

Implementation shortfall consists of two components: implicit and explicit costs. The explicit costs consist of brokerage commissions, order processing costs, and taxes. The implicit costs consist of bid-ask spreads, market impact costs, delay costs, and opportunity costs. The bid-ask spread is a compensation for the costs of the market maker; for example costs induced by order processing, inventory risk, and adverse selection. Market impact costs refer to the costs of immediacy: the difference between the price at which the trade was executed and the price that would have prevailed when the transaction would not have taken place. Delay costs represent the costs

of adverse price movements that occur when trading has been postponed. Finally, opportunity costs refer to the costs of not trading. Clearly, there is a trade off between market impact and opportunity costs. High immediacy leads to high market impact, but high immediacy also implies low opportunity costs.

Some authors report on the magnitudes of the different cost components. Edwards and Wagner (1993) find that the delay costs have the same magnitude as the market impact cost. Moreover, they find opportunity costs equal to 1.8% of the value of the trade and show that opportunity costs are significantly higher for stocks with low market capitalization. Keim and Madhavan (1997) establish high rates of completion, suggesting low opportunity costs. Furthermore, the latter authors shown that, on average, explicit costs contribute about 40% to total execution costs.

To measure implementation shortfall, a benchmark price has to be chosen. There are several ways to do this; see Collins and Frazzini (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 from 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 the price at the moment that the order was passed to the broker. This benchmark will allow us to infer directly the change in prices due to the trade that has taken place. Furthermore, the analysis in this paper focuses on the implicit trading costs, since we are mainly interested in price effects and not in fixed costs such as commission. Moreover, Bodurtha and Quinn (1990) argue that implementation shortfall can be adjusted for market movements, because losses or gains that could arise from market movement can be neutralized through effective hedging practices. Therefore, we will proceed as in Chan and Lakonishok (1993, 1995, and 1997) and subtract delay costs from the implementation shortfall to correct the shortfall for market-wide price movements. More precisely, we measure implementation shortfall (exclusive of delay costs) for a buy transaction in stock i at day t as follows:

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

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, implementation

shortfall for sells is defined as

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

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

Sample properties of price effects

The first and second panel of Table V report sample means, standard deviations, medians and quantiles of the implementation shortfall for buys and sells with and without commission and delay costs.⁷ Moreover, the first two panels of Table V provide average implementation shortfall measured on an equally-weighted average basis. The third and fourth panel of Table V report the same statistics, but computed on a principal-weighted average basis (cf. Chan and Lakonishok (1993)). The principal-weighted averages have the advantage of reflecting the implementation shortfall on a dollar-for-dollar basis, so that smaller trades contribute less to the average shortfall than larger ones.

A striking difference is found between the equally-weighted average implementation shortfall for buys and sells. Buys have much more impact on prices than sells. The average price effect of buys equals 16.5 bp, but that of sells is only -2.7 bp. The considerably lower shortfall of sells is in line with the findings 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)). Chan and Lakonishok (1993) and Saar (2001) argue that institutional selling is more often based on liquidity motives than is buying and that therefore, sells would contain less information than buys.

On a principal-weighted average basis the results are very different. The average impact of buys equals 19.6 bp and that of sells is even larger at 25.6 bp. Apparently, there are some large sells that cause high price impact. On an equally-weighted average basis, these large sell orders receive a relatively low weight. Additionally, Table V demonstrates that the shortfall distribution is much more skewed in the principal-weighted than in the equally-weighted average case.

The substantial differences between equally and principal-weighted averages show the impact of taking into account the importance of the trade as given by its dollar value. Therefore, we will focus on the principal-weighted averages in the remaining part of this section.

The literature distinguishes temporary and persistent price effects. The total price 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. The temporary and persistent price impact can also be corrected for market-wide price movements (delay costs).

We obtain the temporary and the persistent price effects (exclusive of market-wide price movements) 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 buys equal 7.2 bp and 12.4 bp, respectively. For sells, these price effects equal -15.5 bp and -11.3 bp.⁸ For completeness' sake, Table VI also reports temporary and persistent price effects on an equally-weighted basis. 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.

IV Determinants of implementation shortfall

The impact of trades on prices will generally depend on various trade and stock-specific characteristics, including investment style. This section will assess the determinants of the expected implementation shortfall. Moreover, to get an impression of the shortfall *risk* associated with the trades under consideration (i.e. the probability that the shortfall is large), we will also analyze shortfall volatility. In line with the existing literature, the shortfall of buy and sell transactions will be investigated separately.

