Measuring and Predicting Liquidity in the Stock Market

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Introduction

"Liquidity is the lifeblood of financial markets. Its adequate provision is critical for the smooth operation of an economy. Its sudden erosion in even a single market segment or in an individual instrument can stimulate disruptions that are transmitted through increasingly interdependent and interconnected financial markets worldwide. Despite its importance, problems in measuring and monitoring liquidity risk persist."[1]

In recent years a huge amount of literature has emerged that deals in a certain way with liquidity. The security exchanges have also recognized the importance of liquidity and plan the introduction and public communication of liquidity measures, as Gomber & Schweickert (2002), p. 489 state. But in all the literature there are very few descriptions of what liquidity really is, and a consistent summary of liquidity measures with a quantitative comparison is completely missing. We know a lot about the behavior of daily returns and daily volatility, and we can forecast them, but there are few studies about the feasibility of predicting liquidity of markets out of sample. In an intraday context the daily seasonality of liquidity measures and their co-movement is well known and described for the Swiss market in Ranaldo (2001). Aside from the seasonality issue, the common movement of intraday liquidity measures is unknown and not compared to the price changes. There are very few studies such as Ranaldo (2003) that explain what happens in an intraday context to liquidity and returns if new information reaches the market. As Fernandez (1999) stresses, there is also a lack of knowledge among practitioners of how liquidity can be measured and how liquidity risk can be built into the risk management process.

A recent paper in the intraday context is Chordia, Roll & Subrahmanyam (2001), which investigates a huge sample of eleven years (about 2800 trading days) that yield 3.5 billion transactions. This study describes the market-wide variability of liquidity and searches for patterns in liquidity and trading activity. I would like to approach this subject on a more general basis with respect to two aspects:

- How can liquidity be measured?
- How can liquidity be predicted?

Those two general questions will be examined empirically with a sample of eighteen stocks from the Swiss Market Index using three months of intraday data. Bond and derivatives markets are left out.

The first part of this thesis about liquidity measurement in stock markets looks more closely at the following questions:

[1]Fernandez (1999), p. 1.

- What is liquidity in an economic sense? What are the different aspects of liquidity and how do they show up in the limit order book of the Swiss Exchange? Liquidity is not a one-dimensional variable, but may be looked at from different points of view, such as time, tightness, depth, or resiliency. The first chapter investigates liquidity in an intuitive manner to delineate the fields of research.

- How can these aspects be incorporated into liquidity measures? Due to the different aspects, there is no single liquidity measure. A vast variety of liquidity measures exists that will be summarized and described with their advantages and shortcomings in the context of a limit order book in chapter 1.

- What are the special problems that arise if liquidity is measured on an intraday basis in contrast to daily data? The organization of trading at the Swiss Exchange will be described in chapter 2.2, which is necessary to understand the empirical part. The intraday data has to be cleaned from irregular data and certain filters have to be applied. It is necessary to produce out of the inhomogeneous time series homogenous (equally spaced) ones by interpolation.

- How do the different liquidity measures behave with respect to each other? The summary statistics of the different liquidity measures are presented and the most liquid stock of the sample is determined in chapter 3. The correlations among the liquidity measures are investigated to sort out some liquidity measures that are redundant.

- Can the number of liquidity measures be reduced without loss of information? To determine the common behavior of the liquidity measures a principal component analysis is carried out in chapter 4. This will answer the question how many liquidity measures are essential.

In the second part the changes in liquidity over time will be investigated.

- Do changes in some liquidity measures lead to changes in other ones? Is there an impact of returns on liquidity? With the liquidity measures from the first part that are necessary to capture the different dimensions of liquidity, I will investigate the lead-lag patterns in liquidity using a vector autoregressive model. In this model, the stock returns are also included to determine their influence on liquidity.

- Finally, I will look into the question whether liquidity can be predicted. A model to predict the liquidity measures determined at the end of part I is empirically tested in chapter 6.

While the market microstructure certainly plays an important role in determining liquidity, the present thesis does not attempt to build another model of different types of traders who interact at the stock exchange.[2] On the contrary, liquidity will be investigated as a general measure which does not depend on any particular market microstructure model.

[2] Madhavan (2000) gives an excellent overview of the market microstructure literature. He groups this large area of research into: (1) price formation, (2) market structure and design, (3) transparency, and (4) applications to other areas of finance. All types of market microstructure models have a reference to liquidity but none seems to dominate the others.

As Andersen & Bollerslev (1998) stress, there are many studies that look at one of the above subjects in isolation. The goal of this dissertation is to combine the different approaches to liquidity measurement and present new insights about their interrelation.

Part I

Liquidity – Definition and Measurement

The first part gives an overview of the aspects of liquidity and its measurement. The first chapter introduces different dimensions and definitions of liquidity in an economic setting. I show that liquidity is not easily defined and measured. A thorough analysis must incorporate different points of view. Also, the different liquidity measures are summarized and described in section 1.2 with respect to the different aspects of liquidity. Chapter 2 presents the data. The properties of the limit order book at the Swiss Exchange are described and special attention is focused on the use of intraday data and the problems that may arise in this context. In chapter 3, I describe the summary statistics for the different liquidity measures and their interrelation. I demonstrate that different liquidity measures do not necessarily display the same highs and lows if they capture different dimensions of liquidity. The principal component analysis at the end of part I will provide a set of liquidity measures that is able to capture the liquidity of an asset with probably all of its dimensions.

Chapter 1

Liquidity in an Economic Framework

1.1 Properties of Liquidity

Liquidity is not easily defined and no common definition of liquidity exists. Usually, simple definitions in one sentence like "Liquidity in a financial market – the ability to absorb smoothly the flow of buying and selling orders – ..." as in Shen & Starr (2002), p. 1 are not able to capture the phenomenon "liquidity", because liquidity is not a one-dimensional variable but includes several dimensions.[1] Earlier work focused almost uniquely on the spread. Lee, Mucklow & Ready (1993) stress the necessity to include the quantity dimension of depth to the price dimension of the spread. Usually the following four aspects or dimensions are distinguished:[2]

1. Trading Time: The ability to *execute a transaction immediately* at the prevailing price.

   The waiting time between subsequent trades or the inverse, the number of trades per time unit are measures for trading time.

2. Tightness: The ability to buy and to sell an asset *at about the same price* at the same time.

   Tightness shows in the clearest way the cost associated with transacting or the cost of immediacy.[3] Measures for tightness are the different versions of the spread.

3. Depth: The ability to buy or to sell a certain amount of an asset *without influence on the quoted price.*

   A sign of illiquidity is an adverse market impact for the investor when trading. Market depth can be measured, aside from the depth itself, by the order ratio, the trading volume or the flow ratio.

4. Resiliency: The ability to buy or to sell a certain amount of an asset *with little influence on the quoted price.*

[1] See also Brunner (1996), p. 3: "Liquidität ist die Leichtigkeit, mit der Wertpapiere zu angemessenen Preisen gehandelt werden können. Anleger sind daran interessiert, sofort und zu angemessenen Kursen handeln zu können."

[2] See e.g. Brunner (1996), p. 6ff., Campbell, Lo & MacKinlay (1997) , p. 99f., Irvine, Benston & Kandel (2000), Kluger & Stephan (1997) or Ranaldo (2001), p. 311f.

[3] See e.g. Engle & Lange (2001) or Hasbrouck (2003).

While the aspect of market depth regards only the volume at the best bid and ask prices, the resiliency dimension takes the elasticity of supply and demand into account. This aspect of liquidity can be described by the intraday returns, the variance ratio or the liquidity ratio.

The terminology of the attributes of liquidity is not always used in the same way: Baker (1996) e.g., relates "depth" to the size of the spread, whereas the above depth is captured by an aspect called "breadth".

Figure 1.1 shows a static picture of the limit order book. On the horizontal axis the bid and ask volumes are depicted to the left and to the right, respectively. These volumes may be different and the sum of the two is a measure for market depth. On the vertical axis the price is shown. There exist two different prices: the ask price, at which shares are offered, and the bid price, at which shares are demanded. The price of a trade may lie at the bid or at the ask price; under certain circumstances also inside the quote. The difference between bid and ask price is the measure of tightness but it may be expressed in different terms. The horizontal dimension is the depth and finally the elasticities of the supply and demand curve capture the resiliency dimension.

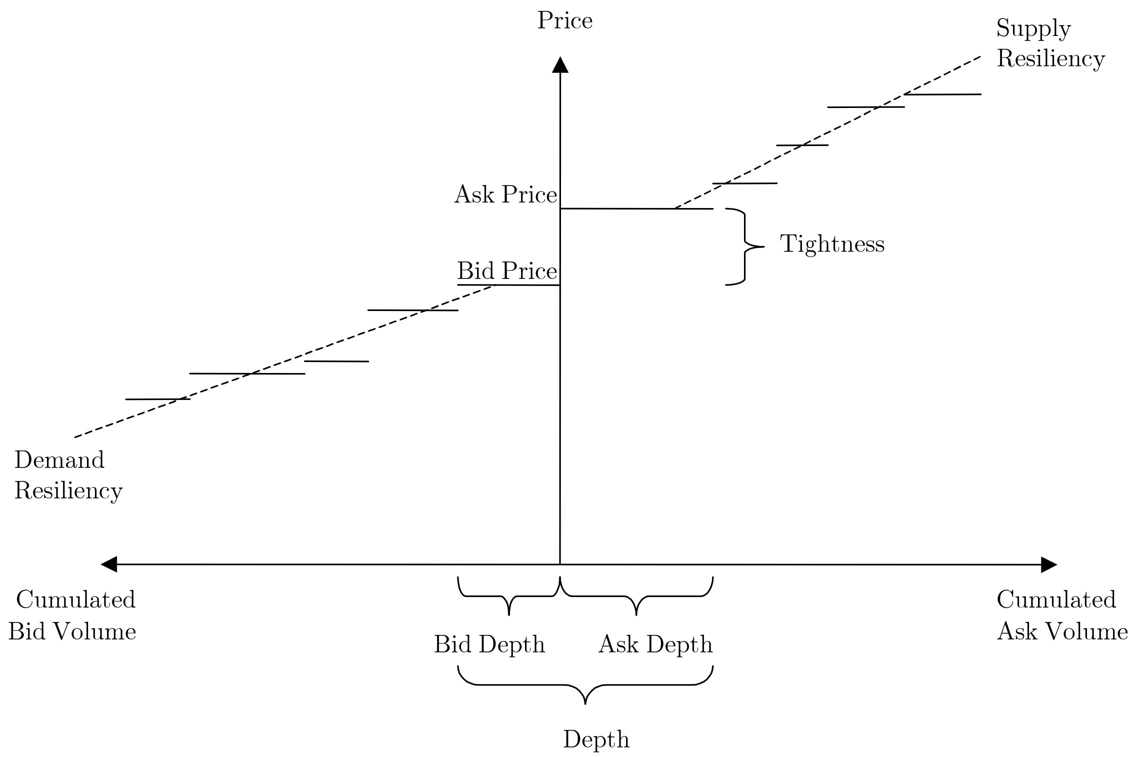

Figure 1.1: Different aspects of liquidity in a static image of the limit order book. Based on Ranaldo (2001), p. 312.

This can be further clarified if the bid curve is flipped horizontally and a traditional price quantity picture is reached, as in figure 1.2. So the limit order book shows the upper branch of the supply curve and the lower branch of the demand curve. When they intersect at the left a trade takes place.

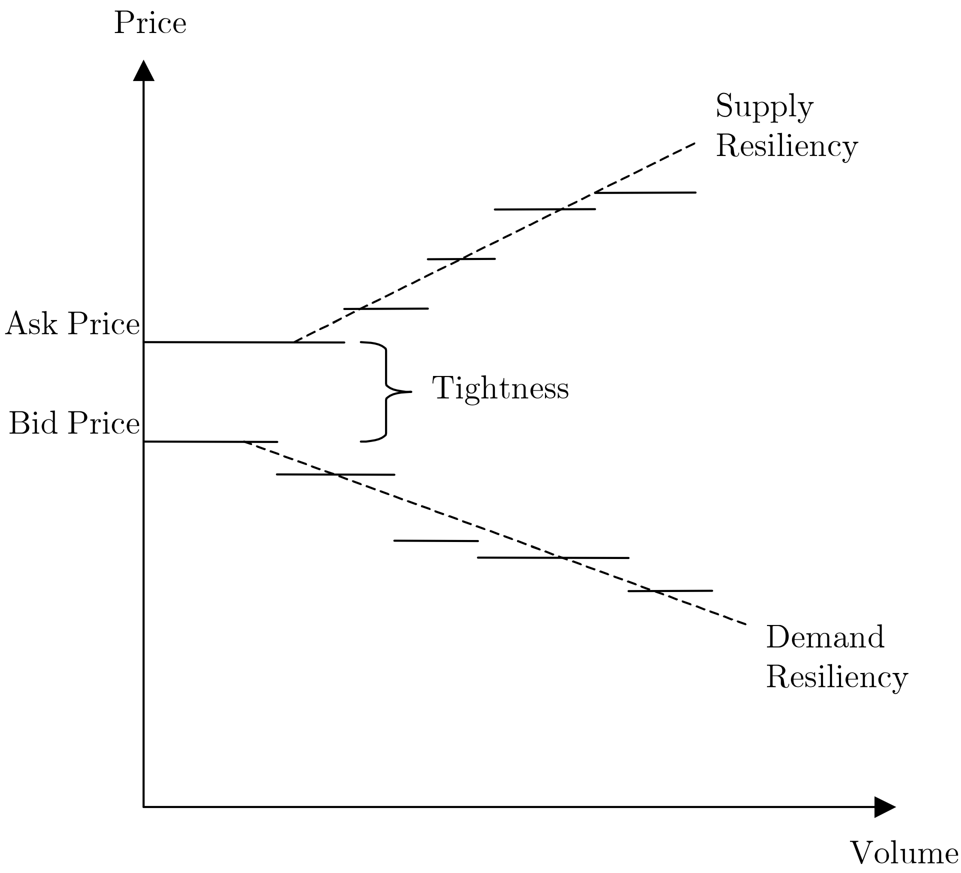

Figure 1.2: Supply and demand in the limit order book. Based on Ranaldo (2001), p. 312.

The static image of figure 1.1 changes every time a new order enters the limit order book. Figure 1.3 presents the same image including the time dimension. The bold lines show the initial order book. This order book develops through time and possible paths for bid and ask prices with their respective volume (the depth) are depicted.

The above aspects of liquidity may be regrouped to display five different levels of liquidity:

1. The ability to trade at all. This first level of liquidity is obvious: If there is no liquidity at all in the market, no trading can take place. In a liquid market there exist at least one bid and one ask quote that make a trade possible.

2. The ability to buy or to sell a certain amount of an asset *with influence on the quoted price.* If it is possible to trade, the next question concerns the price impact of trading. In a liquid market, it is possible to trade a certain amount of shares with little impact on the quoted price.

3. The ability to buy or to sell a certain amount of an asset *without influence on the quoted price.* The more liquid a market becomes, the smaller is the impact on the quoted price. Therefore, as the liquidity increases, eventually a point will be reached where there is no more price impact for a certain amount of shares.

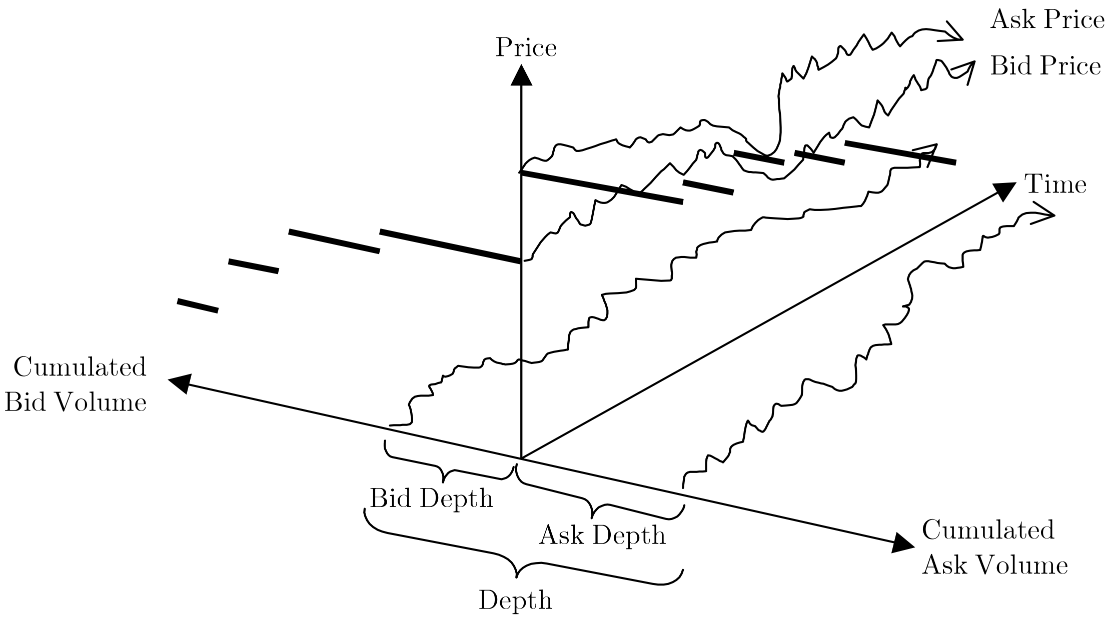

Figure 1.3: Development of the limit order book through time.

4. The ability to buy and to sell an asset *at about the same price* at the same time.

5. The ability to execute a transaction from points 2 to 4 *immediately*.

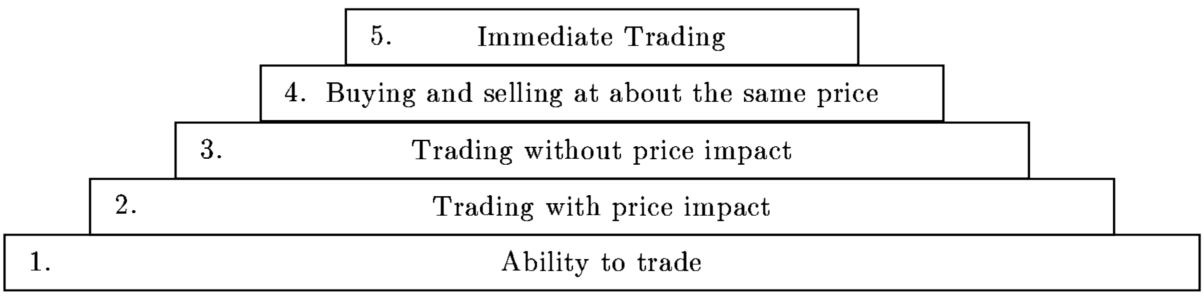

Figure 1.4: Levels of liquidity.

Figure 1.4 shows the different levels of liquidity. The ranks of level one to three are obvious but it is not clear whether level four and five have to be on top of them because they capture other aspects of liquidity. One could imagine a market where it is possible to trade at once with a huge price impact. Then level five should be regrouped at the position of level two.

O'Hara (1995) provides a theoretical introduction into different ways of modelling the nature and provision of liquidity with respect to different trading mechanisms and embeds them in the context of several market microstructure models. But most studies about market liquidity usually either concentrate on one aspect of liquidity or use several liquidity measures to capture different dimensions such as Chan & Pinder (2000) or Elyasiani, Hauser

& Lauterbach (2000). Fernandez (1999), p. 1 stresses the need to use different liquidity measures to capture the different aspects of liquidity. Another possibility is to use multidimensional liquidity measures.

The following section 1.2 gives a summary of the liquidity measures used in literature that is certainly not complete but should provide an overview of how the problem can be addressed.

1.2 Liquidity Measures

Liquidity itself is not observable and therefore, has to be proxied by different liquidity measures. As Baker (1996) states, different liquidity measures lead to conflicting results when evaluating the liquidity of a financial market.

To get an overview, liquidity measures are separated into one-dimensional and multi-dimensional ones: One-dimensional liquidity measures take only one variable into account, whereas the multi-dimensional liquidity measures try to capture different variables in one measure.

1.2.1 One-dimensional Liquidity Measures

The one-dimensional liquidity measures may be roughly separated into four groups: They may capture the size of the firm, the volume traded, the time between subsequent trades or the spread. The liquidity measures related to the firm size are not investigated further because, in the intraday context, they do not show enough variation to get reasonable results. They are listed in appendix A.1.

Volume-related Liquidity Measures

The volume-related liquidity measures may be calculated as a certain volume, or quantity of shares, per time unit. Usually they are used to capture the depth dimension of liquidity, but there is also a relation to the time dimension since a higher volume in the market leads to a shorter time needed for trading a predefined amount of shares. Trading volume is carefully investigated by Lee & Swaminathan (2000) in the context of momentum and value strategies. If the volume-related liquidity measures are high, this is a sign of high liquidity.

