

# The Market Liquidity Impact of Repurchase Trading<sup>\*</sup>

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## Abstract

This study examines the market liquidity impact of repurchase trading in an electronic order-driven market. Our sample consists of 2,806 open market share repurchases executed by 53 firms listed on the Stockholm Stock Exchange. Overall, we find that repurchase trading contributes to market liquidity through narrower bid-ask spreads and increased market depth. After controlling for volume, price, and volatility we find a statistically significant decrease in the average bid-ask spread of approximately 3% on repurchase days. Depth on the bid side increases on repurchase days with relatively small repurchase sizes, but decreases on repurchase days with relatively large repurchase sizes. We argue that when firms repurchase relatively small volumes each repurchase day they submit buy limit orders at the current bid price to a large extent and therefore establish a lower bound on the bid price which narrows the bid-ask spread and increases depth on the bid side. However when firms repurchase relatively large volumes on a trading day they submit buy limit orders within the current bid-ask spread to a large extent which narrows the bid-ask spread but deteriorates depth on the on the bid side. Our results suggest that the change in market liquidity on trading days with open market share repurchases is related to the trading behaviors of the repurchasing firms.

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## 1. Introduction

In recent years share repurchases have become more popular around the world as more countries have adopted enabling regulations.<sup>1</sup> In the U.S. where share repurchase programs have been allowed for decades, share repurchases as a percentage of total dividends increased from 13% in 1980 to 113% in 2000 (Grullon and Michaely, 2002). The most common way to repurchase shares in the U.S. is through an open market share repurchase in which the company instructs a broker to buy shares on the stock market.<sup>2</sup> Open market share repurchases are also the predominant form of share repurchase in the rest of the world, followed by private repurchases and fixed price tender offers (Vermaelen, 2005).<sup>3</sup>

Firms that activate open market share repurchase programs act as insiders and often their daily buyback volumes represent a large fraction of the firms' daily trading volume.<sup>4</sup> Little is known however about the impact of repurchase trading on market liquidity and price. According to the market microstructure literature increased trading volume have an incremental effect on liquidity, however if market participants detect and suspect informed managerial trading, repurchase trading could have a detrimental effect on liquidity. Execution styles of repurchasing firms different from other traders could also affect the liquidity after controlling for the increased volume. In many countries, including the U.S., studies of repurchase trading are difficult to conduct as firms are not required to disclose the precise dates, prices and magnitudes of their repurchase transactions. However in Sweden and some other countries, firms on the major stock exchanges are required to disclose full details of their repurchase activities on a daily basis which provides an opportunity to study the impact of repurchase trading on market liquidity and price.<sup>5</sup>

Previous studies that examine market liquidity on repurchase days report conflicting results. Brockman and Chung (2001), and Ginglinger and Hamon (2007) find that repurchase trading has a detrimental effect on market liquidity on the Stock Exchange of Hong-Kong and

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<sup>1</sup> Prior to 1980 buyback activity was illegal or discouraged by tax laws in all countries except in the U.S.

<sup>2</sup> Grullon and Michaely (2000) find that open market share programs comprised roughly 91 percent of the total value of all repurchase announcements between 1980 and 2000 in the U.S.

<sup>3</sup> On the Stockholm Stock Exchange, share repurchases represented 42% of total dividends for Swedish firms between 2000 and 2005. Open market share repurchases comprised 58% of those repurchases.

<sup>4</sup> Brockman and Chung (2001) find that the average buyback represents 44% of the firm's daily trading volume on the Stock Exchange of Hong Kong. Cook et al. (2004) find that the average buyback represents 33% of the firm's daily trading volume on the NASDAQ and 19% of the firm's daily trading volume on the NYSE.

<sup>5</sup> Other countries where firms have to disclose their repurchase activity on a daily basis are for example Australia, Hong-Kong, Malaysia, Mexico, Singapore, and the U.K. (Vermaelen, 2005).

the Paris Stock Exchange respectively. In contrast, Cook et al. (2004) find that repurchase trading contributes to market liquidity for NASDAQ and NYSE listed firms.

In this study we extend prior research and examine market liquidity effects of repurchase trading on the electronic order-driven Stockholm Stock Exchange which has a similar disclosure environment for open market share repurchases as the Stock Exchange of Hong-Kong.<sup>6</sup> We examine bid-ask spreads and depth on 2,806 repurchase days and use surrounding non-repurchase days as benchmark periods.

Overall, we find that repurchase trading contributes to market liquidity through narrower bid-ask spreads and deeper depth. After controlling for volume, price, and return volatility we find that bid-ask spreads decrease approximately 3% on repurchase days compared to trading days in benchmark periods. However, when repurchases are executed as block transactions we find that bid-ask spreads widen.<sup>7</sup> On repurchase days with relatively small repurchase volumes (less than 10% of the average daily trading volume during the four weeks preceding the week of the repurchase), and days with repurchases executed as block transactions, depth on both the bid and ask side deepen. In contrast, depth deteriorates on the bid side on repurchase days with relatively large repurchase volumes (20% to 25% of the average daily trading volume during the four weeks preceding the repurchase).

Our results suggest that the change in market liquidity on trading days with open market share repurchases is related to the trading behavior of the repurchasing firm. We argue that firms with managers who prioritize a low average repurchase price, are more likely to submit buy limit orders at the current bid price and repurchase relatively small volumes each repurchase day. This trading behavior establishes a lower bound on the bid price which narrows the bid-ask spread and increases depth on the bid side. Contrary, firms with managers who prioritize a fast execution of the repurchase program are more likely to submit buy limit orders within the current bid-ask spread and repurchase close to the maximum allowable repurchase volume each repurchase day.<sup>8</sup> This trading strategy also decreases the bid-ask spread but deteriorates depth on the bid side with lower volumes.

Very large daily repurchase volumes executed as block transactions manually off-exchange do not contribute to lower bid-ask spreads as repurchase transactions over the automated trading system do. When we control for volume, price, and volatility we even find

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<sup>6</sup> The legal entity name of the Stockholm Stock Exchange is NASDAQ OMX Stockholm AB (2009).

<sup>7</sup> Repurchases executed as block transactions consist of at least 250 round lots and are traded manually off-exchange. Block transactions must be reported to the Exchange within five minutes during the trading day.

<sup>8</sup> With the exception of block transactions the maximum repurchase size during a single day is 25% of the average daily trading volume during the four weeks immediately preceding the week of the repurchase.

a significantly higher bid-ask spread at the 10% level on repurchase days. However repurchase transactions executed as block transactions increase market liquidity in terms of depth both on the bid and ask side.

In the analysis we also find that the average daily repurchase price, relative to the average of intraday bid-ask midpoints, is higher on repurchase days with relatively large repurchase volumes compared to repurchase days with relatively small repurchase volumes. This result is consistent with the predicted trading behavior that firms are more likely to submit buy limit orders at the bid price when daily repurchase volumes are relatively small and submit buy limit orders within the bid-ask spread when daily repurchase volumes are relatively large.

In summary, we believe our results contribute to the evidence and debate about the market impact of open market repurchases, and to issues related to repurchase strategies.

Our paper is organized as follows. In Section 2 we summarize prior empirical research on market liquidity effects related to open market share repurchases and develop our hypotheses. Section 3 describes the regulatory environment for open market share repurchases in Sweden and the trading structure on the Stockholm Stock Exchange. Section 4 presents the data, sample, and market liquidity measures. Section 5 reports the empirical results, and Section 6 concludes.