Conditional expectation of the shortfall

We will start with a simple regression model, taking implementation shortfall (excluding commission and excluding delay costs) as the dependent variable and the variables described in Section II as the regressors. Table III provides a description of the abbreviations of the variables.⁹ The full model, containing all variables under consideration, reads as:

$$\begin{aligned}
 IS_{it} = & \alpha_1 + \alpha_2 \log(\text{Medvolshares}) + \alpha_3 \text{Momentumperc} \\
 & + \alpha_4 \text{Momentumperc} \times \log(\text{Volatility}) + \alpha_5 \log(\text{Volatility}) \\
 & + \alpha_6 \log(\text{Lots}) + \alpha_7 \text{Tradesizertso} + \alpha_8 \text{Tradesizertdv} \\
 & + \alpha_9 \log(\text{Inputvalue}) + \alpha_{10} \log(\text{Marketcap}) \\
 & + \alpha_{11} \text{Agencysingledum} + \alpha_{12} \text{Growthdum} + \alpha_{13} \text{Quantdum} \\
 & + \alpha_{14} \text{Eur dum} + \alpha_{15} \text{Jap dum} + \alpha_{16} \text{Usadum} \\
 & + \alpha_{17} \text{Condiscrdum} + \alpha_{18} \text{Consumerstdum} + \alpha_{19} \text{Energydum} \\
 & + \alpha_{20} \text{Findum} + \alpha_{21} \text{Healthdum} + \alpha_{22} \text{ITdum} \\
 & + \alpha_{23} \text{Materdum} + \alpha_{24} \text{Telecomdum} \\
 & + \alpha_{25} \text{Utilitiesdum} + \varepsilon_{it}.
 \end{aligned} \tag{3}$$

We assume that the disturbances $(\varepsilon_{it})_{it}$ are jointly and serially uncorrelated. We have investigated the validity of this assumption by testing whether the correlation between shortfall on buy trades that took place on the same day is significant.¹⁰ For 24 out of 25 days we did not find significant correlation. Additionally, we tested the same hypothesis for buy trades that took place during the same rebalancing period, which led to the same conclusion. Furthermore, we also assume that the disturbances have mean zero and that they are orthogonal to the regressors in equation (3). The model is estimated by means of OLS using White (1980)'s heteroskedasticity consistent covariance matrix.

A specification search from general to specific on the based on the Akaike information criterion leads to the following model for the implementation shortfall of buy transactions:

$$\begin{aligned}
 IS_{it} = & \beta_1 + \beta_2 \text{Momentumperc} + \beta_3 \text{Momentumperc} \times \log(\text{Volatility}) \\
 & + \beta_4 \log(\text{Tradesizertdv}) + \beta_5 \log(\text{Inputvalue}) \\
 & + \beta_6 \log(\text{Marketcap}) + \beta_7 \text{Agencysingledum} \\
 & + \beta_8 \text{Growthdum} + \beta_9 \text{Quantdum} + \beta_{10} \text{Usadum} \\
 & + \beta_{11} \text{Condiscrdum} + \beta_{12} \text{Energydum} \\
 & + \beta_{13} \text{Telecomdum} + \beta_{14} \text{Utilitiesdum} + \varepsilon_{it}.
 \end{aligned} \tag{4}$$

Table VII displays the estimation results, including estimated coefficients, standard errors, and partial correlation coefficients. A partial correlation coefficient represents the partial correlation between a regressor and

the dependent variable, corrected for the influence of the other regressors. The partial correlation coefficient is a measure of that part of the variance in the dependent variable that is not explained by other determinants and can therefore be interpreted as an indication of the relative importance of a regressor.

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. We would therefore expect the impact of momentum on the shortfall of buy transactions to be positive, since high momentum indicates a buying trend. However, the estimation results document a more complicated relation between momentum and shortfall, including a role for volatility. The coefficient of momentum is significantly negative, but the coefficient of the product of momentum and volatility is significantly positive. This means that momentum affects shortfall through the volatility-dependent coefficient $\beta_2 + \beta_3 \log(\text{Volatility})$, with β_2 significantly negative and β_3 significantly positive. This means that, *ceteris paribus*, the impact of momentum will only be negative when volatility is low. We can explain the relation between shortfall, momentum, and volatility as follows. When momentum and volatility are both high, this is a signal to the market that there is positive news in the air. However, when volatility is relatively low, a buying trend may be caused by effects that are not related to asymmetric information. Hence, in the latter situation high momentum does not have the positive impact on shortfall that it would have when volatility is high.

The coefficients corresponding to the variables related to trading volume (input value and trade size relative to daily volume) are jointly significant. The sign of the marginal effect of trading volume in shares is given by $\beta_{lots} = \beta_4 + \beta_5$, which is significantly positive. Therefore, the shortfall is higher the larger the trade. 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. Additional empirical evidence for the positive relation between trading volume and price effects has been established by Spierdijk, Nijman, and Van Soest (2003) and Keim and Madhavan (1997).