- Trading volume:

  Trading volume per time interval (Q_t) is incorporated in a lot of liquidity studies[4]. Trading volume for time $t-1$ until time t is calculated as follows:

$$Q_t = \sum_{i=1}^{N_t} q_i \tag{1.1}$$

[4]Examples are: Chordia, Roll & Subrahmanyam (2001), Chordia, Subrahmanyam & Anshuman (2001), Elyasiani et al. (2000), George & Hwang (1998), Gervais, Kaniel & Mingelgrin (2001), Greene & Smart (1999), Hasbrouck & Saar (2002), Hasbrouck & Seppi (2001), Kamara & Koski (2001), Karagozoglu (2000), Lee et al. (1993), Lee, Fok & Liu (2001), Lin, Sanger & Booth (1995), Van Ness, Van Ness & Pruitt (2000), and Yang, Li & Liu (2001).

N_t denotes the number of trades between $t-1$ and t, q_i is the number of shares of trade i. The average trade size is strongly influenced by the institutional frameset. Barclay, Christie, Harris, Kandel & Schultz (1999) show how the reduction of the minimum quote size on the NASDAQ reduces average trade size. But, in their paper, they stress that in line with the smaller trade sizes "the total quoted size in close proximity to the bid-ask midpoint increases."[5] This discrepancy between the depth at the best bid and ask quotes and the depth deeper in the order book can be overcome with more sophisticated liquidity measures described further below.

Gouriéroux, Jasiak & Le Fol (1999) calculate the reverse of the volume per time unit, the volume duration ($DurQ_t^{Q^*}$). This extended duration measure indicates the time that is needed to trade a certain number of shares Q^*:

$$\begin{aligned} DurQ_t^{Q^*} &= \inf\left(DurQ : Q_{t+DurQ} \geq Q_t + Q^*\right) \\ &= \inf\left(DurQ : \sum_{i=1}^{N_{t+DurQ}} q_i \geq \sum_{i=1}^{N_t} q_i + Q^*\right) \end{aligned}$$

Q_t denotes the cumulative number of shares traded until time t, N_t is the number of trades.

- Turnover[6]:

  Like the trading volume, turnover (V_t) has to be calculated for a specific time interval:

$$V_t = \sum_{i=1}^{N_t} p_i \cdot q_i \tag{1.2}$$

  p_i denotes the price of trade i. N_t is the number of trades between $t-1$ and t. An example of the turnover per time unit in use is the article by Chan, Chung & Fong (2002) who investigate the volume of options and stocks to filter out its informational contents. They refine the turnover to "net-trade volume" , which is calculated as buyer-initiated volume minus seller-initiated volume. Sometimes turnover is refined to a so called "relative turnover" which relates turnover to the free float of a stock as in Brunner (1996), p. 17.

  Gouriéroux et al. (1999) propose the reverse of the turnover, the turnover duration ($DurV_t^{V^*}$) to take the time into account that is needed to trade a certain turnover V^*:[7]

[5] Barclay et al. (1999), p. 3.

[6] As well as the trading volume, turnover is frequently used as in Chordia, Roll & Subrahmanyam (2001), Chordia, Subrahmanyam & Anshuman (2001), Chordia & Swaminathan (2000) , Gervais et al. (2001), Fleming & Remolona (1999), Hasbrouck & Saar (2002), Hasbrouck & Seppi (2001), Jones & Lipson (1999), Kamara & Koski (2001), Lee & Swaminathan (2000), and Lin et al. (1995).

[7] In Gouriéroux et al. (1999), p. 207 the turnover duration is called "capital duration".

$$\begin{aligned} DurV_t^{V^*} &= \inf\left(DurV : V_{t+DurV} \geq V_t + V^*\right) \\ &= \inf\left(DurV : \sum_{i=1}^{N_{t+DurV}} p_i \cdot q_i \geq \sum_{i=1}^{N_t} p_i \cdot q_i + V^*\right) \end{aligned}$$

Trading volume and turnover only need trades as data input which makes them easy to calculate. The turnover per time unit has the advantage that it makes different shares comparable to each other. It is not biased by the absolute share price as e.g. Irvine et al. (2000) point out.

The following three liquidity measures exist at any point in time, even if no transaction takes place. Only the first level of liquidity – the existence of a bid and an ask quote – has to be reached. Therefore, it is not necessary to calculate these liquidity proxies for a specific period.

- Depth:

$$D_t = q_t^A + q_t^B \tag{1.3}$$

  The market depth in time t, D_t, which is also referred to as "quantity depth" as in Huberman & Halka (2001) or "volume depth" as in Brockman & Chung (2000) is calculated as the sum of bid and ask volume in time t. q_t^A and q_t^B refer to the best bid and the best ask volume in the order book. Corwin (1999) shows that market depth differs significantly among the NYSE specialist firms, and Corwin & Lipson (2000) investigate depth around trading halts. Greene & Smart (1999) look at abnormal depth due to liquidity trading.[8]

  The market depth may be divided by two and, therefore, modified to an average depth of the bid and the ask depth as in Chordia, Roll & Subrahmanyam (2001), Goldstein & Kavajecz (2000), or Sarin, Shastri & Shastri (1996).

  The depth of the bid- and the ask-sides of the limit order book do not necessarily move in common and may therefore be investigated separately as in Kavajecz (1999) and Kavajecz & Odders-White (2001).

- Log depth:

  To improve the distributional properties of the depth the log depth ($Dlog_t$) may be used, as in Butler, Grullon & Weston (2002).

$$Dlog_t = \ln(q_t^A) + \ln(q_t^B) = \ln(q_t^A \cdot q_t^B) \tag{1.4}$$

  Log depth is simply the sum of the logarithms of the best bid and ask volume in the order book.

[8] Besides the articles mentioned, depth is also used in Lee et al. (1993) and Van Ness et al. (2000).

- Dollar depth:

  Dollar depth ($D\$_t$) is usually calculated as the average of the quoted bid and ask depths in currency terms, analogously to the average depth.[9]

$$D\$_t = \frac{q_t^A \cdot p_t^A + q_t^B \cdot p_t^B}{2} \tag{1.5}$$

  p_t^A refers to best ask price at time t and p_t^B to the best bid price at time t. Like turnover, dollar depth has the advantage that it makes liquidity of different stocks comparable to each other. It is important not to intermingle the number of shares that can be traded at a certain price with their respective amount of money. But turnover is not a priori the better liquidity measure than volume. For a retail investor, the turnover of one share at 20'000 CHF may be less liquid than the turnover of 20 shares at 1'000 CHF.

All these depth measures only take the depth at the best bid and ask quotes into consideration. Larger orders[10] cannot completely be executed at the best bid and ask prices and therefore have to "walk the book". This issue is considered in the more sophisticated liquidity measures below.

Time-related Liquidity Measures

Time-related liquidity measures indicate how often transactions or orders take place. Therefore, high values of these measures indicate high liquidity.

- Number of transactions per time unit:

  Like the trading volume, the number of trades is a widely used liquidity measure.[11]

$$N_t \tag{1.6}$$

  It counts the number of trades between $t-1$ and t. The number of transactions may be reversed to waiting time between trades

$$WT_t = \frac{1}{N-1}\sum_{i=2}^{N} tr_i - tr_{i-1}.$$

  tr_i denotes the time of the trade and tr_{i-1} the time of the trade before.[12] Therefore, waiting time for a specific time space has to be calculated as an average time between two trades. Waiting time is, for example, investigated by Peng (2001). Since it

[9]See e.g. Brockman & Chung (2000), Chordia, Roll & Subrahmanyam (2001), p. 505 or Hasbrouck & Seppi (2001).

[10]Bacidore, Battalio & Jennings (2002) estimate the fraction of NYSE system market orders to be greater than the quoted depth at 16% which equals about 23% of the order's value. This sample does not include orders handled by floor brokers.

[11]Bacidore (1997), Chordia, Roll & Subrahmanyam (2001), Christie & Schultz (1998), Jones & Lipson (1999), Kamara & Koski (2001), or Kavajecz & Odders-White (2001) count the number of trades per day, Hasbrouck & Seppi (2001) for a 15 minute interval and daily.

[12]See e.g. Gouriéroux et al. (1999) or Ranaldo (2003).

yields essentially the same information as the number of trades, waiting time between trades will not be investigated further. Instead of the waiting time between trades, the waiting time between subsequent orders may be calculated as in Ranaldo (2004). For consistency, this is calculated as the number of orders per time unit.

The number of transactions and the waiting time show the difference of trading taking place in a few large trades or in a huge number of small trades. But these measures are unable to compare liquidity of stocks whose prices differ significantly from each other.

- Number of orders per time unit:

  Similar to the number of transactions per time unit, the number of orders (NO_t) counts the orders inserted into the limit order book within the time interval from $t-1$ until t:

$$NO_t \tag{1.7}$$

  The impact of the number of orders on return volatility is investigated by Walsh (1998).

Spread-related Liquidity Measures

The difference between the ask and the bid price and its related measures gives an approximation of the cost incurred when trading. In addition to fees and taxes, the trader has to pay the spread as cost for the immediate execution of a trade. Most studies investigate spreads on a daily basis: Acker, Stalker & Tonks (2002) e.g. examine the determinants of bid-ask spreads and their behavior around corporate earning announcement dates. The spread is used to determine where price discovery takes place in Harris, McInish & Wood (2002), a study that compares trading at different stock exchanges.

The smaller all the spread-related liquidity measures are, the more liquid is the market.

- Absolute spread, dollar spread or quoted spread:

$$Sabs_t = p_t^A - p_t^B \tag{1.8}$$

  The absolute spread is the difference between the lowest ask price and the highest bid price. This measure is always positive and its lower limit is the minimum tick size. Chordia, Roll & Subrahmanyam (2001) use this measure in their study of the NYSE and Grammig, Schiereck & Theissen (2001) with data of the German stock market.[13] A somewhat different approach is used by Hasbrouck (1999): He models the spread out of different stochastic variables for the bid and the ask price.

  The expression "quoted spread" is ambiguous and refers not only to the difference of the best bid and the best ask price but also to the quoted spread of a single market maker, who quotes bid and ask prices. It is intensively investigated for the whole market and for single market makers in Barclay et al. (1999) who analyze the impact of the NASDAQ market reforms of 1997, which ended the collusion among market makers

[13] Other articles incorporating the spread are Bacidore (1997), Breedon & Holland (1997), Brockman & Chung (2000), Chung & Van Ness (2001), Clyman, Allen & Jaycobs (1997), Clyman & Jaycobs (1998), Greene & Smart (1999), Hasbrouck & Saar (2002), Hasbrouck & Seppi (2001), Kavajecz & Odders-White (2001), Lee et al. (1993), Lin et al. (1995), Ranaldo (2002), or Van Ness et al. (2000).

to artificially inflate the spreads. The quoted spread differs also across the NYSE specialist firms as Corwin (1999) shows. Another study using individual dealer's data is Christie & Schultz (1998) who investigate the liquidity provision during the 1991 market break, when the index fell over 4%. Furthermore, it is possible to compare the quotes of the specialists at the NYSE or the limit order book quotes of a single market maker as it has been done for the NYSE[14] or the London Stock Exchange.[15] In the present dissertation it is not possible to compare the quoted spreads of different market participants because the SWX is not allowed to publicly release this sort of data.

Karagozoglu (2000) divides the quoted spread by two but has to calculate it out of the average price reversals because quote data is not available in the futures market. The quoted spread is largely determined by the minimum tick size, which is investigated in Ball & Chordia (2001). Since the minimum tick size is not constant at the SWX but depends on the stock price, stock prices influence the absolute spread.

- Log absolute spread:

$$LogSabs_t = \ln(Sabs_t) = \ln(p_t^A - p_t^B) \tag{1.9}$$

Like the log depth, the absolute spread may be logarithmized to improve its distributional properties. It is used in Hamao & Hasbrouck (1995) because its distribution is closer to a normal than the absolute spread and, therefore, mathematically easier to use.

- Relative spread or proportional spread calculated with mid price:

$$SrelM_t = \frac{p_t^A - p_t^B}{p_t^M} = \frac{2 \cdot \left(p_t^A - p_t^B\right)}{p_t^A + p_t^B} \tag{1.10}$$

p_t^M denotes the mid price which is calculated as $\frac{p_t^A + p_t^B}{2}$. The relative spread is the liquidity measure most extensively studied because it is easy to calculate and because it makes spreads of different stocks comparable to each other.[16] Sometimes this measure is also referred to as "inside spread" as in Levin & Wright (1999). Another advantage is that it may be calculated even if no trade takes place, in contrast to the relative spread calculated with the last trade (see below).

- Relative spread calculated with last trade:

$$Srelp_t = \frac{p_t^A - p_t^B}{p_t} \tag{1.11}$$

[14] Studies about the NYSE are Battalio, Greene & Jennings (1998), Chung, Van Ness & Van Ness (1999), Goldstein & Kavajecz (2000), and Kavajecz (1999).

[15] Studies using data from the London Stock Exchange are Levin & Wright (1999) and Menyah & Paudyal (2000).

[16] Acker et al. (2002), Brockman & Chung (2000), Chordia, Roll & Subrahmanyam (2001), Chung & Van Ness (2001) Corwin (1999), Elyasiani et al. (2000), Gervais et al. (2001), Goldstein & Kavajecz (2000), Greene & Smart (1999), Hasbrouck & Saar (2002), Jones & Lipson (1999), Kavajecz (1999), Kluger & Stephan (1997), Lin et al. (1995), Menyah & Paudyal (2000), Ranaldo (2003), Sarin et al. (1996), Van Ness et al. (2000), or Yang et al. (2001) use the relative spread.

p_t denotes the last paid price of the asset before time t. This liquidity measure is used e.g. in Fleming & Remolona (1999). On the one hand, this second version of the relative spread has the advantage of taking a moving market into account, because p_t may be at the ask price in an upward moving market, whereas it will be at the bid price in a downward moving market. On the other hand, the paid price p_t has to be known before p_t^A or p_t^B are quoted. If the last trade has occurred long before the current absolute spread is measured, the traded price as well as $Srelp_t$ may be irrelevant for the actual market situation.

The relative spread is calculated with the bid price in the denominator in Loderer & Roth (2001). The authors state that this spread measure is arbitrarily chosen and that they could have equally selected the relative spread with the mid price in the denominator. Therefore, the relative spread with the bid price in the denominator is not investigated further. Amihud & Mendelson (1991) add to the bid price in the denominator the accrued interest to measure liquidity of Treasury bills and notes. This is done in order to account for the realizable liquidation price of these fixed income securities.

- Relative spread of log prices:

$$Srellog_t = \ln(p_t^A) - \ln(p_t^B) = \ln(\frac{p_t^A}{p_t^B}) \tag{1.12}$$

$Srellog_t$ is calculated analogously to the log return of an asset. It is compared to other liquidity measures in Hasbrouck & Seppi (2001) who find only modest common factors in liquidity after removing the time-of-day effects.

- Log relative spread of log prices:

$$LogSrellog_t = \ln(Srellog_t) = \ln(\ln(\frac{p_t^A}{p_t^B})) \tag{1.13}$$

$LogSrellog_t$ is used to generate "better" distributions of the spread measure. All the previous spread measures have a strongly skewed distribution which complicates calculations. The log relative spread of log prices is much more symmetrically distributed and is therefore easier to approximate by a normal distribution.[17]

- Effective spread:

$$Seff_t = \left| p_t - p_t^M \right| \tag{1.14}$$

p_t denotes the last traded price before time t and the mid price p_t^M is calculated as above. The effective spread is a different spread concept: If the effective spread is smaller than half the absolute spread, this reflects trading within the quotes.[18] Sometimes the effective spread and all the following related measures may be multiplied by two to make them better comparable to the other spread measures, as in Barclay

[17] See Dacorogna, Gençay, Müller, Olsen & Pictet (2001), p. 45.

[18] See Chordia, Roll & Subrahmanyam (2000), Chordia, Roll & Subrahmanyam (2001), p. 506, Christie & Schultz (1998), or Hasbrouck & Seppi (2001).

et al. (1999), p. 14, Bacidore (1997), Bacidore et al. (2002), Breedon & Holland (1997), Jones & Lipson (1999), or Lin et al. (1995). In Lee et al. (1993) this doubled effective spread is weighted with the trade size to get an average effective spread for a certain period. This yields similar results as weighting with the number of trades does. With the use of the effective spread, Battalio et al. (1998) calculate a liquidity premium: $LP_t = I \cdot \left(p_t - p_t^M\right)$ where I is the direction of trade indicator. I equals 1 for buyer initiated trades and -1 for seller initiated trades. This liquidity premium is positive if the buyer pays more or if the seller pays less than the spread midpoint.

- Relative effective spread calculated with last trade:

$$Seffrelp_t = \frac{\left|p_t - p_t^M\right|}{p_t} \tag{1.15}$$

  Again, the relative measure allows comparability across different stocks.[19] Also the relative effective spread may be doubled to compare it to other relative spread measures.[20]

- Relative effective spread calculated with mid price:

$$SeffrelM_t = \frac{\left|p_t - p_t^M\right|}{p_t^M} \tag{1.16}$$

  As with the relative spread, the relative effective spread can be calculated with the mid price in the denominator as in Grammig et al. (2001) or Ranaldo (2003). Corwin (1999) uses this measure multiplied by 200.

To make data of different stocks comparable to each other it is always useful to rely on relative spread measures. All the spread measures take only the best bid and ask prices into consideration. But in the market there are usually multiple spreads, each relating to a different volume of shares. Out of the limit order book of the Swiss Exchange it is possible to construct supply and demand curves, which give additional insights into the liquidity of the stock market.[21]

1.2.2 Multi-dimensional Liquidity Measures

Multi-dimensional liquidity measures combine properties of different one-dimensional liquidity measures. Fifteen measures shall be explained in this section. The first four combine spread in the numerator and volume in the denominator. Therefore, a high liquidity measures denotes low liquidity.

- Quote slope:

$$QS_t = \frac{Sabs_t}{Dlog_t} = \frac{p_t^A - p_t^B}{\ln\left(q_t^A\right) + \ln\left(q_t^B\right)} \tag{1.17}$$

[19] The relative effective spread is used in Chordia et al. (2000) and Chordia, Roll & Subrahmanyam (2001).

[20] See Barclay et al. (1999), Goldstein & Kavajecz (2000), Lin et al. (1995), Schultz (2000), or Theissen (2002).

[21] See e.g. Chan & Pinder (2000), p. 485 or Corwin & Lipson (2000).

The spread in the numerator divided by log depth yields the quote slope presented by Hasbrouck & Seppi (2001). A high quote slope denotes low liquidity. Graphically this measure is the slope of a line between the bid quote and the ask quote. Figure 1.5 illustrates this point.

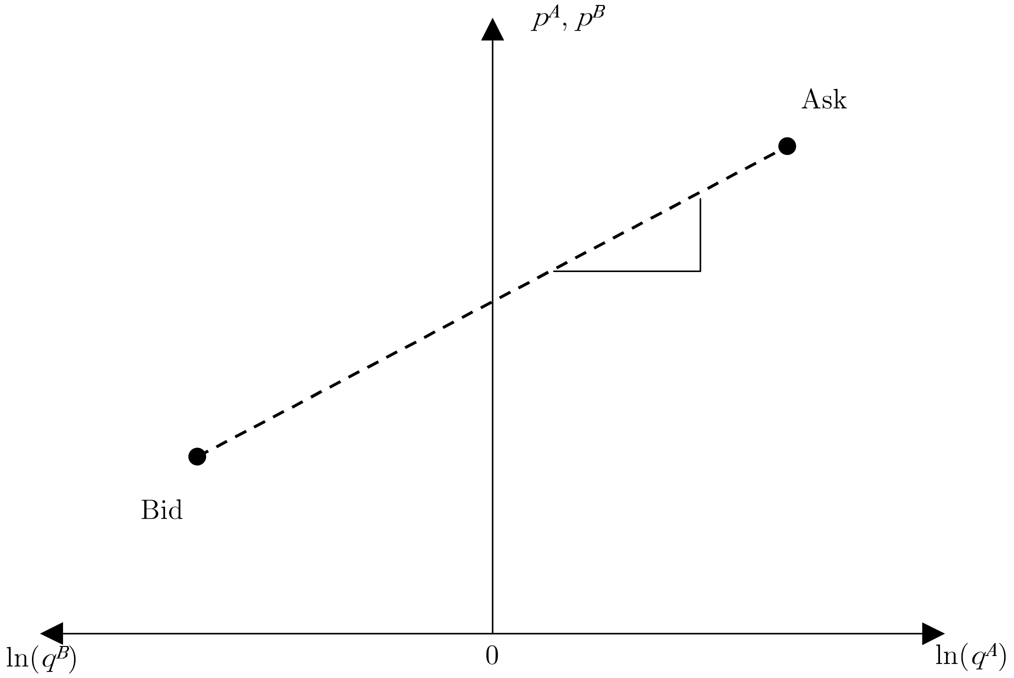

Figure 1.5: Quote slope

- Log quote slope:

$$LogQS_t = \frac{Srellog_t}{Dlog_t} = \frac{\ln\left(\frac{p_t^A}{p_t^B}\right)}{\ln\left(q_t^A \cdot q_t^B\right)} \tag{1.18}$$

  Instead of the quote slope, the log quote slope, also based on Hasbrouck & Seppi (2001) uses the logarithmized relative spread in the numerator. Graphically the situation is similar to figure 1.5 using $ln(p_t)$ instead of p_t.