## **2. Previous research and market liquidity hypotheses**

### *2.1 Previous research*

The first study which examines the market liquidity impact of open market share repurchases is Barclay and Smith (1988). The authors develop two non-mutually exclusive hypotheses and examine NYSE-listed firms. The competing market-maker hypothesis predicts that the bid-ask spread will narrow if firms submit buy limit orders which establish a lower bound on the bid price. In contrast, the information-asymmetry hypothesis predicts that the bid-ask spread will widen if managers are better informed and willing to trade on inside information.<sup>9</sup> Barclay and Smith (1988) test the two hypotheses empirically by examining relative bid-ask spreads before and after 153 open market share repurchase (OMR) program

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<sup>9</sup> Insider trading analyses by Jaffe (1974) and Seyhun (1986), among others, show that managers can identify mispricings in their own firms. Market microstructure models by Copeland and Galai (1983), and Glosten and Milgrom (1985) show that greater information asymmetry between informed and uninformed traders deteriorates market liquidity.

announcements.<sup>10</sup> Consistent with the information-asymmetry hypothesis they find that relative bid-ask spreads widen following repurchase announcements.<sup>11</sup> The authors conclude that the presence of better informed managers in the market increases the bid-ask spread, and thereby increases the repurchasing firm's cost of capital.<sup>12</sup>

Singh et al. (1994), Wiggins (1994), and Miller and McConnell (1995) all refine and extend Barclay and Smith's (1988) study. However, in contrast to Barclay and Smith (1988) they find no support of the information-asymmetry hypothesis. Singh et al. (1994) find that bid-ask spreads increase in the period preceding OMR program announcements but find no further changes in subsequent periods for a sample of National Market System listed firms. Wiggins (1994) finds a small decline in bid-ask spreads and no evidence of a change in bid or ask depths following repurchase announcements for a sample of NYSE and AMEX firms. Finally, Miller and McConnell (1995) find no evidence of changes in bid-ask spreads following announcements of OMR programs for a sample of NYSE-listed firms.

Franz et al. (1995) hypothesize that the bid-ask spread will narrow after an OMR program announcement if the announcement signals managers' private information about the future prospects for the firm. They test the hypothesis by examining bid-ask spreads around OMR program announcements by firms trading on the NASDAQ market. Consistent with their hypothesis they find narrower bid-ask spreads after OMR program announcements after controlling for inventory-holding and order processing costs. Franz et al. attribute the narrower bid-ask spreads to a reduction in the informed trading costs associated with the repurchase announcement.

More recent studies examine market liquidity effects on actual repurchase days. Brockman and Chung (2001) refine and test Barclay and Smith's (1988) hypotheses on the electronic order-driven Stock Exchange of Hong Kong. They examine bid-ask spreads and depth on repurchase days and on disclosure days.<sup>13</sup> As a benchmark they use surrounding non-repurchase days. They find that bid-ask spreads widen and market depth deteriorates on repurchase days after controlling for volume, price, and return volatility. On disclosure days, bid-ask spreads and depth generally return to benchmark levels. Brockman and Chung (2001)

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<sup>10</sup> The relative bid-ask spread is the dollar spread divided by the average of the bid and ask prices.

<sup>11</sup> Since the information-asymmetry hypothesis and the competing market-maker hypothesis are not mutually exclusive, their results imply that the information-asymmetry effect dominates the competing market-maker effect.

<sup>12</sup> Amihud and Mendelson (1986) develop and test a model that shows that wider relative bid-ask spreads lead to higher risk-adjusted stock returns and hence increased cost of capital.

<sup>13</sup> Firms listed on the Stock Exchange of Hong-Kong are required to report details of repurchase transactions to the Exchange no later than 09:30 a.m. the following business day. The information is then aggregated by the Exchange and disseminated to data vendors (Vermaelen, 2005).

conclude that market liquidity deteriorates on repurchase days because market participants detect the presence of informed trading and partially, or completely, withdraw from the market. However, the subsequent day, when market participants learn that the source of trading is the repurchasing firm, market liquidity returns to benchmark levels.

Cook et al. (2004) examine bid-ask spreads around repurchase days for NYSE and NASDAQ listed firms. Since details of repurchase transactions are not publicly disclosed in the U.S., they use voluntarily disclosed repurchase trading data from 64 firms. Counter to the results of Brockman and Chung (2001) they find narrower bid-ask spreads on repurchase days relative to benchmark periods.<sup>14</sup> Cook et al. (2004) argue that the spread narrowing is consistent with the notion that, at the time of a repurchase transaction, the firm competes with market makers to provide liquidity on the bid side of the market.

Ginglinger and Hamon (2007) analyze the market liquidity impact of share repurchases for a sample of 352 French firms listed on the electronic order-driven Paris Stock Exchange.<sup>15</sup> Consistent with Brockman and Chung (2001) they find that bid-ask spreads widen and depth decreases on repurchase days. However, in contrast to Brockman and Chung (2001) they argue that the adverse effect on market liquidity is attributed to managers' trade against the trend to support the firm's share price in a depressed market, with the trades taking place at the ask price.

## *2.2 Market liquidity hypotheses*

We develop three non-mutually exclusive hypotheses of the impact of open market share repurchases on market liquidity. Our first hypothesis is an information-asymmetry hypothesis which predicts that the bid-ask spread will widen and depth deteriorate on repurchase days if market participants detect repurchasing firms' trades and suspect informed trading.<sup>16</sup> We also expect that the information-asymmetry effect will be stronger on repurchase days with relatively large repurchase volumes.<sup>17</sup>

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<sup>14</sup> In contrast to Brockman and Chung (2001), Cook et al. (2004) only analyze bid-ask spreads in a univariate setting, and do not control for volume, price, and return volatility.

<sup>15</sup> Firms listed on the Paris Stock Exchange are required to publicly report on a monthly basis, the total number of shares purchased or sold during the previous month (Ginglinger and Hamon, 2007).

<sup>16</sup> Market microstructure models by Copeland and Galai (1983), and Glosten and Milgrom (1985) show that the presence of informed traders with superior information about the future stock price leads to wider bid-ask spreads on a dealer-based market. Brockman and Chung (2000) find that limit-order traders on the electronic order-driven Stock Exchange of Hong-Kong behave like designated dealers/specialists when confronted with the possibility of trading against informed investors (i.e., wider spreads and less market depth).

<sup>17</sup> Easley and O'Hara (1987) show that the probability of an informed trade increases with trade size.

Our second hypothesis predicts that the bid-ask spread will narrow and depth on the bid side increase on repurchase days if managers of repurchasing firms prioritize a low average repurchase price and are patient. Firms with a low attitude on immediacy will more likely repurchase relatively small volumes each repurchase day and submit buy limit orders at the best bid.<sup>18</sup> These orders will establish a lower bound on the bid price which will narrow the bid-ask spread and increase depth on the bid side.

Finally, our third hypothesis predicts that the bid-ask spread will narrow and depth on the bid side decrease on repurchase days if managers of repurchasing firms desire fast execution of the repurchase programs. Firms that require immediacy in the market are more likely to repurchase relatively large volumes each repurchase day and submit buy limit orders within the current bid-ask spread or at the ask price. Buy limit orders within the current bid-ask spread will narrow the bid-ask spread, but probably decrease the depth for the best bid price. Orders that hit the best ask price consumes liquidity on the sell side and therefore increase the bid-ask spread, however, due to information effects in the order process, there is often a new buy order placed within the quotes after a large purchase which will generate an increase in the best bid price, and thereby the bid-ask spread will not necessarily increase, however market depth on the bid side will probably still deteriorate.<sup>19</sup>

### **3. The Swedish regulatory environment for open market share repurchases and trading structure on the Stockholm Stock Exchange**

#### *3.1. Regulatory environment for open market share repurchases*

New legislation in effect from March 10, 2000, provides firms listed on a Swedish stock exchange with the option to buy back shares on the stock market. Repurchase trading on the Stockholm Stock Exchange is regulated by Swedish Company Law, regulatory code by the Swedish Financial Supervisory Authority, and rules in the Stock Exchange's Listing Agreement.