The coefficient of market capitalization is positive, but not significant. Usually, the literature finds a significantly negative relation between market capitalization and price effects. See, for instance, Hasbrouck (1991a, 1991b), Keim and Madhavan (1997) and Spierdijk, Nijman, and Van Soest (2002). However, Chan and Lakonishok (1993, 1995) show that the importance of firm size disappears in the presence of variables related to investment style. Since the model in expression (4) also contains such a variable (the dummy variable *Quantdum*), this could explain why market capitalization does not

play a significant role.

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 implementation shortfall 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 shortfall 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. Part of the difference in shortfall between agency/single and principal trades disappears when commission is taken into account. When we run the same regression with shortfall *including* commission as dependent variable, the dummy variable for agency/single and principal trades remains significant, but its coefficient drops to 20.5. 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 shortfall 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 implementation shortfall on an *ex post* basis. As a consequence, the coefficient of the agency/single dummy does *not* indicate the difference in shortfall relative to the trade having been a principal trade. The coefficient only reflects the difference in shortfall 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 shortfall of choosing an agency/single trade instead of a principal trade and vice versa.

The value/growth dummy, despite its positive coefficient, is not significant. The coefficient of the dummy indicating whether the trade comes from a quantitative or a fundamental fund is significantly negative, which means that trades by quantitative funds have lower shortfall than compara-

ble trades by fundamental funds. This finding does not coincide with those of Chan and Lakonishok (1993, 1995) or Keim and Madhavan (1997). The latter authors show that the shortfall is higher as the demand for immediacy in the investment style increases, which they explain from the fact that investors with a short-term perspective are willing to pay the price for immediacy. Additionally, Chan and Lakonishok (1993, 1995) show that the importance of variables related to trade difficulty, such as (relative) trade size and market capitalization, pales beside the importance of the demand for immediacy in the execution of a trade, as reflected by variables such as investment style. Although the high partial correlation coefficients show that (relative) trade size and market capitalization are of minor importance compared to investment style, the coefficient of the dummy for quantitative and fundamental funds has a counter intuitive sign. Yet if we correct for the trade duration (i.e. the time that elapses between the moment the trade is passed to the broker and the moment the trade has been executed) this apparent anomaly disappears. This correction also reveals that, for buys, longer trade duration implies higher shortfall. Since the trades of fundamental funds take longer on average (5.5 hours versus 3.4 hours), this explains the negative coefficient of the dummy that distinguishes quantitative and fundamental funds. Apparently, delay comes at a price.

The country dummy in regression equation (4) captures country-related effects on the shortfall that are unrelated to the remaining regressors. Since the coefficient of the country dummy for the United States is significantly negative, buy trades in the USA have lower shortfall than comparable trades in Canada, Japan, and Europe. This result is likely to reflect the higher liquidity of the stock market in the USA. The sector dummies in equation (4) reflect sector-specific effects on the shortfall unrelated to the other regressors. Since the coefficients of the sector dummies are significantly positive, buy trades in stocks belonging to the consumer discretionary, energy, telecommunications, and utilities sectors have higher shortfall than buy trades in comparable stocks in other sectors.

The partial correlation coefficients suggest that the USA country dummy, followed by momentum, the product of momentum and volatility, and the dummy distinguishing agency/single and principal trades contribute most to explaining the shortfall of buys.

For sells we proceed in the same way as for buys. The specification search yields the following model for the shortfall of sells:

$$\begin{aligned}
 IS_{it} = & \beta_1 + \beta_2 \log(\text{Medvolshares}) + \beta_3 \text{Momentumperc} \times \log(\text{Volatility}) \\
 & + \beta_4 \log(\text{Volatility}) + \beta_5 \log(\text{Lots}) + \beta_6 \log(\text{Tradesizertso}) \\
 & + \beta_7 \log(\text{Tradesizertdv}) + \beta_8 \log(\text{Inputvalue}) + \beta_9 \text{Marketcap} \\
 & + \beta_{10} \text{Agencysingledum} + \beta_{11} \text{Quantdum} + \beta_{12} \text{Eur dum} \\
 & + \beta_{13} \text{Japdum} + \beta_{14} \text{Usadum} + \beta_{15} \text{Consdiscrdum}
 \end{aligned}$$

$$\begin{aligned}
& +\beta_{16}\text{Energydum} + \beta_{17}\text{Findum} + \beta_{18}\text{Healthdum} \\
& +\beta_{19}\text{ITdum} + \beta_{20}\text{Materdum} + \varepsilon_{it}.
\end{aligned} \tag{5}$$

Again we assume that the disturbances $(\varepsilon_{it})_{it}$ are jointly and serially uncorrelated,¹¹ that they have mean zero and that they are orthogonal to the regressors in equation (5).