As the ask price is always higher than the bid price, the quote slope and the log quote slope are always positive. The closer p_t^A and p_t^B are to each other, the flatter is the slope of the quote and the market becomes more liquid. Similarly, the larger q^A and q_t^B are the smaller is the slope of the quote and the more liquid is the market.

The following liquidity measure introduced by Schoch (2001) corrects the log quote slope for a market moving in one direction:

- Adjusted log quote slope:

$$
\begin{aligned}
LogQSadj_t &= \frac{\ln\left(\frac{p_t^A}{p_t^B}\right)}{\ln\left(q_t^A \cdot q_t^B\right)} + \frac{\left|\ln\left(\frac{q_t^B}{q_t^A}\right)\right|}{\ln\left(q_t^A \cdot q_t^B\right)} \cdot \ln\left(\frac{p_t^A}{p_t^B}\right) \\
&= \frac{\ln\left(\frac{p_t^A}{p_t^B}\right)}{\ln\left(q_t^A \cdot q_t^B\right)} \cdot \left(1 + \left|\ln\left(\frac{q_t^B}{q_t^A}\right)\right|\right) \\
&= LogQS_t \cdot \left(1 + \left|\ln\left(\frac{q_t^B}{q_t^A}\right)\right|\right) \qquad (1.19)
\end{aligned}
$$

The first term is the log quote slope. If the volume on bid- and ask-side is equal $\left(q_t^B = q_t^A\right)$, the added correction term $\frac{\left|\ln\left(q_t^B\right) - \ln\left(q_t^A\right)\right|}{\ln\left(q_t^A\right) + \ln\left(q_t^B\right)} \cdot \ln\left(\frac{p_t^A}{p_t^B}\right)$ becomes zero. If either bid or ask volume are higher than the other, the correction term is larger than zero and the measure rises, indicating that the market becomes less liquid. An effect of scarce liquidity in down markets is, for example, found in Chordia, Roll & Subrahmanyam (2001).

- Composite liquidity:

$$
CL_t = \frac{SrelM_t}{D\$_t} = \frac{\frac{p_t^A - p_t^B}{p_t^M}}{\frac{q_t^A \cdot p_t^A + q_t^B \cdot p_t^B}{2}} = \frac{2 \cdot \left(p_t^A - p_t^B\right)}{p_t^M \cdot \left(q_t^A \cdot p_t^A + q_t^B \cdot p_t^B\right)} \qquad (1.20)
$$

In a similar way as the quote slope, composite liquidity (CL_t), presented by Chordia, Roll & Subrahmanyam (2001), measures the slope of the quotes: The relative spread calculated with mid price in the numerator is divided by the dollar depth. This renders CL independent from the actual price of a stock if the absolute spread is not affected by the absolute stock price via the minimum tick size. A high composite liquidity denotes low liquidity.

The liquidity ratios combine turnover and return or number of trades and return, respectively:

- Liquidity ratio 1:

$$
LR1_t = \frac{V_t}{|r_t|} = \frac{\sum_{i=1}^{N} p_i \cdot q_i}{|r_t|} \qquad (1.21)
$$

r_t denotes the return from period $t-1$ to t, and V_t is the turnover as calculated in equation 1.2. The liquidity ratio compares the traded volume to the absolute price change during a certain period. The higher the volume, the more price movement can be absorbed. Therefore, high liquidity ratios denote high liquidity.[22] As Elyasiani et al. (2000) state, this measure is also useful if no intraday data is available because turnover and return can be easily calculated on a daily basis. The liquidity ratio 1, also known as "Amivest liquidity ratio" is widely used to measure liquidity of the NASDAQ as Brunner (1996), p. 19 states. If the return in a certain time interval is zero, the liquidity ratio 1 is set to zero.

[22] See Baker (1996), Elyasiani et al. (2000), Kluger & Stephan (1997), or Ranaldo (2000), p. 40f. and 79f.

Similar to the liquidity ratio 1 is the return per turnover

$$\frac{1}{LR1_t} = \frac{|r_t|}{V_t},$$

which is used by Amihud (2002) or the Martin Index

$$M_t = \sum_{i=2}^{N} \frac{(p_i - p_{i-1})^2}{V_t},$$

described in Baker (1996). Ranaldo (2000) proposes the so called "liquidity ratio 2":

$$LR2_t = \frac{LR1_t}{Ne - No} = \frac{V_t}{(Ne - No) \cdot |r_t|} = \frac{\sum_{i=1}^{N} p_i \cdot q_i}{(Ne - No) \cdot |r_t|}$$

In this version of the liquidity ratio, the traded volume is corrected for the free float of the firm. The term $(Ne - No)$ denotes the difference between total number of shares and the number of shares owned by the firm. Another way to account for the free float is to use the Hui-Heubel liquidity ratio

$$LHH_t = \frac{\frac{p_t^{\max} - p_t^{\min}}{p_t^{\min}}}{\frac{V_t}{No \cdot p_t}},$$

also mentioned in Baker (1996). Since free float does not change much in the intraday context, these derivations of the liquidity ratio are left out.

- Liquidity ratio 3:

$$LR3_t = \frac{\sum_{i=1}^{N} |r_i|}{N_t} \tag{1.22}$$

In Brunner (1996) a third liquidity ratio is proposed which indicates the average price change of a transaction. While the liquidity ratios 1 and 2 depend on the absolute price of a stock, the liquidity ratio 3 overcomes this problem by only using the number of trades in the denominator. In contrast to the liquidity ratio one, a high liquidity ratio shows low liquidity. If the number of trades for certain time space is zero, the liquidity ratio 3 is forced to zero.

A combination of turnover and time determines the flow ratio proposed by Ranaldo (2000):

- Flow ratio:

$$FR_t = \frac{V_t}{WT_t} = \frac{\sum_{i=1}^{N_t} p_i \cdot q_i}{\frac{1}{N-1} \sum_{i=2}^{N_t} tr_i - tr_{i-1}}$$

The flow ratio is the ratio of turnover to waiting time. Therefore, it measures whether trading takes place in a few but large transactions or in lots of small trades.

With respect to the interrelation of number of trades and waiting time, the flow ratio will be calculated in the present dissertation as follows:

$$FR_t = N_t \cdot V_t = N_t \cdot \sum_{i=1}^{N} p_i \cdot q_i \tag{1.23}$$

Since liquidity rises with the number of trades and the turnover, a high flow ratio is a sign for high liquidity.

- Order ratio:

$$OR_t = \frac{\left|q_t^B - q_t^A\right|}{V_t} = \frac{\left|q_t^B - q_t^A\right|}{p_t \cdot q_t} \tag{1.24}$$

The order ratio also proposed by Ranaldo (2000) is a refined measure of market depth. It compares depth measured as market imbalance to turnover and recognizes market movements or imbalance in the market since it rises as the difference in the numerator becomes large. If the turnover in a certain time interval is equal to zero, the order ratio is set to zero. A high order ratio denotes low liquidity. A small order ratio denotes high liquidity.

- Market impact:

An increase or decrease in the absolute spread does not guarantee an increase or decrease in liquidity along the order book as Irvine et al. (2000) and Wang (2002) point out. The market impact and the following measures try to overcome this problem.

$$MI_t^{V*} = p_t^{A,V*} - p_t^{B,V*} \tag{1.25}$$

Market impact enlarges the quoted spread to a certain turnover that has to be generated. Therefore, it takes the amount of money that has to be traded into consideration and has to be calculated for a certain amount of money, as Gomber & Schweickert (2002) point out. It may also be calculated separately for the two sides of the market which may be useful in a rapidly moving market. For the ask-side of the market this measure yields:

$$MI_t^{A,V*} = p_t^{A,V*} - p^M \tag{1.26}$$

and for the bid-side:

$$MI_t^{B,V*} = p^M - p_t^{B,V*} \tag{1.27}$$

The three market impacts are calculated for a turnover of CHF 500'000. If it is not possible to generate this turnover with the prevailing order book, the highest ask price or the lowest bid price, respectively, of the order book is used to calculate the market impact. As with the spread-related liquidity measures, high market impacts denote low liquidity.

- Depth for price impact:

$$DI_t^A(k) = Q_k^A \tag{1.28}$$

The depth, which is dependent on a certain price impact, makes it possible to calculate the supply and demand curves of the limit order book. It describes the number of shares DI that has to be traded to move the price a certain amount of k ticks away from the quote midpoint.[23] This measure can be calculated for the ask-side of the market as well as for the bid-side as the market impact above:

$$DI_t^B(k) = Q_k^B \tag{1.29}$$

A linear function of ticks and depth may be a sign of larger orders that are split up into equally sized portions to prevent too large an impact on the market. Since the tick size on the Swiss stock exchange is not constant, k is replaced by a 2% price move. This size of movement is reasonable because a 2% price move induces a trading stop, as stated in Swiss Exchange (2002). The greater the depth for price impact measures, the more liquid is the market.

- Price impact:

  Coppejans et al. (2003) calculate the execution costs dependent on the prevailing demand and supply schedules in the market. A market order of size q is executed at K different prices with q_k shares trading at price p_k and $\sum_{k=1}^{K} q_k = q$. For the ask-side of the order book the price impact is calculated as follows.

$$PI^A(q) = \ln\left(\frac{\sum_{k=1}^{K} p_k \cdot q_k}{q \cdot p^M}\right) \tag{1.30}$$

  For the bid-side, price impact is multiplied by -1 because the expression in brackets is smaller than 1:

$$PI^B(q) = -\ln\left(\frac{\sum_{k=1}^{K} p_k \cdot q_k}{q \cdot p^M}\right) \tag{1.31}$$

  This market impact is the inverse of the depth for a certain price impact, therefore, if the market depth $DI^A(K) = q$, the price movement of an order with size q equals K. Market impact depends on the absolute stock price which makes it difficult to compare this measure for different stocks. In the present dissertation, q is set to 10'000 shares. Naturally, high price impacts are a sign for low liquidity.

The list of liquidity measures presented in this section is long and certainly not complete. The most important insight from this chapter must be, that liquidity is not a one-dimensional variable and therefore can hardly be captured in a single one-dimensional liquidity measure.

[23] See Coppejans, Domowitz & Madhavan (2003), p. 6, Corwin & Lipson (2000) or Hasbrouck & Saar (2002).

For a global liquidity measure, certainly one of the multi-dimensional liquidity measures has to be used. According to Amihud (2002), it is doubtful whether there is one single measure that captures all aspects of liquidity. On the other hand, the one-dimensional measures may give insight into specific questions of market liquidity which more complicated measures are unable to furnish.

For the empirical part, the 31 liquidity measures from the numbered equations will be used. Some more liquidity measures left out can be found in appendix A.

Chapter 2

Data and Institutional Setting

A brief description of the institutional setting of the Swiss Exchange is necessary to understand the trading mechanism and how liquidity is provided. It takes place in the following section. In section 2.2, I describe the data used throughout the dissertation, and how it had to be preprocessed.

2.1 The Limit Order Book of the Swiss Exchange[1]

The Swiss Exchange is organized as a limit order book. For the trading of ordinary shares no market makers provide liquidity. The market is purely order driven which means that liquidity in this market is entirely dependent on public limit orders.

The Swiss Exchange provides so-called "order history reports" (OHR), which makes it possible to reconstruct the order book for every point in time. Kavajecz (1999) describes, in a clear and consistent way, how the limit order book may be constructed out of order history reports. Using an autoregressive conditional duration (ACD) model, Coppejans & Domowitz (2002) give an interesting insight into the mechanisms at work in a limit order book. They use data from the OMX futures contract on the Swedish stock index. In this market, the trading organization is simpler than the Swiss Exchange because neither opening nor closing auctions exist.

Every single event is entered into the order book and appears, therefore, in the order history report. An order that is matched against several other orders appears several times in the OHR which means that the number of events in the OHR is much larger than the number of orders. Table 2.1 summarizes the information provided by the OHR and gives an example.

Fields 1 to 4 describe the security. They contain the same information and, therefore, three of them are redundant. In this case it is the Novartis registered share.

Field five denotes the currency in which the asset is traded. Throughout the sample the currency is CHF.

The following fields 6 to 19 concern the insertion of the order:

[1]The main sources for this section are the General Conditions and the Directives which concretize the General Conditions of the Swiss Exchange. They are available via the homepage www.swx.com. See Swiss Exchange (2001*a*), Swiss Exchange (2001*b*), Swiss Exchange (2001*c*), and Swiss Exchange (2002).

Field	Name	Example
1	Valor number	1200526
2	Valor symbol German	NOVN
3	Security description	Novartis N
4	Security ID	24651
5	Currency	CHF
6	Order ID	113069
7	Transaction date	20010618
8	Transaction time	9294588
9	OH insert state	Trading
10	Buy/sell	B
11	Round/odd lot code	Rnd
12	Original size	55
13	Order price	70
14	Member name	Member
15	Trader name	Trader
16	Order type code	Norm
17	Nostro flag	
18	Expiry date	20010731
19	Expiry period	Trading
20	Delete date	20010618
21	Delete time	9294588
22	Delete same period	X
23	OH delete size	0
24	Delete state	Trading
25	Delete reason	Normal Fil
26	Current size	0
27	OH order age	0
28	Trade date	20010618
29	Trade time	9294588
30	Order book period code	Trading
31	Trade size	55
32	Trade price	67.5
33	Trade ID	24651O0000072730
34	Cpty member name	Cpty member
35	Cpty trader name	Cpty trader
36	Cpty order type	Norm
37	CP nostro	N
38	CP order ID	113068

Table 2.1: Example of an order history report.

Field 7 shows the order insertion date: June 18, 2001. Field 8 is the order insertion time: 9:29 a.m., 45.88 seconds.

Field 9 gives the state of the exchange when the order was entered. Possible states of the exchange are pre-opening, pre-opening auction and trading. The pre-opening starts at 6 a.m. and lasts until 9 a.m. In this period orders can be inserted but no trades are executed. The pre-opening auction takes place after 9 a.m. Afterwards, there is continuous trading until 5.20 p.m when the exchange switches again to the pre-opening state before the closing auction takes place at 5.30 p.m. After the closing auction there is again a pre-opening period until 10 p.m. where orders may be inserted or modified. During continuous trading there is an automatic interruption of trading for 15 minutes if the potential follow-up price deviates by 2% or more from the reference price. During this break the exchange is again in the pre-opening state and it ends with a pre-opening auction. The example order was inserted during the trading state.

Field 11 indicates whether the size inserted is a round or an odd lot. Since the size of a round lot in equity trading is one share and it is impossible to trade fractions of shares, there are no odd lots.

Field 10, 12, and 13 indicate that it is an order to buy 55 shares at CHF 70 or cheaper.

Field 14 and 15 are left blank for data protection reasons. The SWX has access to these fields to investigate cases of insider trading. In this paper, the deletion of the member name as well as the counterparty in fields 34 and 35 prevents comparison of quotes or other market variables across market participants as it is, for example, done in Barclay et al. (1999).

In field 16 the following different orders may be inserted into the order book:

- Normal Order: A normal order is an order to buy or to sell a certain number of shares. Two types of normal orders exist:
  - Market Order: No price is indicated and the order is executed at the prevailing market price.
  - Limit Order: The price is indicated and the order has to be executed at or better than the indicated price.
- Hidden Size Order: A larger order may be placed as hidden size order. Only part of it is visible to the other market participants but it is marked as a hidden size order. The whole order must exceed CHF 3 mio. for SMI shares and CHF 1 mio. for other stocks. The hidden part of the order has the same time priority as the visible part. The minimum visible size of a hidden size order is 100 round lots – therefore, 100 shares.
- Accept Order: The accept order immediately accepts all orders in the order book that correspond to its attributes. If the accept order is not (or only partially) executed, the whole order (or the remaining part) is cancelled.
- Fill or Kill Order: The fill or kill order must be executed as a whole. Otherwise it is cancelled.
- Conditional Order: This sort of order remains invisible for other market participants unless a so called "trigger price" is reached and the order appears in the order book. Three forms of conditional order can be distinguished:

  - On Stop Order: When the trigger price is reached, the trading system creates a *market order to buy.*
  - Stop Loss Order: When the trigger price is reached, the trading system creates a *market order to sell.*
  - Stop Limit Order: When the trigger price is reached, the trading system creates a *limit order to buy* or *to sell.*

Field 17 indicates whether the trade is for a bank's own position (nostro) or not. Field 18 and 19 show the expiration of an order if it is not cancelled before.

The fields 20 to 33 describe the disappearance of the order from the order book:

Field 20 to 22 indicate the moment when the order disappeared from the order book. Field 22 shows an X if it is deleted in the same period. This means immediately if during the trading state of the exchange or in the same pre-opening period. As the order was traded in the same moment as it was inserted, it was a "marketable limit order". Field 23 shows the size of the order that was deleted and not traded.

Every order has to disappear from the order book, which may take place due to several reasons, as field 25 shows:

- Full match with another order: If an order can be fully matched with another order, it disappears from the order book. The order book may also indicate "Normal Fil" which means that the order was merged with other orders to be executed.

- Partial match with another order: If an order can only be partially matched with another order, the remaining part usually stays in the order book. Only in the case of an accept order is the remaining part cleared.

- Cancellation of an order: Any order may be cancelled from the order book by request of the member who inserted it.

- Expiration of an order: To any order an expiration time and date may be added when the order is inserted.

Trading takes only place in the first two possibilities. But one should keep in mind that even if no trading takes place, orders may affect the liquidity of the market.

From field 34 onwards, the counterparty of the trade is identified.

One important determinant of the size of the absolute spread is the minimum tick size which depends, on the Swiss Exchange, on the absolute stock price. In table 2.2 the minimum price increments for the Swiss Exchange are shown with there respective price ranges. The stocks which are used in the present dissertation are listed that trade in each class.

Of the 18 sample stocks, seven traded during the sample period in different classes. This was the case for Adecco, Baer, Ciba, Lonza, Surveillance, Sulzer and Syngenta.

Trading off-exchange is allowed for a value larger than 200'000 CHF, but these trades have to be reported to the order book within 30 minutes. All other trades have to be processed through the limit order book during exchange hours.

Price			Tick size	Stocks trading in this class
0.01	to	9.99	0.01	
10.00	to	99.95	0.05	ADEN, CFR, CIBN, CLN, KUD, LONN, SYNN, UHRN
100.00	to	249.75	0.25	ADEN, CIBN, LONN, RUKN, SUN, SYNN, UHR, UNAX
250.00	to	499.50	0.50	BAER, HOL, SCMN, SGSN, SUN
500.00	to	4999.00	1.00	BAER, GIVN, SEO, SGSN
5000.00	and above		5.00	

Table 2.2: Minimum tick size for stocks on the Swiss Exchange (Source: Swiss Exchange (2002)). The respective ticker symbols are explained in table 2.3.

For the market participants, the following information is released in real time:

- All bid and ask prices with their corresponding quantities.
- All reported off-exchange trades with their corresponding prices, volume and time.
- All indications of interest to trade in a particular security without any commitment.

Information released in real time to the public concerning trades is the following:

- All prices paid on the exchange with volume.
- Best bid and best ask prices with accumulated depths.
- Total volume of on-exchange trades for the day.
- All reported off-exchange trades with their price, volume and time for the day.

When calculating different liquidity measures, one has always to keep in mind which ones are built on publicly available information, and which ones have to rely on information available only to market participants. The information used in the present dissertation is not available to the public in real-time.

2.2 Data

The data covers 65 trading days from May 2 until July 31 of the year 2002 for the 18 stocks in table 2.3 which are part of the Swiss Market Index SMI. On May 2, 2002, these 18 stocks covered about 24% of market capitalization of the Swiss Market Index. On October 1, 2003 Sulzer dropped out of the SMI because its market capitalization became to small with respect to the other blue chips. Unfortunately, the largest stocks of the SMI are missing because the SWX has not enough computer power to extract this huge amount of data from its computer system.

The use of intraday or high-frequency data is becomming more common. Since the necessary data is obtainable from the exchanges and the computer power to process the data is available, lots of new insights were reached in the market microstructure area. Especially the work of Olsen & Associates[2] has encouraged lots of studies on the foreign exchange

[2]A special volume of the Journal of Empirical Finance was dedicated to the use of high frequency data in finance in cooperation with Olsen & Associates. See Baillie & Dacorogna (1997) for the introduction to this special volume.