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<sup>18</sup> Glosten (1994) develops a framework in which "patient" traders with a low attitude on immediacy place limit orders at the best bid or within the quotes and thereby supply liquidity to the market.

<sup>19</sup> Bias et al. (1995) find on the electronic order-driven Paris Bourse that after a large purchase which consumes liquidity on the sell side, and thus induces an increase in the ask price, there is often a new buy order placed within the quotes.

Swedish Company Law stipulates that a repurchase program must be approved by the shareholders with two-thirds of the votes at a general shareholder meeting. The shareholder resolution is valid no longer than until the next general shareholder meeting. During each repurchase program a maximum of 10% of the outstanding shares can be repurchased by the firm. Repurchased shares can be kept as treasury shares, resold, cancelled or used in stock option programs.

The Stock Exchange's Listing Agreement stipulates the trading and disclosure rules for the repurchasing firms. The trading rules in the Listing Agreement are similar to the safe harbor rule 10b-18 provided by the U.S. Securities and Exchange Commission (SEC).<sup>20</sup>

With the exception of block transactions, the repurchase size during a single day may not exceed 25% of the average daily trading volume during the four calendar weeks immediately preceding the week of the repurchase.<sup>21</sup> To facilitate surveillance of this rule, the firm can only commission one of the Exchange's member companies on any given repurchase day.<sup>22</sup> Limit orders must be placed within the current bid-ask spread, and this rule also applies to off-exchange block transactions. Firms are prohibited to repurchase shares the last 30 minutes of trading and during the 30 days prior to the publication of annual or interim reports.

Disclosure rules concerning open market repurchases stipulate that firms must report repurchase transactions to the Exchange no later than the opening of the Stock Exchange on the following trading day.<sup>23</sup> The notification must include details of the number of repurchased shares, distributed by class of share, the average price paid per share class, number of treasury shares, and the total number of outstanding shares. The information is published by the Exchange on the Stock Exchange's website. Open market share repurchases are thereby publicly disclosed within one trading day.

### *3.2. Market structure on the Stockholm Stock Exchange*

Trading in shares listed on the Stockholm Stock Exchange is conducted in a computerized order-driven trading system (SAXESS). Traders submit orders in the trading system through Exchange members. There are no designated market makers, however some smaller firms engage liquidity providers. Buy and sell orders entered into the trading system are

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<sup>20</sup> The Securities and Exchange Commission's rule 10b-18 is a voluntary rule in the U.S. which protects repurchasing firms from charges of market manipulation if the rule is followed.

<sup>21</sup> A block transaction is defined as a trade that encompasses at least 250 round lots.

<sup>22</sup> The commission rule ceased to exist July 1, 2005.

<sup>23</sup> After July 1, 2005, firms must report repurchase transactions to the Exchange no later than 30 minutes before the opening of the Stock Exchange on the following trading day.

automatically matched. Limit orders are first prioritized by price and then by time. If a trader requires immediate execution, the trader must submit a buy (sell) limit order that hits the current best ask (bid) price. Traders can submit hidden limit orders, where only a portion of the order volume is displayed in the limit order book. However, the hidden portion has lower priority than the displayed limit orders with the same price. Most orders are traded in the round lot market, where shares are traded in amounts of trading lots.<sup>24</sup> Transactions of large trading lots may be executed off-exchange. Trading rules regulate when off-exchange trades must be made within the current bid-ask spread.<sup>25</sup> Traders must manually enter off-exchange transactions into the trading system within five minutes during the trading day, or no later than 15 minutes before the opening of the Exchange the following trading day.

The Stockholm Stock Exchange offers a high degree of transparency. Traders observe, in real-time, bid and ask prices with corresponding depth, concluded transactions, as well as the identities of Exchange members behind transactions and limit orders.<sup>26</sup>

The tick size on the Stockholm Stock Exchange is related to the share price, and varies from SEK 0.01 to SEK 5.00 during the sample period.

## **4. Data, sample, and market liquidity measures**

### *4.1. Data and sample*

NASDAQ OMX Stockholm provides a repurchase file with details of all repurchases executed on the Exchange. The data include the name of the repurchasing firm, the repurchase date, the total number of shares repurchased during the day distributed by class of share, the average repurchase price, and the total price of repurchased shares. The Exchange also provides annual trading statistics and market capitalization for all the listed shares. Intraday bid-ask quotes with corresponding market depth stamped every 15 minutes and daily traded volumes executed in- and outside the computerized trading system are also obtained from NASDAQ OMX Stockholm.

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<sup>24</sup> For orders smaller than a trading lot and odd lot portions of orders larger than a trading lot, there is a specific odd lot market.

<sup>25</sup> Off-exchange repurchases must always be made within the current bid-ask quotes and reported within five minutes during the trading day, or no later than 15 minutes before the opening of the Exchange the following trading day.

<sup>26</sup> The identity of the Exchange member (broker) behind the limit order is no longer displayed.

We classify the repurchasing firms into industry groups according to the Global Industry Classification System (GICS). GICS codes are obtained from the Thomson Datastream database.

Since intraday data from the Exchange is only available from May 16, 2002, our study covers the period May 16, 2002 to December 30, 2005. During the sample period, 53 Swedish firms executed 3,039 open market share repurchases on the Exchange. We exclude 79 repurchases on the same day, or the day following interim or annual reports.<sup>27</sup> We lack intraday data for four trading days, and therefore we exclude 8 repurchases for three firms. Four firms repurchased shares in two different share classes. We only include one share class per firm in our sample and therefore we exclude 62 repurchases.<sup>28</sup> Due to violation of trading and disclosure rules by four firms, we exclude 84 repurchases.<sup>29</sup> Our final sample comprises 2,806 repurchase days for 53 firms over the sample period.

#### 4.2. Market liquidity measures

In an order-driven market, limit orders provide market liquidity and establish bid-ask spreads and market depth. The bid-ask spread represents the price dimension and the depth represents the quantity dimension of market liquidity. Lee et al. (1993) argue that both dimensions are required to make inferences about market liquidity. We use two spread measures and three depth measures in our study.

The two spread measures we use are *Absolute Spread* and *Relative Spread*. *Absolute Spread* is the daily average of absolute bid-ask spreads in SEK recorded 15 minutes apart over a trading day. The absolute bid-ask spread is the difference between the buy limit order with the highest price and the sell limit order with the lowest price. *Relative Spread* is the daily average of relative bid-ask spreads recorded 15 minutes apart over a trading day. The relative bid-ask spread is the absolute bid-ask spread divided by the bid-ask midpoint.

The three depth measures we use are *Total Depth*, *Bid Depth* and *Ask Depth*. *Total Depth* is the daily average value in SEK of all shares posted at the highest bid and lowest ask price recorded 15 minutes apart over a trading day. *Bid Depth* is the daily average value in SEK of all shares posted at the highest bid price recorded 15 minutes apart over a trading day.

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<sup>27</sup> Swedish firms are not allowed to repurchase shares during the 30 days prior to interim and annual reports.

<sup>28</sup> We exclude repurchases of shares in the share class with the lowest turnover.

<sup>29</sup> Two firms violated the 25 percent rule of maximum repurchase size, one firm repurchased a too small volume off-exchange, and one firm did not disclose the firm's repurchases according to the Exchange's disclosure rules.

Finally, *Ask Depth* is the daily average value in SEK of all shares posted at the lowest ask price recorded 15 minutes apart over a trading day.