Table VIII displays the estimation results for sells. The coefficient of median trading volume (over the last thirty days) is significantly negative, suggesting that high median trading volume reflects a liquid market which causes the shortfall to be low. The estimation results show that momentum determines the relation between shortfall and volatility. The coefficient of log volatility is momentum-dependent and equals $\beta_3\text{Momentumperc} + \beta_4$, with β_3 significantly negative and β_4 significantly positive. This means that the impact of volatility will only be negative when momentum is very high; i.e. when there is a buying trend. In such a situation high volatility is offset by high momentum. When momentum is low, volatility has a positive impact on shortfall. 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)).

Although only one of the coefficients of the variables related to trade size is individually significant, they appear to be jointly significant. However, the sign of the marginal impact of trading volume (given by the sum of the coefficients of the volume-related variables; i.e. by $\beta_{lots} = \beta_5 + \beta_6 + \beta_7 + \beta_8$) is not significant. The coefficient corresponding to market capitalization is not significant either. As for buys, these results are in line with Chan and Lakonishok (1993, 1995).

There is no significant difference in shortfall between agency/single sells and principal sells. The coefficient of the dummy indicating whether the sell comes from a quantitative or a fundamental fund is significantly positive, trades by quantitative funds cause more shortfall. This is in line with Chan and Lakonishok (1993, 1995) and Keim and Madhavan (1997).

The dummy for trades in the USA does not have a significant coefficient, but the coefficients of the other two country dummies are individually significant and negative, as well as jointly significant. This means that – relative to sells in Canada – sells in Europe and Japan lead to lower implementation shortfall. Contrary to buys, sells in the United States do not cause significantly lower shortfall. With respect to the sector dummies, Table VIII shows that trades in stocks belonging to the consumer discretionary, energy, financials, health, and materials sectors have significantly lower shortfall.

The partial correlation coefficients show that the dummy distinguishing quantitative and fundamental funds, followed by the product of momentum and volatility play the most important role in explaining the shortfall of sells.

Conditional variance of the implementation shortfall

For the conditional variance of the shortfall, we regress the (realized) squared residuals in logarithms (i.e. $\log(e_{it}^2)$) on the variables given in equation (3) and follow the same model selection principle as before. For buys the specification search leads to the model

$$\begin{aligned}\log(e_{it}^2) = & \gamma_1 + \gamma_2 \log(\text{Medvolshares}) + \gamma_3 \log(\text{Volatility}) \\ & + \gamma_4 \log(\text{Lots}) + \gamma_5 \log(\text{Tradesizertso}) \\ & + \gamma_6 \log(\text{Tradesizertdv}) + \gamma_7 \log(\text{Marketcap}) \\ & + \gamma_8 \text{Agency singledum} + \gamma_9 \text{Eur dum} + \gamma_{10} \text{Usadum} \\ & + \gamma_{11} \text{ITdum} + \eta_{it}.\end{aligned}\tag{6}$$

The model is estimated by means of OLS using White (1980)'s heteroskedasticity consistent covariance matrix. The estimation results for buys can be found in Table IX. Median trading volume has a significantly negative coefficient, showing that there is less fluctuation in shortfall in periods of high trading volumes. Volatility has a significantly positive impact on implementation shortfall. This means that there is more variability in shortfall in periods when price fluctuation is higher.

The coefficients of the variables related to trade size are jointly significant. The sum of their coefficients (i.e. $\gamma_{\text{lots}} = \gamma_4 + \gamma_5 + \gamma_6$) reflects the sign of the marginal impact of the number of shares on shortfall volatility and is significantly positive. Hence, there are more fluctuations in the shortfall of large buys than of smaller ones.

The coefficient of market capitalization is not significant. The dummy for the type of trade (agency/single versus principal) is significantly positive, hence the shortfall of agency and single trades shows more fluctuation than the shortfall 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 on principal trades, leading to less shortfall variability in this type of trades.

The coefficients of the country dummies for Europe and the United States are significantly negative, hence buys in these countries cause less fluctuation in shortfall than trades in Canada and Japan. The significantly positive coefficient of the sector dummy for the IT sector, indicates that trades in stocks belonging to this sector cause more fluctuation in shortfall than comparable trades in stocks belonging to other sectors.

The partial correlation coefficients show that the country dummies for Europe and the United States contribute most to explaining the shortfall volatility of buys, followed by the dummy variable that distinguishes agency/single trades and principal trades.