Stock	Ticker Symbol
Adecco	ADEN
Julius Baer	BAER
Richemont	CFR
Ciba	CIBN
Clariant	CLN
Givaudan	GIVN
Holcim	HOLN
Kudelski	KUD
Lonza	LONN
Swiss Re	RUKN
Swisscom	SCMN
Serono	SEO
Surveillance	SGSN
Sulzer	SUN
Syngenta	SYNN
Swatch bearer share	UHR
Swatch registered share	UHRN
Unaxis	UNAX

Table 2.3: List of stocks used in the empirical part.

market due to the huge database, as table B.1 in appendix B shows. Although this data incorporates only indicative quotes[3], Dacorogna et al. (2001) provide a coherent introduction to the treatment of high-frequency data and the methodology in its use. An overview of articles using high-frequency data is presented by Gwilym & Sutcliffe (1999) and Campbell et al. (1997), p. 107ff. contains an earlier summary of the use of intraday data.

Studies incorporating intraday data may be separated into three categories:

1. Studies investigating intraday effects: The data is used to reach results on an intraday basis; for example the intraday distribution of the spread or the intraday seasonality in liquidity.

2. Studies using intraday data to get a certain measure on daily frequency.

3. Studies using intraday data to investigate properties of every quote or every trade regardless of the time series behavior.

The difference between the first and the third category lies in the time spaces between the events. Intraday studies are based on equally spaced observations whereas the investigations on quotes or trades neglect the inhomogeneity of the time series.

Table B.1 in appendix B gives an overview of the different types of empirical studies using intraday data which are incorporated in the present dissertation and their subject of investigation.

Because the SWX data is not preprocessed it has to be cleaned for errors. Errors in the data may be separated into human and system errors. Human errors include unintentional

[3]For problems arising through the use of indicative quotes see Daníelsson & Payne (2002).

errors, such as typing errors and intentional errors, such as dummy ticks, produced just for technical testing of the computer system. System errors are caused by failures of the computer system. In this data cleaning process, negative spreads were sorted out, as well as negative depths. Furthermore, spreads larger than 10% of the actual stock price were eliminated.

Bid, ask and transaction prices arrive in the limit order book in an irregular sequence neither in pairs nor synchronous. Therefore, the original data set is inhomogeneous. A regular time spacing has to be imposed to make the data mathematically tractable. Over the inhomogeneous time series a five minute grid was imposed to get homogeneous ones with a regular spacing. This five minute grid is used for example by Wang (2002) and Andersen & Bollerslev (1997) and it is narrower than the 15 minutes time space used by Ranaldo (2001) for the Swiss market and, therefore, more accurate. On the other hand, it leaves the market participants time to react to the liquidity information provided. The first time space in the morning lasts from 9.00 until 9.05 a.m. Trading goes on until 5.20 p.m. The closing auction is left out because the spreads become too large and distort the data series. At the five minute time interval, one day has 100 data points, yielding for one stock 6500 data points. There are two interpolation methods that may be used:

- linear interpolation
- previous-tick interpolation

Usually, the difference between the two methods leads to apparently the same results. In the present dissertation the previous-tick interpolation will be used because it incorporates only available information at the point of the interpolation, whereas linear interpolation has to rely on future information.

Chapter 3

Summary Statistics and Correlations

In this chapter I present the summary statistics and correlations of the 31 liquidity measures. Correlations among liquidity measures are looked at in a variety of studies, but a complete overview in literature is missing to date.

The empirical findings to date about co-movement of liquidity measures yield a variety of results, which are partially contradictive. One of the few stylized facts is that large spreads are associated with low depth.[1]

The interrelation of trading volume and spread is ambiguous: In Lee et al. (1993) high trading volume leads to larger spreads and lower depth, but Chan & Pinder (2000) as well as Chordia, Roll & Subrahmanyam (2001) document a negative correlation of spreads and trading volume. Acker et al. (2002) show how trading volume is related to spreads around earnings announcements, but their study is based on daily closing bid and ask prices which may not be indicative for liquidity during the day. Additionally, they show in a regression-based approach that the average spread during the day is, in general, an unbiased predictor for the closing spread. With the present sample this finding could not be confirmed. Corwin (1999) describes a negative relationship of the number of trades, trade size and market capitalization to quoted and effective spreads, but the relationship to quoted depth is positive. For the Chinese stock market, Yang et al. (2001) report a negative relation of volume to spread. Karagozoglu (2000) explains the liquidity in the futures market using trading volume and spread as liquidity measures and the trading volume is negatively related to the spread.

Kluger & Stephan (1997) document, in an article using daily data, a high rank correlation for firm size, liquidity ratio, spread, and relative odds ratio. The relative odds ratio was not presented in the liquidity measures in chapter 1, because it is only able to express liquidity of one stock relative to another. The co-movement of five liquidity measures is thoroughly investigated in Chordia et al. (2000).

Commonality in liquidity measures across different stocks is investigated by Hasbrouck & Seppi (2001). They found, for the log quote slope, 13% of the total variation can be attributed to the first common factor, but for other liquidity measures this part is smaller and for the effective spread it does practically not exist. Chordia, Roll & Subrahmanyam (2001) estimate a "market model" of liquidity: Liquidity of a single stock is explained via liquidity of the market. Lin et al. (1995) investigate the relation of the components of the

[1] See e.g. Lee et al. (1993).

spread and trade size and show their intraday variation.

An aspect not considered in this dissertation will be the seasonality in the measures. Daily seasonality is well documented in the literature (see e.g. Andersen & Bollerslev (1997)) and leads usually to an U-shape or an L-shape of liquidity. For the FX market also the weekly patterns are well described.

For the American market, liquidity seems to be highest on Tuesdays and lowest on Fridays, as Chordia, Roll & Subrahmanyam (2001) state.

At the end of this chapter it should be possible to determine a set of liquidity measures that are able to capture the dimensions of liquidity presented in section 1.1.

With the averages of the liquidity measures, the stocks are ranked and the most liquid stock is determined. I also investigate which liquidity measures generate the same rankings and which ones generate rankings that differ from each other.

3.1 Summary Statistics of the Liquidity Measures

For all liquidity measures mean, median, maximum, minimum, standard deviation, skewness, kurtosis and the result of the Jarque-Bera test for normality are shown. The test statistic is calculated as follows:

$$Jarque - Bera = \frac{N}{6} \cdot \left(S^2 + \frac{(Ku - 3)^2}{4} \right) \tag{3.1}$$

N denotes the number of observations, in our case 6500. S is the skewness and Ku the kurtosis of the liquidity measure. Since the normal distribution has a skewness of 0 and a kurtosis of 3, the Jarque-Bera test statistic for a normal distribution becomes zero. Under the null hypothesis of a normal distribution the test statistic is χ^2-distributed with 2 degrees of freedom. The p-value is the probability that the Jarque-Bera test statistic exceeds the observed value under the null hypothesis.

3.1.1 Summary Statistics of Adecco

Table 3.1 presents the summary statistics of the 31 liquidity measures for Adecco.

The average number of shares traded in each five minute interval is 8'209 shares which generates an average turnover of 708'964 CHF. These two liquidity measures have a minimum of zero and are strongly right-skewed. Average depth is 6'158 shares with a skewness of 66. There are about 13 trades per five minute interval generated by 31 orders. The average absolute spread is 0.19 CHF. The relative spreads are around 0.22%. The effective spreads are a little smaller than half the absolute and relative spreads. The average quote slope is 0.0131. Composite liquidity is very small since dollar depth is much larger than the relative spread. The liquidity ratio 1 shows that, on average, a turnover of 3.37 mio. CHF has to be generated to move the price one percent. The liquidity ratio 3 on the other hand indicates that each trade leads to an absolute price move of 0.07%. Since turnover and number of trades may fall to zero in a five minute time space, so does the flow ratio. On average, it is 17.4 mio. CHF. The order ratio as a measure of market imbalance is around 0.0324 shares per CHF. Average composite liquidity is $2.22 \cdot 10^{-8}$. The average market impact for a trade

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	8'209	708'964	6'158	14.45	289'626	12.71	30.93	0.19
Median	4'999	432'878	3'646	14.51	154'423	10.00	25.00	0.20
Maximum	194'558	$1.69 \cdot 10^{7}$	1'500'931	20.48	$6.43 \cdot 10^{7}$	160.00	343.00	1.80
Minimum	0	0	45	5.41	1'787	0.00	0.00	0.05
Std. Dev.	11'003	950'671	19'813	2.18	866'923	10.84	24.51	0.12
Skewness	4.76	5.19	66.24	-0.33	62.09	2.61	2.34	1.64
Kurtosis	46.44	56.75	4'986.00	3.36	4'568.13	19.33	14.89	12.18

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	-1.87	0.22%	0.22%	0.22%	-6.34	0.08	0.10%	0.10%
Median	-1.61	0.23%	0.23%	0.23%	-6.09	0.08	0.10%	0.10%
Maximum	0.59	2.40%	2.37%	2.40%	-3.73	0.90	1.20%	1.20%
Minimum	-3.00	0.05%	0.05%	0.05%	-7.60	0.00	0.00%	0.00%
Std. Dev.	0.68	0.15%	0.15%	0.15%	0.67	0.06	0.07%	0.07%
Skewness	-0.36	2.50	2.48	2.50	-0.29	1.71	2.76	2.77
Kurtosis	2.20	19.47	19.04	19.47	2.51	13.41	24.56	24.60

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	$1.31 \cdot 10^{-2}$	$1.51 \cdot 10^{-4}$	$3.54 \cdot 10^{-4}$	$2.22 \cdot 10^{-8}$	$3.37 \cdot 10^{8}$	0.07%	$1.74 \cdot 10^{7}$	$3.24 \cdot 10^{-2}$
Median	$1.34 \cdot 10^{-2}$	$1.39 \cdot 10^{-4}$	$2.60 \cdot 10^{-4}$	$9.91 \cdot 10^{-9}$	$1.49 \cdot 10^{8}$	0.05%	4'421'876	$3.08 \cdot 10^{-3}$
Maximum	0.12	$1.62 \cdot 10^{-3}$	$6.23 \cdot 10^{-3}$	$1.55 \cdot 10^{-6}$	$1.29 \cdot 10^{10}$	0.94%	$2.70 \cdot 10^{9}$	13.55
Minimum	$2.55 \cdot 10^{-3}$	$2.63 \cdot 10^{-5}$	$3.15 \cdot 10^{-5}$	$1.82 \cdot 10^{-11}$	0.00	0.00%	0.00	0.00
Std. Dev.	$8.01 \cdot 10^{-3}$	$1.04 \cdot 10^{-4}$	$3.74 \cdot 10^{-4}$	$4.98 \cdot 10^{-8}$	$6.57 \cdot 10^{8}$	0.06%	$6.48 \cdot 10^{7}$	0.31
Skewness	1.84	2.88	5.26	14.46	7.15	2.59	21.68	28.91
Kurtosis	13.59	21.59	49.98	337.37	89.61	18.62	704.50	1'049.82

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^{A}(k)$	$DI^{B}(k)$	$PI^{A}(q)$	$PI^{B}(q)$	
Mean	0.72	0.37	0.35	42'804	46'303	$3.80 \cdot 10^{-3}$	$3.67 \cdot 10^{-3}$	
Median	0.60	0.33	0.30	38'431	40'678	$3.24 \cdot 10^{-3}$	$3.10 \cdot 10^{-3}$	
Maximum	5.10	2.98	3.70	156'059	1'592'234	$3.86 \cdot 10^{-2}$	$5.76 \cdot 10^{-2}$	
Minimum	0.05	0.03	0.03	1'361	750	$2.50 \cdot 10^{-4}$	$2.50 \cdot 10^{-4}$	
Std. Dev.	0.43	0.27	0.26	22'459	32'431	$2.69 \cdot 10^{-3}$	$2.61 \cdot 10^{-3}$	
Skewness	2.66	2.76	3.04	1.16	17.78	3.24	4.15	
Kurtosis	17.49	18.30	24.00	5.15	799.14	25.06	47.96	

Table 3.1: Summary statistics of the liquidity measures of Adecco on the five minute interval.

of 500'000 CHF is 0.72 CHF. It is slightly higher on the ask-side of the limit order book. Also the depth for price impact and the price impact show higher liquidity on the bid-side than on the ask-side.

A negative skewness shows the distribution of the log depth, the log absolute spread and the log relative spread of log prices. The distribution of all liquidity measures except the log absolute spread and the log relative spread of log prices are fat-tailed. According to the Jarque-Bera test, none of the liquidity measures is normally distributed.

3.1.2 Summary Statistics of Baer

Table 3.2 presents the summary statistics of the liquidity measures for Baer. On average, 404 shares are traded in each five minute interval, yielding a turnover of 171'782 CHF. The maximum level lies about 50 times above this level while there are five minute periods without any trades. The average depth is 25'831 shares with a minimum of 5 shares and a maximum of 53'369 shares. Depth and log depth are the only liquidity measures that are negatively skewed. The average dollar depth is 5'804'125 CHF with a maximum of 13.8 mio. CHF and

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	404	171'782	25'831	14.94	5'804'125	5.15	14.72	1.00
Median	184	76'786	23'317	15.32	5'040'091	3.00	9.00	1.00
Maximum	20'254	6'915'398	53'369	19.41	$1.38 \cdot 10^7$	60.00	236.00	10.00
Minimum	0	0	5	1.39	878	0.00	0.00	0.50
Std. Dev.	734	309'301	11'310	2.11	2'987'893	5.81	18.42	0.71
Skewness	8.27	7.16	-0.23	-1.65	0.30	2.26	3.31	2.63
Kurtosis	149.92	103.86	3.47	6.91	3.04	11.07	20.57	14.71

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	-0.18	0.24%	0.24%	0.24%	-6.24	0.51	0.12%	0.12%
Median	0.00	0.20%	0.20%	0.20%	-6.22	0.50	0.10%	0.10%
Maximum	2.30	2.20%	2.18%	2.20%	-3.82	12.50	4.40%	4.22%
Minimum	-0.69	0.10%	0.10%	0.10%	-6.91	0.00	0.00%	0.00%
Std. Dev.	0.56	0.19%	0.19%	0.19%	0.59	0.41	0.11%	0.11%
Skewness	0.77	2.93	2.93	2.93	0.82	6.06	10.60	9.78
Kurtosis	2.83	16.17	16.16	16.17	3.03	125.20	335.09	291.75

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	$7.07 \cdot 10^{-2}$	$1.71 \cdot 10^{-4}$	$8.93 \cdot 10^{-4}$	$9.10 \cdot 10^{-9}$	$5.91 \cdot 10^7$	0.09%	2'125'167	0.75
Median	$5.92 \cdot 10^{-2}$	$1.24 \cdot 10^{-4}$	$6.49 \cdot 10^{-4}$	$3.08 \cdot 10^{-10}$	$1.20 \cdot 10^7$	0.06%	275'546	0.13
Maximum	0.69	$1.87 \cdot 10^{-3}$	$9.30 \cdot 10^{-3}$	$1.62 \cdot 10^{-6}$	$2.81 \cdot 10^9$	1.92%	$3.67 \cdot 10^8$	86.02
Minimum	$2.59 \cdot 10^{-2}$	$5.32 \cdot 10^{-5}$	$8.02 \cdot 10^{-5}$	$8.44 \cdot 10^{-11}$	0.00	0.00%	0.00	0.00
Std. Dev.	$6.03 \cdot 10^{-2}$	$1.65 \cdot 10^{-4}$	$7.50 \cdot 10^{-4}$	$4.96 \cdot 10^{-8}$	$1.34 \cdot 10^8$	0.11%	8'003'185	3.57
Skewness	3.28	3.71	3.03	12.58	7.32	3.33	19.63	13.66
Kurtosis	19.26	23.01	18.01	261.40	97.61	27.67	719.77	232.78

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$	
Mean	6.96	1.33	5.63	29'348	4'619	$1.20 \cdot 10^{-2}$	0.10	
Median	3.50	0.50	3.00	27'360	3'462	$1.03 \cdot 10^{-3}$	$4.83 \cdot 10^{-2}$	
Maximum	288.60	69.50	286.85	59'619	23'174	0.41	1.54	
Minimum	0.50	0.25	0.25	130	20	$5.00 \cdot 10^{-4}$	$6.17 \cdot 10^{-4}$	
Std. Dev.	13.93	3.96	12.41	12'539	4'174	$4.70 \cdot 10^{-2}$	0.18	
Skewness	11.74	7.93	14.96	-0.05	2.05	5.20	3.75	
Kurtosis	207.74	91.61	308.40	3.23	7.85	31.44	17.80	

Table 3.2: Summary statistics of the liquidity measures of Baer on the five minute interval.

a minimum of 878 CHF. On average, there are 5.15 trades in each five minute interval but the maximum was 60. The number of orders is about three times as high as the number of trades. The absolute spread has a minimum of 0.50 CHF because this is the minimum tick size. On average it is 1 CHF but shows values as high as 10 CHF. The log absolute spread is the only liquidity measure that has a kurtosis smaller than 3. The relative spreads with the mid price and the last trade are almost equal. The effective spread is about half as large as the absolute spread indicating that there is no trading within the quote. Similarly, the two relative effective spreads are about equal and half the relative spreads. The average quote slope is 0.07 but did rise up to 0.68 and decline to 0.02. Since the adjusted log quote slope has an additional term that takes the imbalance between depth on the bid- and the ask-side into account, it is larger than the log quote slope. Composite liquidity is about 10 times smaller than for Adecco. The liquidity ratio 1 shows that, on average, a turnover of 591'200 CHF is necessary to move the price of Baer one percent. The liquidity ratio 3 in contrast indicates that with each trade the price moves 0.09%. The flow ratio has a huge standard deviation since turnover and number of trades are positively correlated as can be seen further below. The order ratio takes the imbalance between bid and ask depth into account. On average it is 0.75, but with declining turnover it may rise to 86. The market impact for a turnover of 500'000 CHF is 6.96 CHF on average. This market impact is very unevenly distributed since the market impact on the ask-side of the limit order book is only 1.33 CHF, while the market impact on the bid-side is 5.63 CHF. The depth for price impact measures mirror the market impact on the ask-side and the bid-side: Since the market impact on the ask-side is lower, the depth for a 2% price impact on the ask-side is much larger than on the bid-side. This depth is, on average, 29'347 shares on the ask-side and 4619 shares on the bid-side. The price impact is as for the previous liquidity measures much larger on the ask-side than on the bid-side.

The results of the Jarque-Bera tests indicate that none of the liquidity measures of Baer is normally distributed.

3.1.3 Summary Statistics of Richemont

Table 3.3 shows the summary statistics of the liquidity measures for Richemont.

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*
Mean	10'477	355'311	13'789	16.59	239'115	8.13	15.96	0.08
Median	6'635	226'159	11'533	16.80	195'487	7.00	13.00	0.05
Maximum	666'090	$2.16 \cdot 10^7$	153'371	22.30	2'912'935	65.00	221.00	1.30
Minimum	0	0	87	5.86	1'255	0.00	0.00	0.05
Std. Dev.	14'629	497'120	10'955	1.75	202'965	6.78	12.46	0.06
Skewness	15.52	13.99	3.34	-0.79	3.77	1.70	2.72	5.41
Kurtosis	629.60	523.95	26.17	4.78	30.37	8.28	22.35	63.30

	LogSabs	*SrelM*	*Srelp*	*Srellog*	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*
Mean	-2.62	0.25%	0.25%	0.25%	-6.15	0.04	0.11%	0.11%
Median	-3.00	0.17%	0.17%	0.17%	-6.38	0.03	0.08%	0.08%
Maximum	0.26	3.61%	3.57%	3.61%	-3.32	0.65	2.30%	2.25%
Minimum	-3.00	0.12%	0.12%	0.12%	-6.71	0.00	0.00%	0.00%
Std. Dev.	0.50	0.20%	0.20%	0.20%	0.54	0.04	0.12%	0.12%
Skewness	1.18	4.84	4.84	4.84	1.10	5.76	5.63	5.55
Kurtosis	4.02	48.22	48.29	48.23	3.83	65.72	63.19	61.10

	QS	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*	*FR*	*OR*
Mean	$5.17 \cdot 10^{-3}$	$1.55 \cdot 10^{-4}$	$3.64 \cdot 10^{-4}$	$2.37 \cdot 10^{-8}$	$1.21 \cdot 10^{8}$	0.07%	5'206'723	0.14
Median	$3.37 \cdot 10^{-3}$	$1.06 \cdot 10^{-4}$	$2.44 \cdot 10^{-4}$	$1.11 \cdot 10^{-8}$	$4.63 \cdot 10^{7}$	0.05%	1'499'404	$1.59 \cdot 10^{-2}$
Maximum	0.10	$2.82 \cdot 10^{-3}$	$1.06 \cdot 10^{-2}$	$5.16 \cdot 10^{-6}$	$3.12 \cdot 10^{9}$	3.65%	$1.19 \cdot 10^{9}$	49.46
Minimum	$2.24 \cdot 10^{-3}$	$5.84 \cdot 10^{-5}$	$6.43 \cdot 10^{-5}$	$4.52 \cdot 10^{-10}$	0.00	0.00%	0.00	0.00
Std. Dev.	$4.18 \cdot 10^{-3}$	$1.33 \cdot 10^{-4}$	$4.20 \cdot 10^{-4}$	$9.47 \cdot 10^{-8}$	$2.08 \cdot 10^{8}$	0.09%	$1.87 \cdot 10^{7}$	1.29
Skewness	6.77	5.93	7.73	33.79	4.09	13.10	41.13	27.12
Kurtosis	96.62	71.60	120.74	1'553.27	30.65	433.99	2'487.11	918.34

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
Mean	0.61	0.24	0.37	57'738	55'055	$2.78 \cdot 10^{-3}$	$3.20 \cdot 10^{-3}$
Median	0.35	0.13	0.18	48'165	47'603	$1.93 \cdot 10^{-3}$	$2.28 \cdot 10^{-3}$
Maximum	27.65	4.88	26.63	285'663	284'086	$5.05 \cdot 10^{-2}$	0.55
Minimum	0.05	0.03	0.03	149	366	$6.11 \cdot 10^{-4}$	$6.13 \cdot 10^{-4}$
Std. Dev.	1.80	0.38	1.73	37'590	36'867	$3.20 \cdot 10^{-3}$	$1.08 \cdot 10^{-2}$
Skewness	12.76	6.11	13.89	1.59	2.21	5.45	42.26
Kurtosis	178.06	53.62	200.65	6.86	11.57	49.64	2'045.93

Table 3.3: Summary statistics of the liquidity measures of Richemont on the five minute interval.