## 5. Empirical results

### 5.1. Descriptive statistics

In Table 1 we present trading statistics for the shares of repurchasing and non-repurchasing Swedish firms listed on the Stockholm Stock Exchange.<sup>30</sup> Approximately 17% of the Swedish firms on the Exchange executed open market share repurchases during the sample period. Repurchasing firms are significantly larger than non-repurchasing firms. The median market capitalization value of repurchasing firms is almost four times larger than the median market capitalization value of non-repurchasing firms. The median daily turnover and trade size are also significantly larger for the shares of repurchasing firms, while the turnover rate is significantly lower. The percentage of trading days the shares have been traded during a year and the number of daily trades do not differ significantly between repurchasing and non-repurchasing firms. The median end of day relative bid-ask spread for the shares of repurchasing firms (1.07%) is significantly lower than the relative bid-ask spread for the shares of non-repurchasing firms (2.09%).

Table 2 provides the average end-of-day relative bid-ask spread for each year between 2002 and 2005. For both repurchasing and non-repurchasing firms the average end of day relative bid-ask spread decreases each year during the sample period. The decreasing bid-ask spreads suggests that the overall market liquidity improved each year between 2002 and 2005 on the Exchange.

Table 3 presents summary statistics of the open market share repurchases in the sample. The 2,806 repurchases in the sample account for almost 583 million shares repurchased at a total value of SEK 48,322 million (US\$ 6,040 million).<sup>31</sup> The median repurchasing firm activates 2 repurchase programs and repurchases shares on 17 trading days during the sample period. On average the median firm repurchases 65,587 shares valued at SEK 4.98 million (US\$ 0.62 million) on each repurchase day. The average repurchase volume by the median firm on a repurchase day represents almost 41% of the stock's total trading volume of that

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<sup>30</sup> We only include the share class with the highest turnover for firms with several share classes.

<sup>31</sup> US\$ 1 is approximately SEK 8 as of May 2009.

day. This repurchase volume is higher than the repurchase volumes reported by Cook et al. (2004) for firms on the NYSE and NASDAQ and by Ginglinger and Hamon (2007) for firms on the Paris Bourse.

Panel C in Table 3 reports the repurchase frequency by the repurchasing firms during the sample period. Almost one third of the firms repurchase shares between 11 and 50 trading days. Approximately 11% of the firms repurchase shares on only one trading day, while 30% of the firms repurchase shares on more than 50 trading days.

In Table 4 we classify the repurchasing firms into industry groups according to the Global Industry Classification System (GICS). Almost 36% of the repurchasing firms are classified into the Industrial sector (2-digit GICS code 20) and their repurchase days account to approximately 24% of all repurchase days in the sample. Real Estate (523 repurchase days) and Materials (515 repurchase days) are the industry groups (4-digit GICS code) with the largest number of repurchase days. They each account for approximately 18% of the repurchase days in the sample. Ten percent of the sample consists of repurchase days with a daily repurchase size larger than 25% of the firm's average daily trading volume during the four weeks immediately preceding the week of the repurchase day. According to the Exchange's Listing Agreement, daily repurchases sizes larger than 25% of the firm's average daily trading volume during the four weeks immediately preceding the week of the repurchase are only allowed using block transactions.

## *5.2 Univariate analysis of market liquidity and trading measures*

In Table 5 we compare market liquidity and trading measures on repurchase days with the average measures during surrounding non-repurchase days. For each repurchase day in the sample we construct a benchmark period which constitutes five consecutive trading days before and after the repurchase day.<sup>32</sup> We exclude repurchase days and trading days following repurchase days (disclosure days) in the benchmark periods.<sup>33</sup> Trading days the day before, the same day, and the day after the announcement of interim reports are also removed from the benchmark periods. We match the measures on the repurchase days with

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<sup>32</sup>As a robustness check we also use benchmark periods with three consecutive trading days before and after the repurchase day, as well as five consecutive trading days before the repurchase day. These alternative benchmark periods do not produce substantive changes in our main results.

<sup>33</sup> The benchmark period for each repurchase day begins with the first trading day before and after the repurchase day which is not a repurchase day or a disclosure day.

the average measures during the corresponding benchmark periods and calculate differences in measures for all repurchase days.

Our market liquidity measures *Absolute Spread*, *Relative Spread*, *Total Depth*, *Bid Depth*, and *Ask Depth* are described in section 4.2. The trading measures we analyze are daily trading volume, price, and volatility. *Volume* is the total number of shares traded during a trading day and *Volume Ex Rep* is *Volume* excluding the firm's repurchase volume that day. *Price* is the daily average of the share's bid-ask midpoints in SEK recorded 15 minutes apart over a trading day. *Volatility* is the variance of returns over a trading day where returns are calculated by taking the natural logarithm of bid-ask midpoint relatives 15 minutes apart.

We use a paired *t*-test and a non-parametric Wilcoxon matched-pairs signed-ranks test to test for differences in measures between repurchase days and benchmark periods.

Panel A in Table 5 presents the results for 2,524 repurchase days with repurchase sizes less than 25% of the firm's average daily trading volume during the four weeks preceding the week of the repurchase. Most of these repurchases are executed as limit buy orders in the automated trading system.

The average absolute (relative) bid-ask spread is SEK 1.00 (1.14%) on repurchase days and SEK 1.19 (1.41%) during benchmark periods. The results from the difference test show that the average absolute (relative) bid-ask spread is significantly lower on repurchase days. Average depth on both the bid and ask side is significantly higher on repurchase days than during benchmark periods. The average trading volume and price measures are significantly higher on repurchase days, while average trading volume excluding repurchase volumes is significantly lower on repurchase days. Overall our results show that market liquidity improves, and average trading volumes and share prices increase on repurchase days when firms repurchase less than 25% of the firm's average trading volume during the four weeks preceding the week of the repurchase.

Panel B in Table 5 presents the results for repurchase days with repurchase sizes larger than 25% of the firm's average daily trading volume during the preceding four weeks. On these repurchase days at least one of the repurchase trades is a block trade executed off-exchange. The average absolute (relative) bid-ask spread is SEK 1.41 (1.61%) on repurchase days and SEK 1.37 (1.58%) during benchmark periods. The results from the paired *t*-test show no significant changes in average bid-ask spreads, while the non-parametric signed-ranks test show significantly narrower bid-ask spreads on repurchase days. The average depth increases significantly on the bid and ask side on repurchase days. The average trading

volume is significantly higher on repurchase days than during benchmark periods, while there is no statistically significant change in the average price.

### *5.3 Regression analysis of market liquidity measures*

Previous market microstructure research documents that volume, price, and return volatility are important determinants of market liquidity.<sup>34</sup> The univariate analysis in section 5.2 shows that these variables change on repurchase days and therefore we include daily trading volume, share price, and return volatility as control variables in a multiple regression.<sup>35</sup> Further, the results in Table 2 indicate that average relative bid-ask spreads narrow on the Exchange during the sample period. To control for market-wide changes in market liquidity we include year dummy variables in the regression.

Since we want to examine the marginal market liquidity impact of open market share repurchases on trading days with different repurchase sizes we partition the sample into four repurchase size groups. We define the repurchase size as the daily repurchase volume relative the average trading volume during the four weeks preceding the week of the repurchase. Repurchasing firms must always consider this repurchase size definition as it is used by NASDAQ OMX Stockholm for estimating the maximum allowable daily repurchase size.<sup>36</sup> In the regression we include a repurchase dummy variable for each repurchase size group.<sup>37</sup>

A pooled OLS regression that makes no allowance for fixed unobserved differences between repurchasing firms may produce biased results. We therefore conduct a Breusch-Pagan Lagrange Multiplier (LM) test of firm random effects (Breusch and Pagan, 1980). The chi-square test statistic from the Breusch-Pagan Lagrange Multiplier test rejects the null hypothesis at the 1% level that the variances of firm effects are zero in the model for each of the five market liquidity measures. Thus, pooled OLS regressions may produce biased estimators. To compare the firm fixed effects model and the firm random effects model we conduct a Hausman Specification test (Hausman, 1978). The chi-square test statistic from the Hausman test rejects the null hypothesis at the 1% level that the firm effects are uncorrelated with the other regressors in the model for each of the five market liquidity measures. Thus, we use the following firm fixed effects regression:

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<sup>34</sup> See, for example, Benston and Hagerman (1974), and Copeland and Galai (1983).