By proceeding in a similar way, the following specification for sells is

found:

$$\begin{aligned}
\log(e_{it}^2) = & \gamma_1 + \gamma_2 \log(\text{Medvolshares}) + \gamma_3 \log(\text{Volatility}) \\
& + \gamma_4 \log(\text{Lots}) + \gamma_5 \log(\text{Tradesizertso}) \\
& + \gamma_6 \log(\text{Tradesizertdv}) + \gamma_7 \text{Agency singledum} \\
& + \gamma_8 \text{Growthdum} + \gamma_9 \text{Quantdum} + \gamma_{10} \text{Eur dum} \\
& + \gamma_{11} \text{Japdum} + \gamma_{12} \text{Usadum} + \gamma_{13} \text{Energydum} \\
& + \gamma_{14} \text{Materdum} + \gamma_{15} \text{Telecomdum} \\
& + \gamma_{16} \text{Utilitiesdum} + \eta_{it}.
\end{aligned} \tag{7}$$

The estimation results for sell transactions are displayed in Table X. Volatility has a significantly positive coefficient. This means that there is greater shortfall variability during periods when there is more fluctuation in prices anyhow. The coefficients corresponding to the trade-related variables are jointly significant. The sign of the marginal effect of trade size in lots is given by $\gamma_{lot,s} = \gamma_4 + \gamma_5 + \gamma_6$, which is positive but not significant.

The coefficient of the trade type dummy (agency, single or principal) has a significantly positive value: agency and single trades have more fluctuation in shortfall than principal trades. The type of stock dummy (value or growth) is significantly positive, indicating that growth stocks cause more fluctuations in shortfall. This can be explained by noticing that growth stocks are usually more volatile than value stocks. The type of fund dummy (quantitative versus fundamental fund) is significantly negative, hence the sells by quantitative funds cause less variability in shortfall. Hence, although, sells by quantitative funds cause more shortfall on average, they cause less variability in shortfall.

The country dummies are significantly positive and jointly significant. Hence, sell transactions in Europe, Japan, and the United States cause more fluctuation in shortfall than sells in Canada. Only the two dummies for the sectors energy and telecommunications are significantly different from zero.

From the partial correlation coefficients we can deduce that the dummy variable for quantitative and fundamental funds plays the most important role in explaining shortfall volatility of sells. Other important variables are the variables related to trade size and the dummy for agency/single and principal trades.

Table XI reports the most important determinants of expected shortfall and shortfall volatility of both buys and sells, based on the partial correlation coefficients.

V Conclusions

This paper has used a unique data set to investigate the price effects of equity trading by ABP, a major pension fund in the Netherlands. We have

found that, on average, these effects are nonnegligible: 20 bp for buys and 26 bp for sells. The total average execution costs of buys and sells, including commissions, are about 27 bp and 33 bp, respectively.

The data, containing detailed information on all worldwide equity trades of ten different funds at ABP during the first quarter of 2002, have been used to identify the trade and stock-specific characteristics that determine the trading costs. For buys, the stock-specific characteristics momentum and price volatility play a crucial role in explaining the price impact of trading. The expected price effects are larger when momentum and volatility are high and the trading costs exhibit more fluctuations when price volatility is high. Moreover, the type of trade is also an important determinant of the trading costs. Agency and single trades have higher expected price impact than comparable principal trades. Moreover, agency and single trades also have higher volatility of trading costs. The trading venue is another variable that considerably affects the trading costs of buys. For sells we find partly different results. The investment style of the fund – determining the demand for immediacy of the trade – has much influence on both the expected trading and the volatility of the price impact. Trades by quantitative funds that focus on growth strategies affect prices more than trades by fundamental funds that use value strategies. Furthermore, the trading costs of sells by quantitative funds show less fluctuation than those of comparable trades by fundamental funds. As for buys, the volatility of the price effect of agency and single trades is higher than that of comparable principal trades. Additionally, the expected price effects of sells are larger when volatility is high and momentum is low.

The results make clear that (relative) trade size and market capitalization – variables that are often found to be significantly related to trading costs in the existing literature – do have some influence on the expected price impact and the volatility of trading costs. However, they are considerably less important than investment style, trade type (agency, single, or principal), momentum and stock price volatility and their interaction, and trading venue. This is partly in line with Chan and Lakonishok (1993, 1995), who find that the importance of trade size and market capitalization pales beside the importance of investment style. The important role of the trading venue coincides with the findings of Chan and Lakonishok (1997) and Keim and Madhavan (1997), who show that the trading venue is a crucial determinant of the price impact of trades in the USA. Our results point out that this also holds on an international level.

Notes

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

²This is the invested capital of ABP d.d. February 2004.

³Trades 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.