The average volume of 10'477 shares per five minute interval is much larger than the one for Baer and also larger than Adecco's. Also, turnover which is better comparable among different stocks is about twice as high as Baer's but only half as large as Adecco's. Interestingly, depth of Richemont is smaller with respect to Baer while log depth is larger. Log depth is the only liquidity measure with a skewness smaller than zero. The average dollar depth is 239'115 CHF with a maximum of almost 3 mio. CHF and a minimum of 1'255 CHF. There are about 8 trades and 16 orders per five minute interval. Due to the lower price of Richemont with respect to Baer, this stock trades in a smaller tick size range and has an average absolute spread of 0.085 CHF. With 0.25%, the relative spreads are in the range of Baer. The effective spread is smaller than twice the absolute spread, which means that there is trading within the quote. The relative effective spreads are again in the range of Baer. The average quote slope is about 0.0052 and the log quote slope 0.0002 with the adjusted log quote slope twice as high. Composite liquidity of Richemont is in the range of Adecco but larger than Baer's. This is due to the fact that dollar depth of Richemont is much smaller than the one for Baer. The liquidity ratio 1 indicates that a turnover of 1.21 mio. CHF is necessary to move the price one percent. The liquidity ratio 3 is in the range of Adecco and Baer. The flow ratio of Richemont is larger than the one for Baer since turnover and number of trades are also larger. The market impact for Richemont is 0.61 CHF. It is more evenly distributed between bid- and ask-side of the limit order book than for the Baer stock but, again, there is more liquidity on the ask-side than on the bid-side, as the depth for price impact and the price impact measures show.

All the liquidity measures have a kurtosis larger than three indicating that the distributions are fat tailed.

Again, none of the liquidity measures is normally distributed, as the Jarque-Bera test shows.

3.1.4 Summary Statistics of Ciba

The summary statistics of the liquidity measures of Ciba are presented in table 3.4. The average trading volume for a five minute time interval is 2'455 shares, but the maximum was five times higher. Average turnover is 282'889 CHF and lies between Baer and Richemont and well below Adecco. Depth is, with 9'461 shares, relatively low but dollar depth lies also between Baer and Richemont. Log depth is the only liquidity measure with a negative skewness. There are 6 trades and 14 orders per five minute interval which is in line with Baer and Richemont. The absolute spread is 0.29 CHF. At the beginning of the sample period Ciba was trading above 100 CHF but then dropped below that limit which decreased the minimum tick size. The relative spreads are similar to Baer and Richemont. The effective spread is slightly smaller than half the absolute spread. The relative effective spreads are in the range of Baer and Richemont. The average quote slope is 0.0185. Due to the moving market, the adjusted log quote slope is much larger than the log quote slope. Composite liquidity is in the range of Baer. According to the liquidity ratio 1 a turnover 743'000 CHF is needed to move the price 1%. The liquidity ratio 3 is almost equal to that of the other stocks. The flow ratio is, at 4.2 mio., between Baer and Richemont, and the same holds for the order ratio. The market impact is 0.74 CHF and is almost equally distributed on the ask- and the bid-side of the limit order book. The market impact for the ask-side shows slightly less liquidity than the market impact for the bid-side. In contrast to this, the depth for price impact measures show more liquidity on the ask-side than on the bid-side. The

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	2'455	282'889	9'461	15.82	571'026	6.50	14.00	0.29
Median	1'076	127'173	7'745	16.03	460'711	5.00	10.00	0.25
Maximum	120'269	$1.40 \cdot 10^7$	54'236	20.37	3'367'948	91.00	206.00	1.50
Minimum	0	0	115	6.09	5'699	0.00	0.00	0.05
Std. Dev.	4'135	472'061	7'352	1.86	460'126	6.84	14.67	0.11
Skewness	6.62	6.85	1.90	-0.74	1.95	2.64	3.38	2.55
Kurtosis	119.02	128.20	7.81	4.36	7.99	15.86	22.65	13.80

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	-1.29	0.25%	0.25%	0.25%	-6.06	0.13	0.11%	0.11%
Median	-1.39	0.21%	0.21%	0.21%	-6.18	0.13	0.10%	0.10%
Maximum	0.41	1.44%	1.44%	1.44%	-4.24	0.88	0.76%	0.76%
Minimum	-3.00	0.05%	0.05%	0.05%	-7.60	0.00	0.00%	0.00%
Std. Dev.	0.31	0.10%	0.10%	0.10%	0.32	0.07	0.06%	0.06%
Skewness	0.24	2.75	2.75	2.75	0.83	2.32	2.62	2.62
Kurtosis	9.95	15.43	15.43	15.44	7.77	17.30	18.96	18.94

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	$1.85 \cdot 10^{-2}$	$1.58 \cdot 10^{-4}$	$3.60 \cdot 10^{-4}$	$9.29 \cdot 10^{-9}$	$7.43 \cdot 10^7$	0.07%	4'211'835	0.18
Median	$1.60 \cdot 10^{-2}$	$1.34 \cdot 10^{-4}$	$2.91 \cdot 10^{-4}$	$5.07 \cdot 10^{-9}$	240'100	0.05%	577'363	$1.42 \cdot 10^{-2}$
Maximum	0.13	$1.39 \cdot 10^{-3}$	$1.13 \cdot 10^{-2}$	$6.10 \cdot 10^{-7}$	$3.84 \cdot 10^9$	0.69%	$7.85 \cdot 10^8$	53.50
Minimum	$3.39 \cdot 10^{-3}$	$3.51 \cdot 10^{-5}$	$4.46 \cdot 10^{-5}$	$6.31 \cdot 10^{-10}$	0.00	0.00%	0.00	0.00
Std. Dev.	$7.13 \cdot 10^{-3}$	$6.84 \cdot 10^{-5}$	$2.91 \cdot 10^{-4}$	$1.79 \cdot 10^{-8}$	$1.78 \cdot 10^8$	0.07%	$1.64 \cdot 10^7$	1.22
Skewness	3.14	3.60	10.54	12.94	6.87	1.54	22.39	24.78
Kurtosis	24.80	32.38	318.30	304.02	89.08	7.32	879.13	887.98

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
Mean	0.74	0.38	0.36	51'044	41'570	$3.60 \cdot 10^{-3}$	$3.36 \cdot 10^{-3}$
Median	0.50	0.38	0.38	44'644	41'952	$2.89 \cdot 10^{-3}$	$2.80 \cdot 10^{-3}$
Maximum	5.50	3.75	4.13	123'258	127'097	$4.71 \cdot 10^{-2}$	$4.17 \cdot 10^{-2}$
Minimum	0.25	0.05	0.03	1'601	879	$9.89 \cdot 10^{-4}$	$9.90 \cdot 10^{-4}$
Std. Dev.	0.48	0.32	0.28	26'931	14'801	$2.78 \cdot 10^{-3}$	$2.49 \cdot 10^{-3}$
Skewness	2.87	3.28	3.50	0.43	0.18	3.26	3.92
Kurtosis	17.11	21.24	28.40	2.13	3.60	23.53	34.48

Table 3.4: Summary statistics of the liquidity measures of Ciba on the five minute interval.

price impacts again confirm the result of the market impact measures. The depth for price impact on the ask-side is the only liquidity measure that has a kurtosis smaller than 3.

None of the liquidity measures seems to be normally distributed according to the Jarque-Bera test.

3.1.5 Summary Statistics of Clariant

Table 3.5 presents the summary statistics of the liquidity measures for Clariant.

The average volume is 4'607 shares per time interval. Average turnover is 154'065 CHF. There are five minute periods without trades, while maximum volume and turnover are 50 times higher. Depth and dollar depth have a mean of 6'368 shares and 111'392 CHF, respectively, but they could be tenfold. The average log depth is the only liquidity measure with negative skewness. There are 7 trades and 15 orders per time interval. The absolute spread is 0.09 CHF but most of the realizations are 0.05 CHF. Only the log absolute spread has a kurtosis smaller than 3. The relative spreads have an average of 0.27% and are almost identical. The effective spread has a mean of 0.04 CHF, almost half the absolute spread which indicates few trading within the quote. The relative effective spreads have a mean of

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*
Mean	4'607	154'065	6'368	14.89	111'392	6.72	14.83	0.09
Median	2'476	84'538	4'761	15.07	81'819	5.00	11.00	0.05
Maximum	228'412	7'149'231	69'893	19.84	1'158'467	76.00	133.00	0.85
Minimum	0	0	16	4.14	239	0.00	0.00	0.05
Std. Dev.	7'148	232'814	5'736	1.85	104'621	6.71	14.30	0.06
Skewness	7.99	7.37	2.79	-0.72	2.98	2.14	2.45	2.74
Kurtosis	172.88	147.99	15.54	4.30	16.96	10.80	11.82	16.73

	LogSabs	*SrelM*	*Srelp*	*Srellog*	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*
Mean	-2.57	0.27%	0.27%	0.27%	-6.11	0.04	0.12%	0.12%
Median	-3.00	0.17%	0.17%	0.17%	-6.40	0.03	0.07%	0.07%
Maximum	-0.16	2.88%	2.93%	2.88%	-3.55	0.88	3.02%	2.93%
Minimum	-3.00	0.13%	0.13%	0.13%	-6.68	0.00	0.00%	0.00%
Std. Dev.	0.52	0.21%	0.21%	0.21%	0.57	0.04	0.12%	0.12%
Skewness	0.90	3.04	3.05	3.04	0.92	6.02	6.11	6.03
Kurtosis	2.93	18.81	19.02	18.81	3.07	103.14	98.54	95.46

	QS	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*	*FR*	*OR*
Mean	$6.06 \cdot 10^{-3}$	$1.83 \cdot 10^{-4}$	$4.33 \cdot 10^{-4}$	$5.60 \cdot 10^{-8}$	$4.67 \cdot 10^{7}$	0.08%	2'195'390	0.25
Median	$4.09 \cdot 10^{-3}$	$1.25 \cdot 10^{-4}$	$2.86 \cdot 10^{-4}$	$2.69 \cdot 10^{-8}$	$1.51 \cdot 10^{7}$	0.06%	419'630	$1.44 \cdot 10{-}2$
Maximum	$5.81 \cdot 10^{-2}$	$2.01 \cdot 10^{-3}$	$1.09 \cdot 10^{-2}$	$1.12 \cdot 10^{-5}$	$1.46 \cdot 10^{9}$	1.56%	$3.22 \cdot 108$	$2.34 \cdot 102$
Minimum	$2.52 \cdot 10^{-3}$	$6.55 \cdot 10^{-5}$	$7.01 \cdot 10^{-5}$	$1.40 \cdot 10^{-9}$	0.00	0.00%	0.00	0.00
Std. Dev.	$4.15 \cdot 10^{-3}$	$1.44 \cdot 10^{-4}$	$4.83 \cdot 10^{-4}$	$1.95 \cdot 10^{-7}$	$8.20 \cdot 10^{7}$	0.10%	7'514'160	4.35
Skewness	3.07	3.37	5.83	37.75	4.19	3.87	17.94	43.58
Kurtosis	21.79	24.03	72.73	1'940.24	34.93	31.83	581.39	2'124.91

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
Mean	1.19	0.53	0.67	41'248	35'248	$5.08 \cdot 10^{-3}$	$4.74 \cdot 10^{-3}$
Median	0.50	0.28	0.25	36'312	33'334	$3.72 \cdot 10^{-3}$	$3.38 \cdot 10^{-3}$
Maximum	34.59	8.80	29.39	142'028	129'372	0.13	0.10
Minimum	0.05	0.03	0.03	110	0	$6.28 \cdot 10^{-4}$	$6.33 \cdot 10^{-4}$
Std. Dev.	2.61	0.98	2.25	25'246	18'611	$5.73 \cdot 10^{-3}$	$5.71 \cdot 10^{-3}$
Skewness	7.09	5.09	9.08	1.03	0.75	7.05	6.71
Kurtosis	64.31	32.14	93.18	3.94	4.12	91.09	71.76

Table 3.5: Summary statistics of the liquidity measures of Clariant on the five minute interval.

0.12%. The quote slope is about 0.0061 and, therefore, pretty small indicating high liquidity. The log quote slope and the adjusted log quote slope, on the other hand, are larger than the ones for Ciba, Richemont and Adecco. Composite liquidity is about twice as high as for Richemont. The market impact of an order of 500'000 CHF is 1.19 CHF. As the liquidity measures that separate bid- and ask-side of the limit order book show, liquidity on the ask-side is slightly lower than on the bid-side.

According to the Jarque-Bera test, none of the liquidity measures is normally distributed.

3.1.6 Summary Statistics of Givaudan

The summary statistics of Givaudan are presented in table 3.6. The average trading volume is 480 shares, yielding a turnover of 288'285 CHF. But these figures had a maximum of 17'778 shares and 10'730'865 CHF, respectively. Average depth is around 2'000 shares with an average dollar depth of 580'475 CHF. Log depth is, again, the only liquidity measure with a negative skewness. Givaudan shows only 5 trades and 11 orders per five minute interval. The absolute spread is 1.43 CHF with a maximum of 9 CHF. Log absolute spread

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	480	288'285	1'912	12.02	580'475	5.33	11.03	1.43
Median	164	99'125	1'112	12.15	335'235	4.00	8.00	1.00
Maximum	17'778	$1.07 \cdot 10^7$	60'848	19.44	$1.90 \cdot 10^7$	55.00	109.00	9.00
Minimum	0	0	15	2.89	4'540	0.00	0.00	1.00
Std. Dev.	964	584'917	3'593	1.97	1'100'342	5.58	10.48	0.66
Skewness	6.04	6.17	8.51	-0.18	8.52	2.37	2.68	2.06
Kurtosis	60.99	63.10	100.61	3.54	100.97	12.17	14.68	11.80

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	0.28	0.24%	0.24%	0.24%	-6.12	0.62	0.10%	0.10%
Median	0.00	0.17%	0.17%	0.17%	-6.39	0.50	0.08%	0.08%
Maximum	2.20	1.62%	1.63%	1.62%	-4.12	7.50	1.36%	1.34%
Minimum	0.00	0.16%	0.16%	0.16%	-6.44	0.00	0.00%	0.00%
Std. Dev.	0.38	0.11%	0.11%	0.11%	0.39	0.40	0.07%	0.07%
Skewness	0.92	2.23	2.24	2.23	0.93	2.34	2.63	2.59
Kurtosis	2.68	13.69	13.84	13.70	2.78	22.89	28.16	27.19

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	0.12	$2.04 \cdot 10^{-4}$	$4.83 \cdot 10^{-4}$	$1.17 \cdot 10^{-8}$	$9.04 \cdot 10^7$	0.07%	3'679'468	$6.75 \cdot 10^{-2}$
Median	$9.71 \cdot 10^{-2}$	$1.62 \cdot 10^{-4}$	$3.77 \cdot 10^{-4}$	$6.82 \cdot 10^{-9}$	3'835'324	0.05%	373'542	$2.41 \cdot 10^{-3}$
Maximum	1.04	$1.72 \cdot 10^{-3}$	$6.69 \cdot 10^{-3}$	$8.69 \cdot 10^{-7}$	$4.64 \cdot 10^9$	0.69%	$4.19 \cdot 10^8$	28.32
Minimum	$5.15 \cdot 10^{-2}$	$8.23 \cdot 10^{-5}$	$9.44 \cdot 10^{-5}$	$8.41 \cdot 10^{-11}$	0.00	0.00%	0.00	0.00
Std. Dev.	$6.14 \cdot 10^{-2}$	$1.06 \cdot 10^{-4}$	$3.69 \cdot 10^{-4}$	$2.14 \cdot 10^{-8}$	$2.32 \cdot 10^8$	0.07%	$1.45 \cdot 10^7$	0.62
Skewness	2.78	2.88	3.77	15.55	8.25	1.75	12.71	31.25
Kurtosis	20.90	21.55	34.73	471.50	117.82	8.08	245.19	1'252.59

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$	
Mean	3.84	1.91	1.93	9'316	7'580	$2.28 \cdot 10^{-2}$	$4.40 \cdot 10^{-2}$	
Median	3.00	1.50	1.50	7'996	6'770	$1.36 \cdot 10^{-2}$	$1.84 \cdot 10^{-2}$	
Maximum	36.00	26.00	15.50	70'488	81'232	0.14	0.62	
Minimum	1.00	0.50	0.50	451	672	$7.99 \cdot 10^{-4}$	$8.00 \cdot 10^{-4}$	
Std. Dev.	2.25	1.42	1.35	7'547	5'161	$2.24 \cdot 10^{-2}$	$7.11 \cdot 10^{-2}$	
Skewness	2.61	3.21	2.54	4.69	5.64	1.61	3.30	
Kurtosis	17.33	27.88	14.34	32.21	50.95	5.11	15.60	

Table 3.6: Summary statistics of the liquidity measures of Givaudan on the five minute interval.

and log relative spread of log prices are the only liquidity measures which are not fat-tailed with respect to a normal distribution. The relative spread is in line with the other stocks, showing a value of 0.24%. The effective spread is about half the absolute spread. The quote slope is 0.122 and is, therefore, relatively high. Also the log quote slope is higher than those for the previous stocks, which does not hold for the adjusted log quote slope. Composite liquidity is relatively high due to the low dollar depth. The liquidity ratio 1 shows, that 903'620 CHF of turnover are necessary to move the price 1%. On the other hand, every trade leads to a price move of 0.07% as the liquidity ratio 3 indicates. The flow ratio of 3.7 mio. CHF is the second lowest up to now, only Baer's flow ratio is lower. The order ratio shows, with a value of 0.0675, little order imbalance. The market impact for an order of 500'000 CHF is 3.84 CHF and liquidity is almost equally distributed on the both sides of the order book. This is not confirmed by depth for price impact and price impact: Depth for a price impact of 2% is larger on the ask-side and the price impact for an order of 10'000 shares is higher on the bid-side, showing higher ask-side-related liquidity.

The Jarque-Bera test shows, that all liquidity measures are not normally distributed.