<sup>35</sup> Prior research also documents a negative relationship between bid-ask spreads and firm size. Since we use a firm fixed effects regression in our analysis, we also control for this effect.

<sup>36</sup> The maximum daily repurchase size is 25% of the average trading volume during the preceding four weeks of the repurchase, except for off-exchange block transactions.

<sup>37</sup> Since the relationship between repurchase size and market liquidity may be non-linear, we use dummy variables for different repurchase size intervals and not a quantitative variable for repurchase size.

$$\begin{aligned}
Liquidity_{i,t} = & \alpha_1 + \sum_{i=2}^N \alpha_i + \beta_1 REP\_SMALL_{i,t} + \beta_2 REP\_MEDIUM_{i,t} + \beta_3 REP\_LARGE_{i,t} + \beta_4 REP\_BLOCK_{i,t} \\
& + \delta_1 LNVOLUME_{i,t} + \delta_2 LNPRICE_{i,t} + \delta_3 LNVOLAT_{i,t} + \sum_{j=2002}^{2004} \gamma_j YEARDUM_{i,t} + \varepsilon_{i,t}
\end{aligned} \tag{1}$$

*Liquidity* is the dependent variable and is represented by either the natural logarithm of *Absolute Spread*, *Relative Spread*, *Total Depth*, *Bid Depth*, or *Ask Depth*.<sup>38</sup> *Absolute Spread* is the daily average of intraday absolute bid-ask spreads. *Relative Spread* is the daily average of intraday relative bid-ask spreads. The relative bid-ask spread is the absolute bid-ask spread divided by the bid-ask midpoint. *Total Depth* is the daily average value of all shares posted at the highest bid and lowest ask price. *Bid Depth* is the daily average value of all shares posted at the highest bid price. *Ask Depth* is the daily average value of all shares posted at the lowest ask price. *REP\_SMALL* (*REP\_MEDIUM*, *REP\_LARGE*, *REP\_BLOCK*) is a dummy variable coded one if the firm's repurchase volume is less than 10% (10% to 20%, 20% to 25%, more than 25%) of the average daily trading volume during the four weeks preceding the week of the repurchase, and zero otherwise. *LNVOLUME* is the natural logarithm of the total trading volume executed in the automated trading system during a trading day.<sup>39</sup> *LNPRICE* is the natural logarithm of the daily average of bid-ask midpoints. *LNVOLAT* is the natural logarithm of the variance of returns over a trading day. We include a year dummy variable (*YEARDUM*) for 2002, 2003 and 2004 (2005 is the benchmark year). All non-dummy variables except *LNVOLUME* represent daily averages of intraday data taken at 15 minute intervals.

The dataset includes observations on repurchase days and benchmark periods defined in section 5.2. In the benchmark periods we exclude repurchase days, disclosure days, and trading days without transactions. Trading days the day before, the same day, and the day after the announcement of interim reports are also removed from the benchmark periods.

Table 6 provides the results from the firm fixed effects regression for each of the five market liquidity measures. We adjust the standard errors of the estimated coefficients for heteroskedasticity using White (1980) robust estimates of standard errors and report the *p*-values in the table. The goodness of fit is relatively high for all five regressions with adjusted R-squares between 0.84 and 0.93.

<sup>38</sup> Owing to the possibility of skewness in the untransformed measures, all non-dummy variables are transformed to their log values as logged variables are more normally distributed. The Shapiro-Francia test for normality do not reject the null hypothesis that the log-transformed variables are normally distributed.

<sup>39</sup> The variable for volume is defined as daily trading volume in the automated trading system because it determines changes in market liquidity better than total trading volume which also includes off-exchange volumes.

The estimated coefficients for the control variables *LN*VOLUME, *LN*PRICE, and *LN*VOLAT are statistically significant at the 1% level and their signs are consistent with previous research. The results show that larger trading volumes are associated with narrower bid-ask spreads and deeper depth. Higher share prices are associated with wider absolute bid-ask spreads, narrower relative bid-ask spreads, and higher depth. Higher intraday return volatility is associated with wider bid-ask spreads and less depth. All the estimated coefficients on the year dummies are statistically significant at least on the 10% level (coefficients and *p*-values are not reported in Table 6).

Next we turn to the estimated coefficients on the four repurchase dummy variables *REP\_SMALL*, *REP\_MEDIUM*, *REP\_LARGE*, and *REP\_BLOCK*. Since we control for volume, price, and volatility, the estimated coefficients on the repurchase dummy variables determines the marginal impact of open market share repurchases on market liquidity.

On repurchase days with small repurchase sizes (*REP\_SMALL*) bid-ask spreads narrow (statistically significant at the 10% level) and depth on the bid side increases (statistically significant at the 1% level). This result is consistent with our second hypothesis in which we suggest that firms which repurchase relatively small daily repurchase sizes submit buy limit orders at the bid to a large extent. This trading behavior contributes to market liquidity through narrower bid-ask spreads and deeper depth on the bid side since a lower bound on the bid price is established.

On repurchase days with medium repurchase sizes (*REP\_MEDIUM*) bid-ask spreads narrow (statistically significant at the 5% level). The result indicates that firms submit buy limit orders at the bid or within the quotes to a large extent when they repurchase medium repurchase sizes on a repurchase day. This trading behavior narrows bid-ask spreads without necessarily changing the depth on the bid side.

On repurchase days with large repurchase sizes (*REP\_LARGE*) bid-ask spreads narrow (statistically significant at the 1% level) and order depth on the bid side deteriorates (statistically significant at the 1% level). This result is consistent with our third hypothesis in which we suggest that firms which repurchase close to the maximum allowable repurchase size each repurchase day submit buy limit orders within the current bid-ask spread or at the ask price to a large extent. This trading behavior decreases bid-ask spreads but deteriorates depth on the bid side.

On repurchase days when at least part of the repurchase trades are made as off-exchange block transactions (*REP\_BLOCK*) bid-ask spreads widen (statistically significant at the 10% level) and depth increases. It is more difficult to interpret these results since repurchase

trading may be executed off-exchange as well as in the automated trading system on these repurchase days. If however market participants suspect informed trading on these repurchase days the wider bid-ask spread is consistent with our information-asymmetry hypothesis.<sup>40</sup>

#### 5.4 Robustness test

In section 5.3 we suggest that repurchasing firms often submit buy limit orders at the bid on repurchase days with small repurchase sizes and submit buy limit orders within the current bid-ask spread or at the ask on repurchase days with large repurchase sizes. As a robustness test of these trading behaviors we analyze the average repurchase price relative to the average of intraday bid-ask midpoints on repurchase days. We expect to find a low average repurchase price relative the intraday average of bid-ask midpoints on repurchase days with relatively small repurchase sizes and a high average repurchase price relative to the average of intraday midpoint bid-ask on repurchase days with relatively large repurchase sizes.