⁴Note that the data are biased with respect to trading volume, since trades larger than 25% of the average daily volume in the stock under consideration are not allowed (with the average daily volume measured over the past twenty trading days).

⁵Some stocks do not belong to either of these two categories.

⁶Agency and single trades have been aggregated, since there are too few single trades to treat them as a distinct class. It is natural to aggregate agency and single trades, since these are the trades that the broker acts as an agency for.

⁷Since we only have closing prices of the MSCI industry group indices, we approximate the delay costs in expressions (1) as

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

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 implementation shortfall 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 delays costs of sells in expression (2) we use the same approximation.

⁸We 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 implementation shortfall. 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 1,935 buy trades and 1,746 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 implementation shortfall.

⁹One regional- and one sector dummy have been omitted in the regressions to avoid perfect collinearity. Furthermore, we did not find any evidence for multicollinearity in the remaining analysis.

¹⁰In the sequel, the significance level will be 5% in the sequel, unless stated differently.

¹¹As for buys, we investigated the validity of this assumption for sell transactions, but we did not find any significant correlation.

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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 Sector	Materials
Telecommunications Services Sector	Telecommunication Services
Utilities	Utilities

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

buys	duration (hours)	# shares	commission (bp)	trade size (rtdv*)	trade size (rtso**)	trade value (Euro)	input value (Euro)
mean	3.96	70,303	12.2	2.08	0.01	1,464,844	1,464,363
st.dev.	2.44	198,535	10.0	16.19	0.03	2,799,983	2,797,021
median	4.75	14,428	8.0	0.27	0.11e-02	3,05,958	306,796
0.5% quantile	0.22	4	2.0	0.98e-04	3.71e-06	269	268
5% quantile	0.50	169	2.0	0.19e-02	8.51e-05	3,852	3,839
95% quantile	6.50	305,197	29.0	6.36	0.03	6,813,513	6,834,569
99.5% quantile	6.75	1,116,399	50.0	45.91	0.14	17,188,953	17,475,886
sells							
mean	4.50	84,132	11.53	1.94	0.01	1,597,814	1,605,437
st.dev.	2.40	249,622	9.84	16.37	0.02	2,916,597	2,934,101
median	5.95	17,457	8.00	0.22	0.10e-02	349,341	351,763
0.5% quantile	0.50	14	2.00	0.32e-03	0.21e-05	797	798
5% quantile	0.50	170	2.00	0.29e-02	0.13e-04	6,025	6,011
95% quantile	6.50	306,861	29.00	5.27	0.03	7,950,280	7,982,833
99.5% quantile	6.75	1,363,861	29.00	56.65	0.14	16,646,239	16,922,149

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

* Trade size rtdv stands for trade size *relative to daily volume*.

** Trade size rtso refers to trade size *relative to shares outstanding*.

variable	description
Medvolshares	median trading volume over the last thirty days (in shares)
Momentumpc	momentum computed over the last five trading days (in %)
Volatility	price volatility computed over the last thirty trading days
Inputvalue	Euro value of the trade at the pre-trade moment
Lots	number of shares of the trade
Tradesizerso	trade size relative to shares outstanding
Tradesizerv	trade size relative to daily volume
Marketcap	market capitalization (in Euro)
Commissionbp	commission (in bp)
Agencyingledum	dummy for agency or single (= 1) or principal (= 0) trade
Growthdum	dummy for growth (= 1) or value (= 0) stock
Quantdum	dummy for trade done by quantitative (= 1) or fundamental (= 0) fund
Eurdum	dummy for trade in Europe
Japdum	dummy for trade in Japan
Usadum	dummy for trade in USA
(Candum)	(dummy for trade in Canada)
Capgooddum	dummy for capital goods sector
Consdiscrdum	dummy for consumer discretionary sector
Consumerstdum	dummy for consumer staples sector
Energydum	dummy for energy sector
Findum	dummy for financial sector
Healthdum	dummy for health sector
(Industriydum	dummy for industrials sector)
ITdum	dummy for IT sector
Materialdum	dummy for materials sector
Telecomdum	dummy for media sector
Utilitiesdum	dummy for energy sector

Table III: Descriptions of the variables and their abbreviations

One region- and one sector dummy (in parentheses) have been omitted in the regressions in equations (3),(4), (5), (6), and (7) to avoid exact collinearity.