3.1.7 Summary Statistics of Holcim

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	1'058	366'036	1'856	12.39	332'881	7.99	18.80	0.70
Median	607	208'172	1'318	12.52	230'510	6.00	14.00	0.50
Maximum	44'201	$1.54 \cdot 10^{7}$	21'549	18.27	4'172'533	81.00	163.00	4.50
Minimum	0	0	27	3.26	5'144	0.00	0.00	0.50
Std. Dev.	1'602	570'839	1'854	1.92	347'836	7.09	17.13	0.35
Skewness	8.57	9.11	3.19	-0.40	3.25	1.97	2.45	2.48
Kurtosis	162.28	175.02	19.70	3.41	20.24	10.31	11.77	13.63

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	-0.45	0.20%	0.20%	0.20%	-6.30	0.30	0.09%	0.09%
Median	-0.69	0.15%	0.15%	0.15%	-6.50	0.25	0.07%	0.07%
Maximum	1.50	1.26%	1.25%	1.26%	-4.37	2.75	0.97%	0.98%
Minimum	-0.69	0.13%	0.13%	0.13%	-6.66	0.00	0.00%	0.00%
Std. Dev.	0.39	0.11%	0.11%	0.11%	0.43	0.21	0.07%	0.07%
Skewness	1.29	2.53	2.53	2.53	1.23	2.55	2.88	2.88
Kurtosis	3.59	12.71	12.68	12.71	3.62	16.23	19.36	19.50

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	$5.79 \cdot 10^{-2}$	$1.71 \cdot 10^{-4}$	$3.95 \cdot 10^{-4}$	$1.63 \cdot 10^{-8}$	$1.32 \cdot 10^{8}$	0.06%	5'615'104	$1.45 \cdot 10^{-2}$
Median	$4.37 \cdot 10^{-2}$	$1.29 \cdot 10^{-4}$	$2.90 \cdot 10^{-4}$	$7.81 \cdot 10^{-9}$	$3.45 \cdot 10^{7}$	0.05%	1'354'325	$1.91 \cdot 10^{-3}$
Maximum	0.40	$1.45 \cdot 10^{-3}$	$6.38 \cdot 10^{-3}$	$4.76 \cdot 10^{-7}$	$5.36 \cdot 10^{9}$	0.79%	$1.16 \cdot 10^{9}$	5.73
Minimum	$2.80 \cdot 10^{-2}$	$7.52 \cdot 10^{-5}$	$8.10 \cdot 10^{-5}$	$3.60 \cdot 10^{-10}$	0.00	0.00%	0.00	0.00
Std. Dev.	$3.21 \cdot 10^{-2}$	$1.07 \cdot 10^{-4}$	$3.67 \cdot 10^{-4}$	$2.83 \cdot 10^{-8}$	$2.69 \cdot 10^{8}$	0.06%	$2.23 \cdot 10^{7}$	0.14
Skewness	2.69	2.77	4.42	6.13	6.86	2.50	29.44	31.55
Kurtosis	15.30	15.62	39.85	59.41	89.65	16.61	1'304.63	1'153.95

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
Mean	2.84	1.47	1.37	15'526	14'330	$1.20 \cdot 10^{-2}$	$1.05 \cdot 10^{-2}$
Median	2.00	1.25	1.00	13'096	13'209	$8.71 \cdot 10^{-3}$	$8.05 \cdot 10^{-3}$
Maximum	21.50	16.25	10.75	60'110	54'055	$8.04 \cdot 10^{-2}$	$4.72 \cdot 10^{-2}$
Minimum	0.50	0.25	0.25	93	606	$6.38 \cdot 10^{-4}$	$6.75 \cdot 10^{-4}$
Std. Dev.	2.07	1.37	1.11	11'021	8'445	$1.03 \cdot 10^{-2}$	$7.55 \cdot 10^{-3}$
Skewness	2.02	3.16	2.13	1.24	1.49	2.01	1.45
Kurtosis	9.67	19.54	10.39	4.51	7.14	8.40	5.09

Table 3.7: Summary statistics of the liquidity measures of Holcim on the five minute interval.

The summary statistics for Holcim are available in table 3.7. Its trading volume is, on average, 1'058 shares per five minute interval. Turnover is 366'036 CHF. The depth of 1'856 shares leads to a dollar depth of 332'881 CHF. Log depth has a negative skewness. Eight trades take place in each time space and 19 orders are inserted. The average absolute spread is 0.70 CHF with a maximum of 4.50 CHF. The relative spreads are 0.2%. The effective spread is with 0.30 CHF slightly smaller than half the absolute spread. The quote slope shows a value of 0.058 and is close to the one for Baer. Log quote slope and adjusted log quote slope are close to those of Givaudan. According to the liquidity ratio 1, 1'317'274 CHF have to be traded to move the price one percent. One trade results in an average price move of 0.06% as the liquidity ratio 3 shows. The market impact is relatively low with 2.84 CHF and liquidity is equally distributed on the bid- and the ask-side of the limit order book. For Holcim this is confirmed by depth for price impact and price impact.

All liquidity measures are fat-tailed with respect to a normal distribution as the kurtosis' show. And, again, all of them are not normally distributed as the Jaque-Bera test indicates.

3.1.8 Summary Statistics of Kudelski

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	3'068	169'182	2'195	12.32	60'784	10.73	20.50	0.19
Median	1'718	96'748	1'290	12.43	37'803	8.00	15.50	0.15
Maximum	61'868	3'404'575	99'020	19.77	2'574'528	190.00	241.00	1.20
Minimum	0	0	9	2.64	180	0.00	0.00	0.05
Std. Dev.	4'208	234'114	4'661	1.96	120'125	11.41	19.47	0.12
Skewness	3.93	4.41	12.62	-0.45	12.66	4.03	3.16	1.41
Kurtosis	29.65	38.24	207.24	3.86	211.68	36.74	20.60	6.64

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	-1.90	0.34%	0.34%	0.34%	-5.95	0.09	0.16%	0.16%
Median	-1.90	0.28%	0.28%	0.28%	-5.89	0.08	0.12%	0.12%
Maximum	0.18	2.83%	2.82%	2.83%	-3.56	0.68	1.21%	1.19%
Minimum	-3.00	0.07%	0.07%	0.07%	-7.33	0.00	0.00%	0.00%
Std. Dev.	0.68	0.26%	0.26%	0.26%	0.75	0.07	0.14%	0.14%
Skewness	-0.19	1.85	1.85	1.85	-0.09	1.57	1.87	1.87
Kurtosis	2.19	8.91	8.86	8.91	2.31	7.01	7.93	7.89

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	$1.53 \cdot 10^{-2}$	$2.82 \cdot 10^{-4}$	$6.81 \cdot 10^{-4}$	$1.55 \cdot 10^{-7}$	$6.01 \cdot 10^{7}$	0.12%	3'867'378	$4.96 \cdot 10^{-2}$
Median	$1.33 \cdot 10^{-2}$	$2.26 \cdot 10^{-4}$	$4.79 \cdot 10^{-4}$	$7.30 \cdot 10^{-8}$	$2.45 \cdot 10^{7}$	0.09%	768'331	$4.87 \cdot 10^{-3}$
Maximum	$9.32 \cdot 10^{-2}$	$2.26 \cdot 10^{-3}$	$9.53 \cdot 10^{-3}$	$3.45 \cdot 10^{-5}$	$1.77 \cdot 10^{9}$	1.51%	$5.17 \cdot 10^{8}$	27.91
Minimum	$2.53 \cdot 10^{-3}$	$4.01 \cdot 10^{-5}$	$4.90 \cdot 10^{-5}$	$5.10 \cdot 10^{-10}$	0.00	0.00%	0.00	0.00
Std. Dev.	$1.03 \cdot 10^{-2}$	$2.17 \cdot 10^{-4}$	$7.20 \cdot 10^{-4}$	$5.44 \cdot 10^{-7}$	$1.07 \cdot 10^{8}$	0.12%	$1.47 \cdot 10^{7}$	0.46
Skewness	1.55	2.00	3.98	42.80	4.63	2.63	16.67	40.06
Kurtosis	7.57	10.19	29.65	2'518.41	37.22	15.66	420.16	2'160.81

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$	
Mean	2.12	1.04	1.08	14'680	13'576	$1.08 \cdot 10^{-2}$	$1.17 \cdot 10^{-2}$	
Median	1.90	0.83	0.95	12'493	11'221	$8.87 \cdot 10^{-3}$	$1.01 \cdot 10^{-2}$	
Maximum	10.45	9.75	5.08	71'717	121'302	0.10	$5.93 \cdot 10^{-2}$	
Minimum	0.10	0.03	0.03	55	100	$3.89 \cdot 10^{-4}$	$3.73 \cdot 10^{-4}$	
Std. Dev.	1.17	0.82	0.66	9'553	10'382	$7.81 \cdot 10^{-3}$	$7.09 \cdot 10^{-3}$	
Skewness	1.65	2.78	1.39	1.71	3.78	2.62	1.58	
Kurtosis	7.56	16.53	5.86	7.10	28.13	16.31	7.03	

Table 3.8: Summary statistics of the liquidity measures of Kudelski on the five minute interval.

Trading volume of Kudelski in table 3.8 is much higher than Holcim's: On average, 3'068 shares are traded, leading to a turnover of 169'182, which is lower than the turnover for Holcim. The same holds for the depth measures: depth is higher but dollar depth is lower. Log depth, the log absolute spread and the log relative spread of log prices have a skewness smaller than zero. 11 trades take place in each time space, coming from 21 orders. The maximum lies at 190 trades and 241 orders. The absolute spread is 0.19 CHF and the relative spreads are relatively high with 0.34%. The kurtosis of the log absolute spread and the log relative spread of log prices are smaller than the one of the normal distribution. The effective spread is half the absolute spread, therefore, no trading takes place within the quote. The quote slope is with 0.0153 rather small. On the other hand, log quote slope and adjusted log quote slope are high compared to the other stocks. Also composite liquidity is relatively high, denoting low liquidity. To move the price one percent, a turnover of 601'000 CHF has to be generated as the liquidity ratio 1 suggests. According to the liquidity ratio 3 every trade moves the price 0.12%, which means again low liquidity. The flow ratio is in the range of Givaudan and the order ratio is slightly smaller. The market impact is 2.12

CHF and it is equally distributed on the bid- and ask-side of the limit order book. This is confirmed by the depth for price impact and the price impact measures.

The Jarque-Bera test suggests that all liquidity measures are not normally distributed.

3.1.9 Summary Statistics of Lonza

The summary statistics of Lonza are provided by table 3.9.

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*
Mean	1'826	202'088	7'038	15.17	404'051	4.70	10.36	0.29
Median	617	70'247	5'693	15.38	324'225	3.00	7.00	0.25
Maximum	77'045	8'840'914	61'557	20.11	3'538'592	55.00	128.00	2.00
Minimum	0	0	39	4.41	1'891	0.00	0.00	0.05
Std. Dev.	3'320	375'614	5'929	1.88	346'641	5.25	10.76	0.12
Skewness	6.13	6.55	2.47	-0.69	2.39	2.15	2.80	2.34
Kurtosis	81.81	91.27	12.97	3.94	12.40	10.51	15.74	15.91

	LogSabs	*SrelM*	*Srelp*	*Srellog*	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*
Mean	-1.31	0.26%	0.26%	0.26%	-6.03	0.14	0.12%	0.12%
Median	-1.39	0.22%	0.22%	0.22%	-6.14	0.13	0.11%	0.11%
Maximum	0.69	2.04%	2.06%	2.04%	-3.89	1.25	1.21%	1.20%
Minimum	-3.00	0.05%	0.05%	0.05%	-7.60	0.00	0.00%	0.00%
Std. Dev.	0.40	0.12%	0.12%	0.12%	0.39	0.07	0.07%	0.07%
Skewness	-0.91	2.96	2.98	2.96	-0.18	2.78	3.27	3.22
Kurtosis	8.84	21.76	22.15	21.76	7.39	25.03	29.07	28.29

	QS	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*	*FR*	*OR*
Mean	$1.93 \cdot 10^{-2}$	$1.74 \cdot 10^{-4}$	$3.95 \cdot 10^{-4}$	$1.51 \cdot 10^{-8}$	$5.38 \cdot 10^{7}$	0.07%	2'268'868	0.15
Median	$1.66 \cdot 10^{-2}$	$1.44 \cdot 10^{-4}$	$3.18 \cdot 10^{-4}$	$7.34 \cdot 10^{-9}$	0.00	0.05%	222'757	$1.02 \cdot 10^{-2}$
Maximum	0.14	$1.48 \cdot 10^{-3}$	$5.80 \cdot 10^{-3}$	$1.97 \cdot 10^{-6}$	$3.61 \cdot 10^{9}$	0.81%	$3.80 \cdot 10^{8}$	39.48
Minimum	$3.19 \cdot 10^{-3}$	$3.26 \cdot 10^{-5}$	$3.91 \cdot 10^{-5}$	$6.15 \cdot 10^{-10}$	0.00	0.00%	0.00	0.00
Std. Dev.	$8.37 \cdot 10^{-3}$	$8.67 \cdot 10^{-5}$	$3.10 \cdot 10^{-4}$	$3.85 \cdot 10^{-8}$	$1.42 \cdot 10^{8}$	0.09%	8'394'540	1.02
Skewness	2.87	3.49	4.56	24.83	7.53	1.73	19.56	20.43
Kurtosis	21.04	26.00	45.22	1'095.50	108.83	7.69	703.17	576.55

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
Mean	1.17	0.59	0.58	33'113	28'989	$6.19 \cdot 10^{-3}$	$7.50 \cdot 10^{-3}$
Median	0.75	0.38	0.38	29'236	25'645	$3.56 \cdot 10^{-3}$	$3.63 \cdot 10^{-3}$
Maximum	96.00	17.75	95.38	223'975	99'434	0.15	0.74
Minimum	0.25	0.10	0.03	281	286	$1.03 \cdot 10^{-3}$	$7.24 \cdot 10^{-4}$
Std. Dev.	2.95	1.00	2.71	22'235	16'226	$9.78 \cdot 10^{-3}$	$3.35 \cdot 10^{-2}$
Skewness	24.99	9.83	31.04	1.62	1.00	6.06	14.30
Kurtosis	736.67	133.52	1'004.13	7.44	3.98	54.47	231.96

Table 3.9: Summary statistics of the liquidity measures of Lonza on the five minute interval.

For Lonza 1'826 shares traded per five minute interval that generate a turnover of 202'088 CHF. Average depth is 7'038 shares which corresponds to a dollar depth of 404'051 CHF. Log depth, the log absolute spread and the log relative spread of log prices are the only three liquidity measures with a skewness smaller than zero. 4.7 trades occur in each interval and 10.4 orders. The absolute spread is on average 0.29 CHF. The relative spread is 0.26%. The effective spread is about half the absolute spread indicating that almost no trading within the quotes takes place. The relative effective spread is 0.12%, while the quote slope is relatively small with 0.0193. Log quote slope and adjusted log quote slope are in the range of Holcim which holds for composite liquidity either. To move the price of Lonza one percent, a turnover of 538'203 CHF was necessary and with every trade, the price moved 0.07%. The flow ratio is rather low and lies in the range of the Baer stock, while the order ratio is rather high and equals almost that of Ciba. Market impact for a turnover of 500'000 CHF is 1.17 CHF and liquidity is almost equally distributed on the bid- and the ask-side of the order book according to market impact for the bid-side and the ask-side, respectively. Depth for price impact and price impact show slightly higher liquidity on the ask-side of the limit order book.

All liquidity measures have a kurtosis larger than 3, suggesting fat-tails with respect to the normal distribution and none is normally distributed as the Jarque-Bera test shows.

3.1.10 Summary Statistics of Swiss Re

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*
Mean	13'715	1'926'097	14'829	16.75	1'106'249	16.56	30.05	0.29
Median	9'364	1'341'058	12'414	17.04	907'248	13.00	24.00	0.25
Maximum	530'815	$7.07 \cdot 10^{7}$	113'363	21.40	9'016'972	133.00	238.00	1.25
Minimum	0	0	153	7.89	10'770	0.00	0.00	0.05
Std. Dev.	15'820	2'166'690	10'148	1.88	810'437	12.90	22.93	0.10
Skewness	7.04	6.67	2.09	-1.11	2.12	1.82	2.10	2.82
Kurtosis	182.53	163.99	11.64	4.65	11.61	8.83	10.53	13.50

	LogSabs	*SrelM*	*Srelp*	*Srellog*	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*
Mean	-1.28	0.20%	0.20%	0.20%	-6.26	0.13	0.09%	0.09%
Median	-1.39	0.17%	0.17%	0.17%	-6.35	0.13	0.09%	0.09%
Maximum	0.22	1.06%	1.05%	1.06%	-4.55	1.00	0.72%	0.72%
Minimum	-3.00	0.05%	0.05%	0.05%	-7.60	0.00	0.00%	0.00%
Std. Dev.	0.27	0.08%	0.08%	0.08%	0.31	0.06	0.05%	0.05%
Skewness	1.89	3.16	3.15	3.16	1.72	2.44	2.71	2.71
Kurtosis	7.57	18.04	17.88	18.04	6.20	19.54	19.10	19.01

	QS	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*	*FR*	*OR*
Mean	$1.74 \cdot 10^{-2}$	$1.23 \cdot 10^{-4}$	$3.00 \cdot 10^{-4}$	$3.23 \cdot 10^{-9}$	$5.68 \cdot 10^{8}$	0.06%	$5.37 \cdot 10^{7}$	$5.33 \cdot 10^{-2}$
Median	$1.51 \cdot 10^{-2}$	$1.05 \cdot 10^{-4}$	$2.25 \cdot 10^{-4}$	$2.07 \cdot 10^{-9}$	$2.62 \cdot 10^{8}$	0.05%	$1.80 \cdot 10^{7}$	$3.67 \cdot 10^{-3}$
Maximum	$8.01 \cdot 10^{-2}$	$6.78 \cdot 10^{-4}$	$3.00 \cdot 10^{-3}$	$1.65 \cdot 10^{-7}$	$1.07 \cdot 10^{10}$	0.60%	$6.86 \cdot 10^{9}$	106
Minimum	$3.29 \cdot 10^{-3}$	$3.31 \cdot 10^{-5}$	$5.62 \cdot 10^{-5}$	$1.63 \cdot 10^{-10}$	0.00	0.00%	0.00	0.00
Std. Dev.	$6.15 \cdot 10^{-3}$	$5.23 \cdot 10^{-5}$	$2.46 \cdot 10^{-4}$	$4.60 \cdot 10^{-9}$	$8.37 \cdot 10^{8}$	0.05%	$1.34 \cdot 10^{8}$	1.42
Skewness	2.79	3.12	2.90	14.47	3.03	1.90	22.76	67.21
Kurtosis	14.98	18.91	15.29	407.90	18.96	11.27	1'042.08	4'940.76

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
Mean	0.50	0.25	0.25	89'155	87'477	$2.10 \cdot 10^{-3}$	$2.16 \cdot 10^{-3}$
Median	0.50	0.13	0.13	84'501	80'730	$1.79 \cdot 10^{-3}$	$1.78 \cdot 10^{-3}$
Maximum	2.75	1.88	2.63	222'304	335'769	$1.36 \cdot 10^{-2}$	$1.81 \cdot 10^{-2}$
Minimum	0.25	0.05	0.08	6'541	5'945	$5.32 \cdot 10^{-4}$	$7.32 \cdot 10^{-4}$
Std. Dev.	0.28	0.18	0.20	39'754	47'488	$1.38 \cdot 10^{-3}$	$1.64 \cdot 10^{-3}$
Skewness	2.08	2.13	2.83	0.47	1.53	2.23	2.82
Kurtosis	10.57	10.86	16.76	2.90	7.07	11.51	15.13

Table 3.10: Summary statistics of the liquidity measures of Swiss Re on the five minute interval.

Table 3.10 presents the summary statistics of the Swiss Re stock. It has a trading volume of 13'715 shares per five minute time space. This leads to a turnover of almost 2 mio. CHF. Also for the most liquid stock Swiss Re there are time spaces without trades. Depth is close to 15'000 shares yielding an average dollar depth of more than one million CHF. There are 17 trades per five minute interval from 30 orders. The average absolute spread is 0.29 CHF and the average relative spread 0.2%. The effective spread is 0.13 CHF and the relative effective spread 0.09% which indicates some trading inside the quote. Composite liquidity is, due to the large dollar depth, rather low. According to the liquidity ratio 1, 5.68 mio. CHF of turnover is necessary to move the price of Swiss Re one percent – a very high value. On the other hand, each trade moves the price for 0.06% which is as low, as for Holcim. The flow ratio is very high due to the large number of trades and the high turnover. The market imbalance on the other side lies in the range of Kudelski, for example. The market impact for a trade of 500'000 CHF is on average 0.50 CHF and is equally distributed on both sides of the limit order book. Depth for price impact and price impact show slightly larger liquidity on the ask-side of the limit order book.

Only the log depth shows a negative skewness and only the depth for price impact on the ask-side has a kurtosis smaller than the normal distribution.