As can be seen in Table 7, the percentage of repurchase days with an average repurchase price above the average of intraday bid-ask midpoints is higher on repurchase days with large repurchase sizes. On repurchase days with large (small) repurchase sizes we find that 67.2% (49.1%) of the repurchase days have an average repurchase price above the average of intraday bid-ask midpoints. We also analyze the relative price difference between the average repurchase price and the average of intraday bid-ask midpoints over a trading day on repurchase days with various repurchase sizes. The relative price difference is defined as:

$$Relative\ Price\ difference_{i,t} = \frac{Repurchase\ Price_{i,t} - BidAsk\ Midpoint_{i,t}}{BidAsk\ Midpoint_{i,t}} \quad (3)$$

where  $Repurchase\ Price_{i,t}$  is the average daily repurchase price for firm  $i$  on repurchase day  $t$ , and  $BidAsk\ Midpoint_{i,t}$  is the average of intraday bid-ask midpoints for firm  $i$  on repurchase day  $t$ . The results in Table 7 show that both the mean and median of the *Relative Price difference* is lower on repurchase days with small repurchase sizes than on repurchase days with large repurchase sizes. On repurchase days with small repurchase sizes the average repurchase price is on average 0.1% lower than the average of intraday bid-ask midpoints. On repurchase days with large repurchase sizes the average repurchase price is on average 0.3% higher than the average of intraday bid-ask midpoints. Overall the results from the robustness

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<sup>40</sup> Traders must manually enter off-exchange transactions and internal transactions into the trading system within five minutes during the trading day, or no later than 15 minutes before the opening of the Exchange the following trading day.

tests are consistent with the predicted trading behavior by the repurchasing firms on repurchase days with various repurchase sizes.

## **6. Conclusion**

This study extends earlier empirical research on the market liquidity impact of open market share repurchases. We examine 2,806 repurchases by 53 firms listed on the electronic order-driven Stockholm Stock Exchange.

Overall, we find that repurchase trading contributes to market liquidity through narrower bid-ask spreads and increased depth. After controlling for volume, price, and volatility, we find an improvement in bid-ask spreads of approximately 3% on repurchase days except for repurchases executed as off-exchange block transactions for which we find a significantly higher bid-ask spread. Our main results are consistent with Cook et al. (2004) who find that repurchase trading narrows bid-ask spreads for firms listed on NASDAQ and the NYSE.

Interestingly our results stand in contrast to Brockman and Chung (2001) and Ginglinger and Hamon (2007) who analyze the market liquidity impact of share repurchases on the electronic order driven Exchanges in Hong-Kong respectively Paris.

We find that changes in market liquidity on trading days with open market share repurchases are related to the trading behavior by the repurchasing firms. We argue that firms with patient managers who prioritize a low average repurchase price, will more likely submit buy limit orders at the current bid price and repurchase relatively small volumes each repurchase day. This trading behavior establish a lower bound on the bid price which narrows the bid-ask spread and increases depth on the bid side. Firms with managers who prioritize a fast execution of repurchase programs are more likely to submit buy limit orders within the current bid-ask spread or at the ask price and repurchase close to the maximum allowable repurchase size each repurchase day. This trading strategy also decreases the bid-ask spread but deteriorates depth on the bid side with lower volumes.

Consistent with the predicted trading behavior we find that the average daily repurchase price relative the average of intraday bid-ask midpoints is higher on repurchase days with large repurchase sizes than on repurchase days with small repurchase sizes. We believe our results contribute to the evidence and debate about the market impact of open market repurchases and to issues related to repurchase strategies.

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**Table 1****Trading statistics for Swedish shares on the Stockholm Stock Exchange**

Trading statistics are provided for Swedish shares on the Stockholm Stock Exchange during the sample period May 16, 2002 to December 30, 2005. Firms with one or more open market share repurchases during the sample period are classified as *Repurchase Firms*. Only the share class with the highest turnover is included for firms with several share classes. The measures are average annual measures averaged across the sample years for each firm. Market capitalization is the average end-of-year market value of the firms' listed shares during the sample period. The end-of-day relative bid-ask spread is the absolute bid-ask spread at the end of the day divided by the bid-ask midpoint at the end of the day. The *t*-statistics are for the difference in mean measures between repurchase and non-repurchase firms. W-statistics are from the non-parametric Wilcoxon rank sum test. *p*-values from the difference tests are reported in brackets.

	<i>Repurchase Firms</i> (n=53)	<i>Non-Repurchase Firms</i> (n=267)	Difference test	
	Mean (Median)	Mean (Median)	<i>t</i> -statistic [ <i>p</i> -value]	W-statistic [ <i>p</i> -value]
Market capitalization (MSEK)	16,284 (2,725)	6,777 (698)	2.40 [0.017]	4.34 [<0.001]
Daily turnover (TSEK)	61,659 (4,147)	32,728 (1,351)	1.09 [0.275]	2.27 [0.018]
Trade size (SEK)	173,082 (117,422)	87,401 (48,227)	5.15 [<0.001]	5.49 [<0.001]
Turnover rate per share (percent)	58.66 (40.36)	80.76 (56.19)	-1.83 [0.069]	-1.81 [0.071]
Percentage of trading days the shares have been traded	93.77 (99.60)	90.96 (98.41)	1.26 [0.210]	1.14 [0.254]
Number of trades per trading day	151 (37)	128 (30)	0.37 [0.715]	0.31 [0.754]
End-of-day relative bid-ask spread (percent)	1.60 (1.07)	3.19 (2.09)	-2.59 [0.010]	-3.47 [0.001]

**Table 2****Average end-of-day relative bid-ask spreads for Swedish shares on the Stockholm Stock Exchange**

Trading statistics are provided for Swedish shares on the Stockholm Stock Exchange during the sample period May 16, 2002 to December 30, 2005. Firms with one or more open market share repurchases during the sample period are classified as *Repurchase Firms*. Only the share class with the highest turnover is included for firms with several listed share classes. The end of day relative bid-ask spread is the absolute bid-ask spread at the end of the day divided by the bid-ask midpoint at the end of the day.

	<i>Repurchase Firms</i>		<i>Non-Repurchase Firms</i>	
	Mean (Median)	Number of firms	Mean (Median)	Number of firms
Average end of day relative bid-ask spread 2002 (percent)	2.44 (1.29)	37	5.07 (3.27)	260
Average end of day relative bid-ask spread 2003 (percent)	1.95 (1.30)	35	3.14 (2.23)	246
Average end of day relative bid-ask spread 2004 (percent)	0.81 (0.66)	26	1.48 (1.19)	252
Average end of day relative bid-ask spread 2005 (percent)	0.74 (0.47)	14	1.06 (0.90)	257

**Table 3****Summary statistics of open market share repurchase activity**

The sample comprises 2,806 open market share repurchase days during the period May 16, 2002 to December 30, 2005 for 53 Swedish firms listed on the Stockholm Stock Exchange. *Panel A* provides statistics of the open market share repurchases in the sample. *Panel B* presents open market share repurchase activity per firm, and *Panel C* provides the repurchase frequency of the repurchasing firms.

*Panel A: Statistics of repurchases in the sample*

Number of repurchase days	2,806
Number of shares repurchased over the sample period	582,967,947
Value of shares repurchased over the sample period (MSEK)	48,322

*Panel B: Repurchase activity per firm*

	Mean	Median
Number of repurchase programs per firm	1.92	2
Number of repurchase days per firm	52.94	17
Average number of shares repurchased by a firm on a repurchase day	262,738	65,587
Average value of shares repurchased by a firm on a repurchase day (MSEK)	17.69	4.98
Average repurchase volume by a firm on a repurchase day as a percentage of the stock's total trading volume of that day	46.36	40.93

*Panel C: Repurchase frequency*

	Number	Percent
Firms with 1 repurchase day	6	11.3
Firms with 2 to 10 repurchase days	14	26.4
Firms with 11 to 50 repurchase days	17	32.1
Firms with 51 to 100 repurchase days	8	15.1
Firms with over 100 repurchase days	8	15.1

**Table 4****Repurchasing firms and repurchases classified into industry groups**

The sample comprises 2,806 open market share repurchase days during the period May 16, 2002 to December 30, 2005 for 53 Swedish firms listed on the Stockholm Stock Exchange. Repurchasing firms are classified into industry groups according to the Global Industry Classification System (4-digit GICS codes). Repurchase days >25% are repurchase days with repurchase sizes larger than 25% of the firm's average daily trading volume during the four calendar weeks immediately preceding the week of the repurchase day.