buys					
	Quantdum	Candum	Japdum	Eurdum	Usadum
mean (in %)	73.0	8.8	15.9	41.0	34.3
st.dev. (in %)	44.4	28.4	36.6	49.2	47.5
	Findum	Telecomdum	Energydum	ITdum	Utilitiesdum
mean (in %)	13.8	3.4	4.3	11.5	5.4
st.dev. (in %)	34.5	18.2	20.4	31.9	22.5
	Consdiscrdum	Healthdum	Consumstddum	Materdum	Industrydum
mean (in %)	20.8	7.9	4.7	8.9	19.2
st.dev. (in %)	40.6	27.0	21.1	28.5	39.4
sells					
	Quantdum	Candum	Japdum	Eurdum	Usadum
mean (in %)	66.5	3.6	27.0	27.8	41.7
st.dev. (in %)	47.2	18.6	44.4	44.8	49.3
	Findum	Telecom	Energydum	ITdum	Utilitiesdum
mean (in %)	18.7	3.8	3.1	15.7	5.3
st.dev. (in %)	39.0	19.1	17.3	36.4	22.4
	Consdiscrdum	Healthdum	Consumerstddum	Materdum	Industrydum
mean (in %)	20.1	6.6	7.7	7.7	11.2
st.dev. (in %)	40.1	24.8	26.7	26.6	31.5

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

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

buys (equally-weighted)	excl.comm.	incl. comm.	incl. comm.	excl. comm.
	incl. delay	incl. delay	excl. delay	excl. delay
mean	4.4	16.6	28.7	16.5
st.dev. mean	2.6	2.6	2.7	2.7
st.dev.	113.5	114.2	119.3	119.5
median	0.0	19.7	26.5	7.9
quantile 0.5%	-410.2	-405.2	-389.0	-391.5
quantile 5%	-149.8	-143.5	-154.6	-163.0
quantile 95%	165.1	171.7	208.7	201.9
quantile 99.5%	489.1	497.1	509.0	501.6
sells (equally-weighted)				
mean	20.9	32.4	8.8	-2.7
st.dev. mean	3.5	3.5	3.7	3.7
st.dev.	148.1	146.8	153.8	154.2
median	5.9	27.5	17.4	2.2
quantile 0.5%	-507.4	-499.4	-528.6	-536.6
quantile 5%	-179.6	-171.9	-242.1	-251.8
quantile 95%	244.1	250.0	218.4	210.5
quantile 99.5%	605.4	607.4	559.7	557.3
buys (principal-weighted)				
mean	3.9	11.6	27.4	19.6
st.dev. mean	5.3	5.4	5.7	5.7
st.dev.	235.6	238.4	254.2	251.3
median	0.0	0.8	1.1	0.2
quantile 0.5%	-1,056.5	-1,046.8	-922.8	-942.8
quantile 5%	-171.7	-155.4	-123.1	-133.1
quantile 95%	174.8	207.0	265.7	241.6
quantile 99.5%	993.6	1,024.8	1,341.9	1,329.6
sells (principal-weighted)				
mean	45.5	53.3	33.3	25.6
st.dev. mean	7.7	7.7	6.9	6.9
st.dev.	325.2	323.5	290.0	291.8
median	0.1	2.1	0.4	0.0
quantile 0.5%	-1,211.8	-1,148.0	-1,011.9	-1,052.8
quantile 5%	-129.3	-111.2	-145.8	-158.9
quantile 95%	431.5	440.6	372.4	353.8
quantile 99.5%	1,901.9	1,914.3	1,434.0	1,420.2

Table V: Implementation shortfall for buys and sells (in bp)

	temporary (equally-weighted)	persistent (equally-weighted)	temporary (principal-weighted)	persistent (principal-weighted)
buys				
mean	0.4	16.3	7.2	12.4
st.dev.	7.2	7.8	10.5	12.1
median	317.6	341.2	461.3	532.8
quantile 0.5%	-0.6	23.6	0.0	0.4
quantile 5%	-925.4	-1039.9	-2024.0	-2028.2
quantile 95%	-446.8	-434.5	-383.0	-398.3
quantile 99.5%	418.8	475.7	418.5	509.6
	855.1	1206.6	2345.1	2463.6
sells				
mean	-7.8	10.6	-15.5	-11.3
st.dev.	8.7	9.3	9.7	11.7
median	364.6	388.9	403.9	489.5
quantile 0.5%	-1.4	-4.9	0.0	-0.1
quantile 5%	-1377.3	-1284.7	-1837.2	-2464.1
quantile 95%	-502.3	-490.3	-487.8	-553.6
quantile 99.5%	453.6	601.4	360.4	477.8
	1216.5	1343.2	1703.9	1912.2