3.1.11 Summary Statistics of Swisscom

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	1'057	467'858	1'817	12.64	405'509	7.45	14.77	0.69
Median	613	271'293	1'499	12.82	331'236	6.00	12.00	0.50
Maximum	43'172	$1.81 \cdot 10^{7}$	17'015	17.33	3'765'288	75.00	147.00	4.00
Minimum	0	0	33	4.66	7'389	0.00	0.00	0.50
Std. Dev.	1'489	660'016	1'391	1.66	315'404	6.72	12.61	0.33
Skewness	6.46	6.13	2.68	-0.70	2.71	2.04	3.10	2.20
Kurtosis	119.50	102.34	16.33	3.99	16.44	10.93	20.16	10.13
	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	-0.46	0.16%	0.16%	0.16%	-6.55	0.30	0.07%	0.07%
Median	-0.69	0.12%	0.12%	0.12%	-6.76	0.25	0.06%	0.06%
Maximum	1.39	0.99%	1.00%	0.99%	-4.62	2.00	0.50%	0.50%
Minimum	-0.69	0.10%	0.10%	0.10%	-6.88	0.00	0.00%	0.00%
Std. Dev.	0.38	0.08%	0.08%	0.08%	0.38	0.19	0.04%	0.04%
Skewness	1.27	2.33	2.34	2.33	1.28	1.88	2.01	2.00
Kurtosis	3.44	11.45	11.51	11.45	3.54	10.35	11.34	11.29
	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	$5.51 \cdot 10^{-2}$	$1.25 \cdot 10^{-4}$	$2.78 \cdot 10^{-4}$	$6.71 \cdot 10^{-9}$	$2.13 \cdot 10^{8}$	0.04%	6'823'334	$1.43 \cdot 10^{-2}$
Median	$4.24 \cdot 10^{-2}$	$9.65 \cdot 10^{-5}$	$2.15 \cdot 10^{-4}$	$4.24 \cdot 10^{-9}$	$5.18 \cdot 10^{7}$	0.04%	1'543'146	$1.58 \cdot 10^{-3}$
Maximum	0.34	$8.36 \cdot 10^{-4}$	$3.34 \cdot 10^{-3}$	$1.64 \cdot 10^{-7}$	$1.52 \cdot 10^{10}$	0.65%	$9.61 \cdot 10^{8}$	2.14
Minimum	$2.89 \cdot 10^{-2}$	$6.43 \cdot 10^{-5}$	$7.05 \cdot 10^{-5}$	$2.98 \cdot 10^{-10}$	0.00	0.00%	0.00	0.00
Std. Dev.	$2.78 \cdot 10^{-2}$	$6.53 \cdot 10^{-5}$	$2.26 \cdot 10^{-4}$	$8.88 \cdot 10^{-9}$	$4.15 \cdot 10^{8}$	0.04%	$2.30 \cdot 10^{7}$	$8.57 \cdot 10^{-2}$
Skewness	2.64	2.79	4.05	6.60	10.10	2.31	19.32	14.97
Kurtosis	14.62	16.19	32.68	77.47	283.95	15.59	605.12	271.90
	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$	
Mean	1.94	1.01	0.93	14'495	16'301	$8.28 \cdot 10^{-3}$	$1.20 \cdot 10^{-2}$	
Median	1.50	0.75	0.75	14'402	15'922	$7.04 \cdot 10^{-3}$	$6.12 \cdot 10^{-3}$	
Maximum	9.50	6.75	7.00	34'161	50'211	$8.26 \cdot 10^{-2}$	0.57	
Minimum	0.50	0.25	0.25	1'620	2'364	$5.33 \cdot 10^{-4}$	$9.43 \cdot 10^{-4}$	
Std. Dev.	1.11	0.70	0.67	5'101	6'240	$5.53 \cdot 10^{-3}$	$3.47 \cdot 10^{-2}$	
Skewness	1.94	1.97	2.46	0.38	0.68	3.14	7.93	
Kurtosis	9.08	9.83	13.82	3.09	4.69	20.44	75.13	

Table 3.11: Summary statistics of the liquidity measures of Swisscom on the five minute interval.

Table 3.11 presents the summary statistics of the 31 liquidity measures for the Swisscom stock. On average, there are 1'057 shares traded per five minutes, generating a turnover of 467'858 CHF. Average depth at the best bid and ask quote is 1'817 shares leading to a dollar depth of 405'509 CHF. There occur 7.45 trades per time space from about twice as many orders. The absolute spread is 0.69 CHF and the relative spread 0.16%, which is a rather low value. The effective spread and relative effective spread show with their values, which are slightly smaller than half the absolute spread and half the relative spread, respectively, some trading inside the quote. The quote slope is 0.055, which is similar to Holcim. Log quote slope and adjusted log quote slope are close to the respective liquidity measures of Swiss Re. Composite liquidity of Swisscom is twice as large as composite liquidity of Swiss Re, denoting lower liquidity. The liquidity ratio 1 shows liquidity half as large for Swisscom as for Swiss Re. The liquidity ratio 3 has a very low value, which indicates that every trade moves the stock price by only 0.04%, on average. The flow ratio is about 6.8 mio. and the order ratio shows relatively few order imbalance between bid- and ask-side of the limit order book. Market impact is close to 2 CHF and the Market impact for bid- and ask-side, depth for price impact and price impact measures show slightly higher liquidity on the bid-side than on the ask-side of the limit order book.

Only the log depth shows a negative skewness and all of the liquidity measures have a kurtosis larger than 3. No liquidity measure is normally distributed according to the Jarque-Bera test.

3.1.12 Summary Statistics of Serono

Table 3.12 presents the summary statistics of the 31 liquidity measures for the Serono stock. On average, only 485 shares per five minute time space are traded which is similar to Givaudan but average turnover is, with 490'000 CHF, much higher. Average depth is with 245 shares very low but dollar depth, which is more comparable among different stocks, is not the lowest. Log depth is, once more, the only liquidity measure with a negative skewness. In each time space there are 11.5 trades stemming from 23 orders. Due to the minimum tick size, the average absolute spread is relatively large with 2.62, but the relative spread is well in the range of the other stocks. A kurtosis smaller than the normal distribution show the log absolute spread and the log relative spread of log prices. The effective spread measures are somewhat smaller than the respective absolute spread measures indicating some trading inside the quote. Due to the larger spread and the relatively low depth, the quote slope is, on average, high. The log quote slope is with $3.07 \cdot 10^{-4}$ very large, but the adjusted log quote slope, which takes the moving market into account, is smaller than the one for Baer. Average composite liquidity is large because of the large relative spread. As the liquidity ratio 1 indicates, it takes a turnover of 1.89 mio. CHF to move the stock price one percent, and with a value of 0.09% the liquidity ratio 3 is rather large. The flow ratio is with 11.7 mio. higher than the one for Swisscom while the order ratio is about 10 times smaller indicating higher liquidity. The market impact of a trade of 500'000 CHF is, with 13.8 CHF, the highest so far, and is equally distributed on both sides of the limit order book. In contrast to this, depth for price impact shows higher liquidity on the bid-side of the limit order book, and the price impact measures show higher liquidity on the ask-side. The different liquidity distribution on bid-side and ask-side of the limit order book stems from the measurement

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	485	489'689	245	8.60	127'675	11.53	22.76	2.62
Median	279	291'209	197	8.73	103'806	9.00	17.00	2.00
Maximum	12'081	$1.20 \cdot 10^7$	5'542	13.55	2'588'102	178.00	316.00	15.00
Minimum	0	0	6	2.08	2'842	0.00	0.00	1.00
Std. Dev.	655	641'818	213	1.63	105'772	11.39	19.78	1.54
Skewness	4.18	4.15	5.54	-0.48	4.52	3.12	2.73	1.33
Kurtosis	37.05	36.89	87.29	3.46	61.82	22.99	19.29	6.01

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	0.80	0.26%	0.26%	0.26%	-6.16	1.19	0.12%	0.12%
Median	0.69	0.22%	0.22%	0.22%	-6.12	1.00	0.09%	0.09%
Maximum	2.71	1.96%	1.94%	1.96%	-3.93	9.50	1.01%	1.00%
Minimum	0.00	0.08%	0.08%	0.08%	-7.19	0.00	0.00%	0.00%
Std. Dev.	0.58	0.17%	0.17%	0.17%	0.62	0.89	0.10%	0.10%
Skewness	0.00	1.94	1.93	1.94	0.06	1.71	2.08	2.08
Kurtosis	2.07	10.86	10.68	10.86	2.29	8.70	11.28	11.28

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	0.31	$3.07 \cdot 10^{-4}$	$6.79 \cdot 10^{-4}$	$3.62 \cdot 10^{-8}$	$1.89 \cdot 10^8$	0.09%	$1.17 \cdot 10^7$	$1.37 \cdot 10^{-3}$
Median	0.27	$2.54 \cdot 10^{-4}$	$4.92 \cdot 10^{-4}$	$2.11 \cdot 10^{-8}$	$8.70 \cdot 10^7$	0.07%	2'506'806	$2.13 \cdot 10^{-4}$
Maximum	1.93	$2.55 \cdot 10^{-3}$	$1.06 \cdot 10^{-2}$	$1.48 \cdot 10^{-6}$	$5.36 \cdot 10^9$	1.31%	$1.02 \cdot 10^9$	0.22
Minimum	$7.86 \cdot 10^{-2}$	$6.12 \cdot 10^{-5}$	$7.11 \cdot 10^{-5}$	$7.88 \cdot 10^{-10}$	0.00	0.00%	0.00	0.00
Std. Dev.	0.20	$2.13 \cdot 10^{-4}$	$6.61 \cdot 10^{-4}$	$5.67 \cdot 10^{-8}$	$3.19 \cdot 10^8$	0.08%	$3.73 \cdot 10^7$	$7.41 \cdot 10^{-3}$
Skewness	1.81	2.31	4.31	8.75	5.05	2.58	11.11	15.17
Kurtosis	9.11	13.75	38.23	140.87	47.09	19.94	186.91	298.15

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$	
Mean	13.78	6.95	6.84	1'983	2'333	0.16	0.55	
Median	12.00	5.50	5.50	1'840	2'006	0.14	0.47	
Maximum	933.99	92.50	930.99	6'612	8'070	0.64	2.99	
Minimum	1.00	0.50	0.50	58	69	$2.10 \cdot 10^{-2}$	0.02	
Std. Dev.	14.08	5.47	12.41	1'035	1'338	$8.27 \cdot 10^{-2}$	0.47	
Skewness	43.53	4.88	63.75	1.03	0.95	1.05	0.93	
Kurtosis	2'810.20	56.03	4'736.18	4.30	3.51	4.59	3.41	

Table 3.12: Summary statistics of the liquidity measures of Serono on the five minute interval.

of different depths in the order book. Market impact measures a turnover of 500'000 CHF. Depth for price impact shows values of 1'983 shares on the ask-side and 2'333 shares on the bid-side which yields, with a stock price moving between 610 and 1'325 CHF, a much higher turnover. The turnover generated for the price impact, with 10'000 shares, is the highest. Therefore, for lower turnovers the liquidity is evenly distributed on both sides of the limit order book; for higher turnovers it is higher on the bid-side and for very high turnovers liquidity is higher on the ask-side.

3.1.13 Summary Statistics of Surveillance

Table 3.13 shows the summary statistics of Surveillance. On average 252 shares were traded which generated a turnover of 115'162 CHF in each five minute time space. Depth is, on average, 588 shares with a huge maximum of 246'805 shares. This is reflected in the values of dollar depth. Only the log depth has a negative skewness. In every five minute interval, only four trades take place that stem from about 8 orders. The absolute spread is 1.56 CHF and the relative spread is relatively large with 0.33%. A kurtosis smaller than three have

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	252	115'162	588	9.78	138'933	3.96	8.17	1.56
Median	80	37'138	346	9.87	81'079	2.00	6.00	1.50
Maximum	10'502	4'696'910	246'805	18.16	$6.03 \cdot 10^{7}$	53.00	103.00	15.50
Minimum	0	0	9	2.30	1'938	0.00	0.00	0.50
Std. Dev.	527	240'864	3'208	1.72	782'373	4.86	8.85	1.07
Skewness	6.21	6.27	69.75	-0.33	70.10	2.55	2.87	2.76
Kurtosis	65.70	66.06	5'337.79	3.86	5'374.67	13.79	17.12	20.35

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	0.26	0.33%	0.33%	0.33%	-5.89	0.71	0.15%	0.15%
Median	0.41	0.30%	0.30%	0.30%	-5.81	0.50	0.11%	0.11%
Maximum	2.74	3.38%	3.33%	3.38%	-3.39	10.00	1.98%	2.02%
Minimum	-0.69	0.10%	0.10%	0.10%	-6.91	0.00	0.00%	0.00%
Std. Dev.	0.61	0.23%	0.23%	0.23%	0.61	0.67	0.14%	0.15%
Skewness	0.10	3.02	2.99	3.02	0.14	3.72	3.71	3.73
Kurtosis	2.60	23.02	22.50	23.02	2.66	31.10	29.46	29.90

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	0.16	$3.49 \cdot 10^{-4}$	$7.98 \cdot 10^{-4}$	$5.68 \cdot 10^{-8}$	$3.71 \cdot 10^{7}$	0.09%	1'291'766	$2.13 \cdot 10^{-2}$
Median	0.14	$2.93 \cdot 10^{-4}$	$5.91 \cdot 10^{-4}$	$3.41 \cdot 10^{-8}$	2'883'971	0.05%	96'370	$9.77 \cdot 10^{-4}$
Maximum	2.50	$5.31 \cdot 10^{-3}$	$1.38 \cdot 10^{-2}$	$3.78 \cdot 10^{-6}$	$1.81 \cdot 10^{9}$	1.26%	$1.83 \cdot 10^{8}$	18.22
Minimum	$2.75 \cdot 10^{-2}$	$5.64 \cdot 10^{-5}$	$9.33 \cdot 10^{-5}$	$1.70 \cdot 10^{-11}$	0.00	0.00%	0.00	0.00
Std. Dev.	0.12	$2.55 \cdot 10^{-4}$	$7.51 \cdot 10^{-4}$	$1.07 \cdot 10^{-7}$	$8.47 \cdot 10^{7}$	0.12%	5'815'208	0.29
Skewness	3.73	3.96	4.41	15.77	6.09	2.58	14.48	45.55
Kurtosis	41.42	42.10	43.38	425.15	69.52	13.69	301.25	2'512.24

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
Mean	12.29	5.65	6.65	2'688	2'488	$9.69 \cdot 10^{-2}$	0.51
Median	10.00	4.50	4.50	2'240	1'957	$6.63 \cdot 10^{-2}$	0.45
Maximum	359.85	48.50	352.85	248'500	13'803	0.57	2.15
Minimum	1.00	0.25	0.25	37	94	$5.12 \cdot 10^{-4}$	$5.20 \cdot 10^{-4}$
Std. Dev.	12.52	4.81	10.91	3'541	1'901	$8.75 \cdot 10^{-2}$	0.39
Skewness	13.86	3.06	19.99	51.80	2.22	2.33	0.63
Kurtosis	342.74	17.99	577.20	3'574.17	9.12	8.66	2.66

Table 3.13: Summary statistics of the liquidity measures of Surveillance on the five minute interval.

the log absolute spread, the log relative spread of log prices and the price impact for the bid-side. The effective spread is 0.71 CHF and the relative effective spread 0.15%. Those figures indicate some trading inside the quote. The quote slope is steep with 0.16. Composite liquidity is, with a value of $5.68 \cdot 10^{-8}$, in the range of Clariant. It takes a turnover of 370'696 CHF to move the price of Surveillance one percent, and one trade moves the price by 0.09%. With the few trades and the low turnover per time space also the flow ratio is low. On the other hand, the order ratio is, with a value of 0.021, not a sign of very low liquidity. The market impact for an order of 500'000 CHF is on average 12.29 CHF and the ask-side is more liquid than the bid-side as market impact, depth for price impact and price impact suggest.

The Jarque-Bera test indicates that the null hypothesis of a normal distribution can be rejected for all liquidity measures.

3.1.14 Summary Statistics of Sulzer

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	139	44'630	738	10.69	118'992	2.72	6.26	1.39
Median	29	8'917	567	10.79	91'588	1.00	4.00	1.00
Maximum	11'326	3'774'300	11'128	16.14	1'965'106	37.00	122.00	15.00
Minimum	0	0	8	2.48	1'175	0.00	0.00	1.00
Std. Dev.	338	109'082	876	1.54	140'696	3.57	7.45	0.79
Skewness	10.89	10.96	7.10	-0.51	7.51	2.42	3.78	3.99
Kurtosis	247.30	260.35	70.73	3.91	80.78	12.39	29.12	34.36

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	0.23	0.44%	0.44%	0.44%	-5.54	0.64	0.20%	0.20%
Median	0.00	0.33%	0.33%	0.33%	-5.72	0.50	0.16%	0.16%
Maximum	2.71	7.06%	7.32%	7.06%	-2.65	16.00	7.27%	6.78%
Minimum	0.00	0.28%	0.27%	0.28%	-5.89	0.00	0.00%	0.00%
Std. Dev.	0.39	0.29%	0.29%	0.29%	0.43	0.59	0.22%	0.22%
Skewness	1.58	5.68	5.90	5.68	1.57	6.98	12.12	10.76
Kurtosis	5.01	73.95	80.52	74.02	5.39	152.17	345.30	286.42

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	0.13	$4.23 \cdot 10^{-4}$	$9.74 \cdot 10^{-4}$	$7.13 \cdot 10^{-8}$	$1.19 \cdot 10^{7}$	0.10%	352'103	$4.01 \cdot 10^{-2}$
Median	0.10	$3.19 \cdot 10^{-4}$	$7.17 \cdot 10^{-4}$	$4.25 \cdot 10^{-8}$	0.00	0.02%	15'708	$2.08 \cdot 10^{-3}$
Maximum	1.29	$6.06 \cdot 10^{-3}$	$1.89 \cdot 10^{-2}$	$2.90 \cdot 10^{-6}$	$1.12 \cdot 10^{9}$	4.56%	$9.06 \cdot 10^{7}$	20.02
Minimum	$6.36 \cdot 10^{-2}$	$1.94 \cdot 10^{-4}$	$2.03 \cdot 10^{-4}$	$1.55 \cdot 10^{-9}$	0.00	0.00%	0.00	0.00
Std. Dev.	$8.08 \cdot 10^{-2}$	$2.98 \cdot 10^{-4}$	$9.46 \cdot 10^{-4}$	$1.20 \cdot 10^{-7}$	$3.47 \cdot 10^{7}$	0.18%	1'947'016	0.32
Skewness	4.06	5.32	5.79	10.07	9.82	5.85	26.92	42.35
Kurtosis	31.04	55.69	63.80	162.37	206.33	89.07	1'022.41	2'365.19

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
Mean	16.70	8.38	8.32	2'463	3'241	0.40	0.56
Median	11.00	5.50	4.50	2'082	2'652	0.16	0.56
Maximum	323.00	66.00	297.50	9'309	16'678	1.25	2.47
Minimum	1.00	0.50	0.50	2	0	$1.04 \cdot 10^{-2}$	$1.42 \cdot 10^{-3}$
Std. Dev.	29.24	8.46	25.90	1'746	2'598	0.39	0.39
Skewness	7.78	3.18	8.95	1.34	2.57	0.45	0.68
Kurtosis	70.33	15.56	85.31	4.86	10.50	1.58	3.72

Table 3.14: Summary statistics of the liquidity measures of Sulzer on the five minute interval.

The summary statistics of the 31 liquidity measures of Sulzer are presented in table 3.14. On average, only 139 shares per five minute interval were traded generating a turnover of 44'630 CHF. Average depth is 738 shares, which yields a dollar depth of 118'992 CHF. The log depth is the only liquidity measure with a negative skewness. 6 orders per time space lead to an average of 2.7 trades. The absolute spread is, on average, 1.39 CHF with a minimum at the minimal tick size of one CHF. The relative spread is with 0.44% rather high. The effective spread measures are slightly smaller than half the absolute spread and the relative spread measures, respectively. In connection with log depth, the absolute spread leads to a quote slope of 0.13. Compared to the other stocks, log quote slope and adjusted log quotes slope are high. Also, composite liquidity is with $7.13 \cdot 10^{-8}$ relatively high. To move the price of Sulzer one percent an average turnover of 119'000 CHF was necessary, while each trade leads to a price move of 0.09%. With the low turnover and number of trades, also the flow ratio is low, while the order ratio is in the range of the other stocks. The market impact of 16.7 CHF is evenly distributed on the bid- and the ask-side of the limit order book as the market impact measures show. However, the depth for price impact measures show a higher liquidity on the bid-side of the limit order book. Interestingly, the liquidity on the ask-side is higher, using the price impact as reference. The reason is the same as for Serono above: The different ask- and bid-side-specific liquidity measures take different trade sizes into account and may, therefore, show differences in liquidity for the same stock.

None of the liquidity measures is normally distributed as the Jarque-Bera test statistics indicate.