GICS Industry Group (4-digit GICS code)	Number (percentage) of firms	Repurchase days (percentage)	Repurchase days >25% (percentage <sup>*</sup> )
Materials (1510)	5 (9.4)	515 (18.4)	27 (5.2)
Capital Goods (2010)	14 (26.4)	357 (12.7)	36 (10.1)
Commercial Services & Supplies (2020)	2 (3.8)	62 (2.2)	0 (0.0)
Transportation (2030)	3 (5.7)	262 (9.3)	9 (3.4)
Consumer Durables & Apparel (2520)	1 (1.9)	89 (3.2)	6 (6.7)
Hotels, Restaurants & Leisure (2530)	1 (1.9)	233 (8.3)	2 (0.9)
Media (2540)	1 (1.9)	19 (0.7)	0 (0.0)
Retailing (2550)	1 (1.9)	22 (0.8)	7 (31.8)
Food, Beverage & Tobacco (3020)	2 (3.8)	222 (7.9)	6 (2.7)
Health Care Equipment (3510)	1 (1.9)	10 (0.4)	0 (0.0)
Pharmaceuticals & Biotechnology (3520)	1 (1.9)	68 (2.4)	7 (10.3)
Banks (4010)	4 (7.5)	299 (10.7)	93 (31.1)
Diversified Financials (4020)	4 (7.5)	93 (3.3)	17 (18.3)
Real Estate (4040)	8 (15.1)	523 (18.6)	49 (9.4)
Software & Services (4510)	2 (3.8)	18 (0.6)	9 (50.0)
Technology Hardware & Equipment (4520)	3 (5.7)	14 (0.5)	14 (100.0)
Total	53 (100)	2,806 (100)	282 (10.0)

\* Percentage of repurchase days >25% in the specific industry group.

**Table 5**  
**Univariate analysis of market liquidity and trading measures**

The sample comprises 2,806 open market share repurchase days during the period May 16, 2002 to December 30, 2005 for 53 Swedish firms listed on the Stockholm Stock Exchange. For each repurchase day in the sample we construct a benchmark period which constitutes five consecutive trading days before and after the repurchase day. In the benchmark periods we exclude repurchase days and trading days following repurchase days (disclosure days). Trading days the day before, the same day, and the day after the announcement of interim reports are also removed from the benchmark periods. We match the measures on the repurchase days with the average measures during the corresponding benchmark periods and calculate differences in measures for all repurchase days. *Absolute Spread* is the daily average of absolute bid-ask spreads in SEK recorded 15 minutes apart over a trading day. *Relative Spread* is the daily average of relative bid-ask spreads recorded 15 minutes apart over a trading day. The relative bid-ask spread is the absolute bid-ask spread divided by the bid-ask midpoint. *Total Depth* is the daily average value in SEK of all shares posted at the highest bid and lowest ask price recorded 15 minutes apart over a trading day. *Bid Depth* is the daily average value in SEK of all shares posted at the highest bid price recorded 15 minutes apart over a trading day. *Ask Depth* is the daily average value in SEK of all shares posted at the lowest ask price recorded 15 minutes apart over a trading day. *Volume* is the total trading volume recorded over a trading day. *Volume Ex Rep* is the total trading volume recorded over a trading day excluding repurchased shares that day. *Price* is the daily average of bid-ask midpoints in SEK recorded 15 minutes apart over a trading day. *Volatility* is the variance of returns over a trading day where returns are calculated by taking the natural logarithm of bid-ask midpoint relatives 15 minutes apart. The *t*-statistics are from the paired *t*-test for the differences in mean measures between repurchase days and benchmark periods. The *W*-statistics are from the non-parametric Wilcoxon matched-pairs signed-ranks test. *p*-values from the difference tests are reported in brackets.

*Panel A: Repurchase days with repurchase sizes less than 25% of the firm's average daily trading volume during the four calendar weeks immediately preceding the week of the repurchase.*

Variable	<i>Repurchase days</i>	<i>Benchmark periods</i>	Difference	Difference test	
	Mean (Median)	Mean (Median)	Mean (Median)	<i>t</i> -statistic [ <i>p</i> -value]	<i>W</i> -statistic [ <i>p</i> -value]
<i>Absolute Spread</i>	1.0045 (0.5303)	1.1948 (0.5612)	-0.1903 (-0.0214)	-7.82 [<0.001]	-16.26 [<0.001]
<i>Relative Spread</i>	0.0114 (0.0071)	0.0141 (0.0079)	-0.0027 (-0.0002)	-11.23 [<0.001]	-15.42 [<0.001]
<i>Total Depth</i>	7,137,606 (450,750)	6,068,201 (363,202)	1,069,404 (17,586)	5.37 [<0.001]	7.71 [<0.001]
<i>Bid Depth</i>	3,359,366 (204,513)	2,812,995 (168,507)	546,371 (461)	4.99 [<0.001]	4.31 [<0.001]
<i>Ask Depth</i>	3,778,239 (247,264)	3,255,206 (191,471)	523,032 (8,652)	4.47 [<0.001]	6.53 [<0.001]
<i>Volume</i>	947,288 (53,750)	897,384 (34,134)	49,904 (1,155)	2.10 [0.036]	2.98 [0.003]
<i>Volume Ex Rep</i>	813,477 (42,602)	897,384 (34,134)	-83,907 (-1,932)	-3.48 [0.001]	-7.54 [<0.001]
<i>Price</i>	104.6263 (92.4470)	104.3686 (91.8122)	0.2576 (0.0766)	2.67 [0.008]	2.66 [0.008]
<i>Volatility</i> ( $\times 10^{-6}$ )	29.2769 (6.3394)	20.0183 (8.4552)	9.2586 (-1.3229)	1.18 [0.237]	-9.97 [<0.001]
Number of observations	2,524	2,524	2,524		
Number of firms	41	41	41		

*Panel B: Repurchase days with repurchase sizes larger than 25% of the firm's average daily trading volume during the four calendar weeks immediately preceding the week of the repurchase.*

Variable	<i>Repurchase days</i>	<i>Benchmark periods</i>	Difference	Difference test	
	Mean (Median)	Mean (Median)	Mean (Median)	<i>t</i> -statistic [ <i>p</i> -value]	W-statistic [ <i>p</i> -value]
<i>Absolute Spread</i>	1.4150 (0.6000)	1.3713 (0.6561)	0.0437 (-0.0157)	0.48 [0.631]	-3.28 [0.001]
<i>Relative Spread</i>	0.0161 (0.0066)	0.0158 (0.0070)	0.0002 (-0.0002)	0.32 [0.750]	-2.69 [0.007]
<i>Total Depth</i>	15,452,903 (1,026,470)	12,959,820 (761,435)	2,493,083 (29,978)	3.58 [<0.001]	4.05 [<0.001]
<i>Bid Depth</i>	7,110,068 (399,825)	5,872,336 (330,035)	1,237,731 (1,067)	2.92 [0.004]	1.76 [0.079]
<i>Ask Depth</i>	8,342,835 (466,084)	7,087,484 (424,832)	1,255,351 (18,188)	3.49 [0.001]	3.91 [<0.001]
<i>Volume</i>	2,330,848 (381,750)	1,427,057 (44,736)	903,790 (235,140)	6.25 [<0.001]	12.12 [<0.001]
<i>Volume Ex Rep</i>	1,460,886 (75,163)	1,427,057 (44,736)	33,828 (1,363)	0.31 [0.760]	2.12 [0.034]
<i>Price</i>	100.5591 (92.0669)	100.3851 (91.8122)	0.1740 (0.0104)	0.97 [0.334]	0.75 [0.452]
<i>Volatility</i> ( $\times 10^{-6}$ )	21.6651 (6.1751)	24.7162 (9.7964)	-3.0511 (-1.4970)	-1.07 [0.283]	-3.65 [<0.001]
Number of observations	282	282	282		
Number of firms	41	41	41		