Table VI: Temporary and persistent price effects of buys and sells (in bp)

variable	coeff.	st.dev.	PCC
const	28.8	21.4	
Momentumperc	-84.8	32.2	-0.12
Momentumperc*log(Volatility)	27.4	9.2	0.15
log(Tradesizertdv)	5.6	2.0	0.07
log(Inputvalue)	-3.2	2.1	-0.03
log(Marketcap)	3.8	2.9	0.03
Agencysingleum	38.4	6.4	0.13
Growth	10.4	5.5	0.04
Quantdum	-19.6	7.0	-0.07
Usadum	-55.8	7.7	-0.17
Consdiscrdum	17.4	6.3	0.06
Energydum	43.5	13.2	0.08
Telecomdum	35.3	13.6	0.05
Utilitiesdum	23.3	10.0	0.05
R^2	0.12		
adj. R^2	0.11		
Akaike	12.29		

Table VII: Estimation results for buys (conditional expectation)

The standard errors are obtained using White (1980)'s heteroskedasticity consistent covariance matrix. The column captioned 'PCC' reports partial correlation coefficients.

variable	coeff.	st.dev.	PCC
const	-1333.9	838.8	
log(Medvolshares)	-33.1	7.7	-0.10
Momentumperc*log(Volatility)	-4.3	1.0	-0.20
log(Volatility)	29.9	8.3	0.11
log(Lots)	-91.0	60.7	-0.12
log(Tradesizertso)	-110.2	61.0	-0.15
log(Tradesizertdv)	-16.0	6.9	-0.06
log(Inputvalue)	216.3	122.2	0.14
log(Marketcap)	-102.8	61.0	-0.14
Agency singledum	-26.6	14.6	-0.05
Quantdum	104.4	12.8	0.26
Eurdum	-126.0	28.8	-0.12
Japdum	-103.4	19.2	-0.13
Usadum	-33.0	21.7	-0.04
Consdiscrdum	-47.2	8.7	-0.12
Energydum	-45.5	13.6	-0.06
Findum	-47.0	8.9	-0.12
Healthdum	-28.4	10.8	-0.05
ITdum	-25.7	14.0	-0.06
Materdum	-37.3	12.0	0.00
R^2	0.21		
adj. R^2	0.20		
Akaike	12.56		

Table VIII: Estimation results for sells (conditional expectation)

The standard errors are obtained using White (1980)'s heteroskedasticity consistent covariance matrix. The column captioned 'PCC' reports partial correlation coefficients.

variable	coeff.	st.dev	PCC
const	6.06	0.86	
log(Medvolshares)	-0.25	0.11	-0.05
log(Volatility)	0.41	0.10	0.08
log(Lots)	0.19	0.06	0.07
log(Tradesizertso)	0.18	0.07	0.06
log(Tradesizertdv)	-0.31	0.09	-0.07
log(Marketcap)	0.12	0.07	0.03
Agency singledum	0.99	0.25	0.11
Eurdum	-1.63	0.29	-0.14
Usadum	-1.03	0.18	-0.12
ITdum	0.58	0.18	0.07
R^2	0.21		
adj. R^2	0.21		
Akaike	4.54		

Table IX: Estimation results for buys (conditional variance)

The standard errors are obtained using White (1980)'s heteroskedasticity consistent covariance matrix. The column captioned 'PCC' reports partial correlation coefficients.

variable	coeff.	st.dev.	PCC
const	8.83	1.09	
log(Medvolshares)	-0.32	0.08	-0.10
log(Volatility)	0.42	0.13	0.08
log(Lots)	0.19	0.06	0.09
log(Tradesizertso)	0.34	0.07	0.11
log(Tradesizertdv)	-0.49	0.09	-0.14
Agency singledum	1.31	0.20	0.13
Growth	0.55	0.12	0.10
Quantdum	-1.22	0.16	-0.18
Eurdum	1.27	0.43	0.09
Japdum	1.26	0.34	0.10
Usadum	1.65	0.35	0.07
Energydum	0.50	0.24	0.04
Materdum	0.40	0.24	0.04
Telecomdum	0.88	0.25	0.07
Utilitiesdum	-0.44	0.30	0.00
R^2	0.18		
adj. R^2	0.17		
Akaike	4.55		

Table X: Estimation results for sells (conditional variance)

The standard errors are obtained using White (1980)'s heteroskedasticity consistent covariance matrix. The column captioned 'PCC' reports partial correlation coefficients.

	expected	volatility
buys	country dummy USA momentum $\times$ volatility agency/single/principal	country dummy Europe country dummy USA agency/single/principal volatility
sells	dummy quantitative/fundamental funds momentum $\times$ volatility trade size relative to shares outstanding	quantitative/fundamental trade size relative to daily volume agency/single/principal

Table XI: The most important determinants of expected shortfall and shortfall volatility.

The partial correlation coefficients in Tables VII, VIII, IX, and X have been used to establish the most important determinants of expected shortfall and shortfall volatility.

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.