**Table 6**  
**Firm fixed effects regression of market liquidity measures**

The sample comprises 2,806 open market share repurchase days during the period May 16, 2002 to December 30, 2005 for 53 Swedish firms listed on the Stockholm Stock Exchange. The dataset includes observations on repurchase days and benchmark periods. The benchmark period constitutes five consecutive non-repurchase trading days before and after a repurchase day. In the benchmark periods we exclude repurchase days, disclosure days, and trading days without transactions. Trading days the day before, the same day, and the day after the announcement of interim reports are also removed from the benchmark periods. The table reports the parameter estimates from the following firm fixed effects regression:

$$Liquidity_{i,t} = \alpha_1 + \sum_{i=2}^N \alpha_i + \beta_1 REP\_SMALL_{i,t} + \beta_2 REP\_MEDIUM_{i,t} + \beta_3 REP\_LARGE_{i,t} + \beta_4 REP\_BLOCK_{i,t} + \delta_1 LNVOLUME_{i,t} + \delta_2 LNPRICE_{i,t} + \delta_3 LNVOLAT_{i,t} + \sum_{j=2002}^{2004} \gamma_j YEARDUM^j_{i,t} + \varepsilon_{i,t}$$

$Liquidity_{i,t}$  is the dependent variable and is represented by either the natural logarithm of *Absolute Spread*<sub>*i,t*</sub>, *Relative Spread*<sub>*i,t*</sub>, *Total Depth*<sub>*i,t*</sub>, *Bid Depth*<sub>*i,t*</sub>, or *Ask Depth*<sub>*i,t*</sub>. *Absolute Spread*<sub>*i,t*</sub> is the daily average of absolute bid-ask spreads in SEK recorded 15 minutes apart over day *t* for firm *i*. *Relative Spread*<sub>*i,t*</sub> is the daily average of relative bid-ask spreads recorded 15 minutes apart over day *t* for firm *i*. The relative bid-ask spread is the absolute bid-ask spread divided by the bid-ask midpoint. *Total Depth*<sub>*i,t*</sub> is the daily average value in SEK of all shares posted at the highest bid and lowest ask price recorded 15 minutes apart over day *t* for firm *i*. *Bid Depth*<sub>*i,t*</sub> is the daily average value in SEK of all shares posted at the highest bid price recorded 15 minutes apart over day *t* for firm *i*. *Ask Depth*<sub>*i,t*</sub> is the daily average value in SEK of all shares posted at the lowest ask price recorded 15 minutes apart over day *t* for firm *i*.  $REP\_SMALL_{i,t}$  ( $REP\_MEDIUM_{i,t}$ ,  $REP\_LARGE_{i,t}$ ,  $REP\_BLOCK_{i,t}$ ) is a dummy variable coded one if firm *i* has repurchased on day *t*, a repurchase size less than 10% (10% to 20%, 20% to 25%, more than 25%) of the average daily trading volume during the four weeks preceding the week of the repurchase, and zero otherwise.  $LNVOLUME_{i,t}$  is the natural logarithm of the total trading volume executed in the automated trading system on trading day *t* for firm *i*.  $LNPRICE_{i,t}$  is the natural logarithm of the daily average of bid-ask midpoints in SEK recorded 15 minutes apart over day *t* for firm *i*.  $LNVOLAT_{i,t}$  is the natural logarithm of the variance of returns over day *t* for firm *i* where returns are calculated by taking the natural logarithm of bid-ask midpoint relatives 15 minutes apart. Regression parameters are estimated with year dummies  $YEARDUM^j$  where *j* is the year the repurchase takes place (2005 is the benchmark year with no year dummy variable). The constant and coefficients on firm and year dummies are not reported. *p*-values in parentheses are adjusted for heteroskedasticity using White (1980) robust estimates of standard errors. \*, \*\* and \*\*\* denote that the value is significantly different from zero at the 10%, 5%, and 1% levels.

Explanatory Variable	No. of dum=1	<i>Absolute Spread</i>	<i>Relative Spread</i>	<i>Total Depth</i>	<i>Bid Depth</i>	<i>Ask Depth</i>
		coefficient (p-value)	coefficient (p-value)	coefficient (p-value)	coefficient (p-value)	coefficient (p-value)
<i>REP_SMALL</i>	859	-0.0219* (0.092)	-0.0225* (0.083)	0.1003*** (<0.001)	0.1191*** (<0.001)	0.0723*** (0.010)
<i>REP_MEDIUM</i>	688	-0.0321** (0.044)	-0.0321** (0.044)	-0.0097 (0.691)	-0.0400 (0.146)	0.0021 (0.940)
<i>REP_LARGE</i>	977	-0.0388*** (0.010)	-0.0385** (0.011)	-0.0182 (0.442)	-0.0777*** (0.003)	0.0320 (0.244)
<i>REP_BLOCK</i>	282	0.0437* (0.059)	0.0438* (0.058)	0.1150*** (0.002)	0.0723* (0.094)	0.1389*** (0.002)
<i>LNVOLUME</i>		-0.1695*** (<0.001)	-0.1696*** (<0.001)	0.1905*** (<0.001)	0.2237*** (<0.001)	0.1740*** (<0.001)
<i>LNPRICE</i>		0.6155*** (<0.001)	-0.3851*** (<0.001)	0.4225*** (<0.001)	0.5114*** (<0.001)	0.4209*** (<0.001)
<i>LNVOLAT</i>		0.1546*** (<0.001)	0.1548*** (<0.001)	-0.1064*** (<0.001)	-0.1007*** (<0.001)	-0.0996*** (<0.001)
Year dummies		Yes	Yes	Yes	Yes	Yes
Number of observations		5,376	5,376	5,376	5,376	5,376
Number of firms		53	53	53	53	53
Adjusted R <sup>2</sup>		0.868	0.845	0.926	0.910	0.900

**Table 7****Relationship between repurchase price and repurchase size**

The sample comprises 2,806 open market share repurchase days during the period May 16, 2002 to December 30, 2005 for 53 Swedish firms listed on the Stockholm Stock Exchange. *Small reprice* (*Medium reprice*, *Large reprice*, *Block*) is a repurchase day with a repurchase size less than 10% (10% to 20%, 20% to 25%, larger than 25%) of the average daily trading volume during the four weeks preceding the week of the repurchase. *Relative Price difference* is defined as:

$$Relative\ Price\ difference_{i,t} = \frac{Repurchase\ Price_{i,t} - BidAsk\ Midpoint_{i,t}}{BidAsk\ Midpoint_{i,t}} ,$$

where *Repurchase Price<sub>i,t</sub>* is the average daily repurchase price for firm *i* on repurchase day *t*, and *BidAsk Midpoint<sub>i,t</sub>* is the average of intraday bid-ask midpoints for firm *i* on repurchase day *t*.

	<i>Small reprice</i>	<i>Medium reprice</i>	<i>Large reprice</i>	<i>Block</i>
Number of repurchase days	859	688	977	282
Percentage of repurchase days with a daily average repurchase price above the average of intraday bid-ask midpoints	49.1	57.6	67.2	62.4
Mean <i>Relative Price difference</i> (percent)	-0.10	0.10	0.30	0.20
Median <i>Relative Price difference</i> (percent)	0.00	0.05	0.15	0.11