3.1.15 Summary Statistics of Syngenta

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	2'679	243'436	3'485	13.52	163'883	7.03	19.16	0.20
Median	1'326	121'196	2'500	13.67	114'509	5.00	15.00	0.20
Maximum	173'561	$1.59 \cdot 10^7$	439'886	20.59	$2.13 \cdot 10^7$	66.00	174.00	2.05
Minimum	0	0	24	4.68	1'179	0.00	0.00	0.05
Std. Dev.	4'250	386'910	6'372	1.94	309'791	6.34	16.18	0.14
Skewness	12.05	12.29	49.98	-0.51	49.45	2.06	2.09	2.15
Kurtosis	413.17	426.70	3'388.48	3.67	3'337.90	9.95	9.81	16.91

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	-1.82	0.22%	0.22%	0.22%	-6.34	0.09	0.10%	0.10%
Median	-1.61	0.20%	0.20%	0.20%	-6.20	0.08	0.08%	0.08%
Maximum	0.72	2.75%	2.71%	2.75%	-3.59	1.03	1.36%	1.37%
Minimum	-3.00	0.05%	0.05%	0.05%	-7.60	0.00	0.00%	0.00%
Std. Dev.	0.70	0.16%	0.16%	0.16%	0.71	0.07	0.08%	0.08%
Skewness	-0.29	2.61	2.58	2.61	-0.24	2.31	2.80	2.81
Kurtosis	2.32	23.37	22.73	23.37	2.38	17.15	23.71	24.01

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	$1.51 \cdot 10^{-2}$	$1.65 \cdot 10^{-4}$	$4.06 \cdot 10^{-4}$	$2.91 \cdot 10^{-8}$	$1.41 \cdot 10^8$	0.07%	3'354'181	0.14
Median	$1.37 \cdot 10^{-2}$	$1.47 \cdot 10^{-4}$	$2.94 \cdot 10^{-4}$	$1.57 \cdot 10^{-8}$	$4.02 \cdot 10^7$	0.05%	665'290	$6.58 \cdot 10^{-3}$
Maximum	0.16	$1.93 \cdot 10^{-3}$	$5.85 \cdot 10^{-3}$	$2.16 \cdot 10^{-6}$	$4.47 \cdot 10^9$	0.87%	$7.49 \cdot 10^8$	50.72
Minimum	$2.85 \cdot 10^{-3}$	$2.88 \cdot 10^{-5}$	$3.06 \cdot 10^{-5}$	$1.21 \cdot 10^{-10}$	0.00	0.00%	0.00	0.00
Std. Dev.	$1.01 \cdot 10^{-2}$	$1.17 \cdot 10^{-4}$	$3.95 \cdot 10^{-4}$	$5.76 \cdot 10^{-8}$	$2.83 \cdot 10^8$	0.08%	$1.24 \cdot 10^7$	1.22
Skewness	2.44	2.86	3.44	14.45	4.97	2.43	35.63	25.21
Kurtosis	21.53	26.69	25.44	385.00	41.08	13.40	2'024.00	795.43

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
Mean	0.96	0.54	0.42	24'549	25'965	$5.75 \cdot 10^{-3}$	$4.48 \cdot 10^{-3}$
Median	0.75	0.38	0.35	22'410	22'918	$3.73 \cdot 10^{-3}$	$3.56 \cdot 10^{-3}$
Maximum	14.00	10.98	10.85	460'253	86'730	0.10	$8.19 \cdot 10^{-2}$
Minimum	0.10	0.03	0.03	784	122	$2.53 \cdot 10^{-4}$	$2.52 \cdot 10^{-4}$
Std. Dev.	0.93	0.72	0.41	15'722	13'482	$7.55 \cdot 10^{-3}$	$4.14 \cdot 10^{-3}$
Skewness	5.77	6.65	7.13	4.79	1.01	5.93	6.00
Kurtosis	52.51	65.97	105.39	97.26	3.88	50.85	63.71

Table 3.15: Summary statistics of the liquidity measures of Syngenta on the five minute interval.

Table 3.15 shows the summary statistics of the 31 liquidity measures for the Syngenta stock. It generates a volume of 2'679 shares per time space that yields a turnover of 243'436 CHF. Average depth is 3'485 shares which leads to a dollar depth of 163'883 CHF. Log depth, log absolute spread and the log relative spread of log prices have a negative skewness. There are 7 trades and 19 orders per five minute interval. The absolute spread is 0.20 CHF and the average relative spread 0.22%. The log absolute spread and the log relative spread of log prices have a kurtosis smaller than the normal. The average effective spread is 0.09

CHF and the average relative effective spread 0.10% which denotes some trading inside the quote. The quote slope is, with 0.015, relatively flat, while log quote slope and adjusted log quote slope lie in the region of Lonza. Composite liquidity is, with $2.91 \cdot 10^{-8}$, half as large as the one for Surveillance. 1.41 mio. CHF of turnover was necessary to move the price of Syngenta one percent, as the liquidity ratio 1 shows. Each trade induces a price change of 0.07% according to the liquidity ratio 3. The number of trades and the turnover lead to a flow ratio of 3.35 mio. The order ratio is the same as for Richemont showing some imbalance between bid- and ask-side of the limit order book. A trade of 500'000 CHF leads to a market impact of 0.96 CHF. Liquidity is higher on the bid-side of the limit order book as the ask-side-specific and bid-side-specific liquidity measures, respectively, show.

No one of the 31 liquidity measures is normally distributed, according to the Jarque-Bera test.

3.1.16 Summary Statistics of Swatch Bearer Share

As there are two sorts of Swatch shares in the sample, it is interesting to compare them. The summary statistics of the Swatch bearer share are available in table 3.16.

Turnover of the Swatch bearer share is 1'165 shares per time space, generating a turnover of 157'986 CHF. The average depth is 1'892 shares, yielding a dollar depth of 130'286 CHF. Log depth is the only liquidity measure with a negative skewness. 5.7 trades per time space come from about 13 orders. The absolute spread is 0.47 CHF and the relative spread 0.36%. The log absolute spread and the log relative spread of log prices show a kurtosis smaller than the normal distribution. The effective spread is 0.21 CHF, and the relative effective spread of 0.16% is a sign for some trading inside the quote. The quote slope is, with 0.038, more than twice as large as the one for Syngenta. Also, log quote slope, adjusted log quote slope and composite liquidity show a lower liquidity for Swatch bearer share than for Syngenta. A turnover of 420'000 CHF was necessary to move the stock price of Swatch bearer share one percent, and, with every trade, the stock price changes on average for 0.11%. The average flow ratio is, at 1.9 mio., rather low but the order ratio shows few imbalance between bid- and ask-side of the order book. The market impact of a trade of 500'000 CHF is 3.42 CHF. Liquidity on the bid- and the ask-side of the limit order book is unevenly distributed: As the market impact, the depth for price impact and the price impact measures demonstrate, liquidity on the ask-side is smaller than on the bid-side.

Only the log depth is left-skewed and log absolute spread and the log spread of log prices have a kurtosis smaller than the normal distribution. No liquidity measure is normally distributed according to the Jarque-Bera test.

3.1.17 Summary Statistics of Swatch Registered Share

The summary statistics of the other Swatch share's liquidity measures are presented in table 3.17. The volume generated, is with 2'522 shares, twice as high as for Swatch bearer share. But, since the price of the bearer share is much higher, turnover of the registered share is only 71'334 CHF. The same picture is obtained for depth and dollar depth: depth of the registered share is higher, but dollar depth is lower. Log depth shows a negative skewness. The number of orders and trades are comparable among registered share and bearer share.

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	1'165	157'986	1'892	12.59	130'286	5.70	13.09	0.47
Median	628	84'450	1'452	12.78	98'708	4.00	10.00	0.50
Maximum	63'975	8'698'600	53'510	18.49	3'511'645	73.00	119.00	5.25
Minimum	0	0	10	3.18	781	0.00	0.00	0.25
Std. Dev.	1'929	261'889	2'095	1.74	145'383	5.71	11.61	0.29
Skewness	11.83	11.49	10.56	-0.71	9.66	2.49	2.37	2.57
Kurtosis	313.48	295.25	201.68	4.15	168.96	15.50	11.93	20.27
	LogSabs	*SrelM*	*Srelp*	*Srellog*	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*
Mean	-0.89	0.36%	0.36%	0.36%	-5.81	0.21	0.16%	0.16%
Median	-0.69	0.32%	0.32%	0.32%	-5.75	0.13	0.10%	0.10%
Maximum	1.66	4.35%	4.26%	4.35%	-3.13	2.63	2.13%	2.18%
Minimum	-1.39	0.15%	0.15%	0.15%	-6.48	0.00	0.00%	0.00%
Std. Dev.	0.52	0.24%	0.24%	0.24%	0.56	0.16	0.13%	0.13%
Skewness	0.58	2.83	2.78	2.83	0.61	2.40	2.74	2.77
Kurtosis	2.44	21.89	20.86	21.89	2.59	16.78	19.02	19.71
	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	$3.82 \cdot 10^{-2}$	$2.87 \cdot 10^{-4}$	$6.46 \cdot 10^{-4}$	$5.17 \cdot 10^{-8}$	$4.20 \cdot 10^{7}$	0.11%	1'891'540	$3.04 \cdot 10^{-2}$
Median	$3.45 \cdot 10^{-2}$	$2.39 \cdot 10^{-4}$	$4.73 \cdot 10^{-4}$	$3.04 \cdot 10^{-8}$	$1.02 \cdot 10^{7}$	0.07%	375'694	$3.83 \cdot 10^{-3}$
Maximum	0.40	$3.35 \cdot 10^{-3}$	$1.33 \cdot 10^{-2}$	$2.10 \cdot 10^{-6}$	$2.36 \cdot 10^{9}$	1.83%	$3.36 \cdot 10^{8}$	8.61
Minimum	$1.41 \cdot 10^{-2}$	$9.07 \cdot 10^{-5}$	$1.00 \cdot 10^{-4}$	$5.42 \cdot 10^{-10}$	0.00	0.00%	0.00	0.00
Std. Dev.	$2.37 \cdot 10^{-2}$	$1.98 \cdot 10^{-4}$	$6.26 \cdot 10^{-4}$	$8.13 \cdot 10^{-8}$	$8.47 \cdot 10^{7}$	0.13%	7'369'832	0.20
Skewness	2.60	2.88	5.30	9.41	7.42	2.83	22.51	21.97
Kurtosis	19.35	21.41	64.09	164.62	128.12	17.70	801.53	672.54
	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$	
Mean	3.42	1.90	1.52	7'675	10'896	$2.43 \cdot 10^{-2}$	$1.55 \cdot 10^{-2}$	
Median	2.75	1.38	1.25	6'829	8'893	$1.70 \cdot 10^{-2}$	$1.29 \cdot 10^{-2}$	
Maximum	16.50	13.38	12.38	188'248	67'777	0.58	0.30	
Minimum	0.25	0.13	0.13	240	50	$8.78 \cdot 10^{-4}$	$8.22 \cdot 10^{-4}$	
Std. Dev.	2.23	1.68	1.14	4'843	8'106	$3.38 \cdot 10^{-2}$	$1.17 \cdot 10^{-2}$	
Skewness	1.96	2.61	2.85	8.65	2.35	8.84	4.69	
Kurtosis	8.31	12.66	18.46	299.92	10.07	107.56	69.41	

Table 3.16: Summary statistics of the liquidity measures of Swatch bearer share on the five minute interval.

The absolute spread of the Swatch registered share is 0.11 CHF and, therefore, much smaller than the absolute spread of the bearer share, while the relative spreads are in the same range. The same holds for the different effective spread measures. Again, the log absolute spread and the log relative spread of log prices show a kurtosis smaller than three. The quote slope of the registered share is 0.0074 and, therefore, much smaller than the bearer share's, while log quote slope and adjusted log quote slope are about the same. Due to the lower dollar depth, composite liquidity is larger for the registered share, denoting lower liquidity. The liquidity ratio 1 is, with 190'000 CHF per one percent move, even lower than for the bearer share, while the liquidity ratios 3 are the same. Flow ratio and order ratio show less liquidity for the registered share than for the bearer share. Market impact for the registered share is with 1.94 CHF lower than for the bearer share, a sign for higher liquidity. The bid-side- and ask-side-specific liquidity measures show higher liquidity on the ask-side of the order book for Swatch registered share than for the bearer share.

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	2'522	71'334	7'446	14.96	103'809	4.38	14.71	0.11
Median	1'100	31'115	5'116	15.11	75'485	3.00	10.00	0.10
Maximum	114'101	3'189'123	105'079	20.02	1'523'615	44.00	147.00	1.25
Minimum	0	0	32	4.09	424	0.00	0.00	0.05
Std. Dev.	4'335	123'554	6'541	1.98	85'725	4.98	14.55	0.07
Skewness	6.25	6.32	2.22	-0.81	2.26	2.27	2.49	2.67
Kurtosis	95.17	93.71	15.90	4.78	19.45	10.58	12.10	20.97

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	-2.37	0.40%	0.40%	0.40%	-5.73	0.05	0.19%	0.19%
Median	-2.30	0.33%	0.33%	0.33%	-5.71	0.05	0.15%	0.15%
Maximum	0.22	5.49%	5.63%	5.49%	-2.90	0.85	3.77%	3.63%
Minimum	-3.00	0.14%	0.14%	0.14%	-6.54	0.00	0.00%	0.00%
Std. Dev.	0.57	0.29%	0.29%	0.29%	0.61	0.04	0.18%	0.18%
Skewness	0.38	3.25	3.30	3.25	0.39	3.55	4.39	4.25
Kurtosis	2.27	30.11	31.71	30.13	2.42	33.69	49.83	45.95

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	$7.44 \cdot 10^{-3}$	$2.65 \cdot 10^{-4}$	$6.91 \cdot 10^{-4}$	$7.79 \cdot 10^{-8}$	$1.90 \cdot 10^{7}$	0.11%	739'208	0.49
Median	$6.48 \cdot 10^{-3}$	$2.24 \cdot 10^{-4}$	$4.84 \cdot 10^{-4}$	$4.24 \cdot 10^{-8}$	2'025'931	0.07%	93'561	$2.96 \cdot 10^{-2}$
Maximum	$9.17 \cdot 10^{-2}$	$4.03 \cdot 10^{-3}$	$1.89 \cdot 10^{-2}$	$4.61 \cdot 10^{-6}$	$5.93 \cdot 10^{8}$	1.44%	$1.24 \cdot 10^{8}$	297
Minimum	$2.57 \cdot 10^{-3}$	$7.95 \cdot 10^{-5}$	$7.97 \cdot 10^{-5}$	$2.45 \cdot 10^{-9}$	0.00	0.00%	0.00	0.00
Std. Dev.	$4.86 \cdot 10^{-3}$	$1.88 \cdot 10^{-4}$	$7.13 \cdot 10^{-4}$	$1.63 \cdot 10^{-7}$	$4.21 \cdot 10^{7}$	0.15%	2'761'923	5.11
Skewness	3.07	3.72	5.79	13.38	5.33	2.62	19.18	38.63
Kurtosis	28.59	40.62	89.15	291.00	46.65	13.25	681.27	1'927.23

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$	
Mean	1.94	0.55	1.39	23'329	21'891	$6.15 \cdot 10^{-3}$	$7.71 \cdot 10^{-3}$	
Median	1.05	0.45	0.50	21'888	21'199	$4.91 \cdot 10^{-3}$	$5.22 \cdot 10^{-3}$	
Maximum	28.19	6.85	27.09	110'793	91'579	$6.12 \cdot 10^{-2}$	0.18	
Minimum	0.15	0.03	0.03	0	0	$7.38 \cdot 10^{-4}$	$7.28 \cdot 10^{-4}$	
Std. Dev.	3.66	0.38	3.61	11'742	10'819	$5.02 \cdot 10^{-3}$	$9.51 \cdot 10^{-3}$	
Skewness	5.67	2.66	5.75	1.48	0.57	3.01	5.66	
Kurtosis	36.62	23.66	37.27	8.74	3.51	18.00	51.63	

Table 3.17: Summary statistics of the liquidity measures of Swatch registered share on the five minute interval.

3.1.18 Summary Statistics of Unaxis

Finally, the summary statistics of the liquidity measures for Unaxis are presented in table 3.18. On average, 544 shares are traded in each five minute time space leading to an average turnover of 94'068 CHF. Depth is 928 CHF with the respective dollar depth of 81'764 CHF. Similar to the other stocks, log depth has a skewness smaller than zero. The 14 orders per time interval lead to about 4.5 trades. The average absolute spread is 0.57 CHF, and the relative spread is relatively high at 0.34%. The liquidity measures with low kurtosis are as for the other stocks the log absolute spread and the log relative spread of log prices. The effective spread measures are slightly smaller than the respective absolute and relative spreads which indicates some trading inside the quote. The quote slope is in the range of Swisscom, but the log quote slope and the adjusted log quote slope are much higher. Composite liquidity is about the same as for Swatch registered share. To move the price of Unaxis one percent, a turnover of 293'000 CHF was necessary and each trade leads to a price move of 0.09%, according to the liquidity ratio 3. The average flow ratio is about 1 mio. CHF and the order ratio is close to the one for Swiss Re, the most liquid stock in this study. The market impact

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$
Mean	544	94'068	928	11.19	81'764	4.57	14.15	0.57
Median	226	39'256	749	11.37	64'422	3.00	9.00	0.50
Maximum	15'250	2'562'000	12'823	16.29	1'224'523	57.00	172.00	9.75
Minimum	0	0	16	2.71	1'485	0.00	0.00	0.25
Std. Dev.	913	161'478	770	1.69	70'869	5.14	16.84	0.35
Skewness	4.55	4.85	3.36	-0.64	3.53	2.37	2.98	4.75
Kurtosis	38.66	43.04	26.73	3.82	29.13	12.62	15.27	88.29

	$LogSabs$	$SrelM$	$Srelp$	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$
Mean	-0.70	0.34%	0.34%	0.34%	-5.85	0.25	0.14%	0.14%
Median	-0.69	0.29%	0.29%	0.29%	-5.84	0.25	0.13%	0.13%
Maximum	2.28	6.72%	6.49%	6.72%	-2.70	5.13	3.41%	3.53%
Minimum	-1.39	0.12%	0.12%	0.12%	-6.70	0.00	0.00%	0.00%
Std. Dev.	0.52	0.22%	0.22%	0.22%	0.55	0.21	0.13%	0.13%
Skewness	0.19	5.66	5.35	5.67	0.21	4.18	4.75	4.95
Kurtosis	2.61	119.79	106.85	119.94	2.67	57.32	71.94	79.81

	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$	FR	OR
Mean	$5.21 \cdot 10^{-2}$	$3.07 \cdot 10^{-4}$	$7.02 \cdot 10^{-4}$	$7.89 \cdot 10^{-8}$	$2.93 \cdot 10^{7}$	0.09%	1'024'839	$5.30 \cdot 10^{-2}$
Median	$4.49 \cdot 10^{-2}$	$2.63 \cdot 10^{-4}$	$5.27 \cdot 10^{-4}$	$4.72 \cdot 10^{-8}$	3'117'456	0.06%	117'312	$2.82 \cdot 10^{-3}$
Maximum	0.73	$5.01 \cdot 10^{-3}$	$1.37 \cdot 10^{-2}$	$3.51 \cdot 10^{-6}$	$1.16 \cdot 10^{9}$	1.50%	$1.13 \cdot 10^{8}$	18.62
Minimum	$1.54 \cdot 10^{-2}$	$7.81 \cdot 10^{-5}$	$8.86 \cdot 10^{-5}$	$1.07 \cdot 10^{-9}$	0.00	0.00%	0.00	0.00
Std. Dev.	$3.20 \cdot 10^{-2}$	$2.05 \cdot 10^{-4}$	$6.59 \cdot 10^{-4}$	$1.33 \cdot 10^{-7}$	$6.63 \cdot 10^{7}$	0.12%	3'803'772	0.40
Skewness	4.23	4.60	5.05	10.53	5.86	2.91	14.98	25.63
Kurtosis	58.82	65.96	55.76	181.42	58.46	19.40	344.43	946.93

	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
Mean	14.36	4.26	10.10	6'059	4'940	$7.05 \cdot 10^{-2}$	0.30
Median	5.50	2.00	2.63	4'960	3'950	$3.46 \cdot 10^{-2}$	0.14
Maximum	211.99	55.25	185.49	32'499	23'062	1.06	2.04
Minimum	0.50	0.13	0.13	0	0	$6.55 \cdot 10^{-4}$	$1.12 \cdot 10^{-3}$
Std. Dev.	27.75	7.09	26.11	4'735	3'399	0.10	0.34
Skewness	3.99	3.58	4.37	1.99	1.21	3.00	1.24
Kurtosis	20.05	16.15	22.46	8.02	4.64	13.74	4.01

Table 3.18: Summary statistics of the liquidity measures of Unaxis on the five minute interval.

is 14.36 CHF and is very unevenly distributed: Liquidity on the ask-side of the limit order book is much higher than on the bid-side as the depth for price impact and price impact measures confirm.

3.1.19 General Remarks about the Summary Statistics of the Liquidity Measures

In general, there are huge differences in the means of the different liquidity measures across the 18 stocks. The highest turnover, for example shows the Swiss Re stock with almost 2 mio. CHF in each time space. In contrast, the average turnover of Sulzer is only 44'630 CHF. There are clear differences in liquidity.

The liquidity measures show also high variability. The maxima are usually several times as high as the mean or median. The minima have very low values. For example, there are for all stocks time spaces without trades. Therefore, the standard deviations of the liquidity measures are high.

None of the liquidity measures is normally distributed as the Jarque-Bera test indicates. In general, the mean is higher than median and the liquidity measures are, therefore, right-skewed. With respect to the normal distribution they show fat-tails. To improve the distributional properties of the liquidity measures I calculated the first differences from the time series and calculated the principal component analysis and the vector autoregressive model in the following chapters with these changes in liquidity.

3.2 Stock Ranking according to the Different Liquidity Measures

Out of the liquidity measures, rankings are produced for the different stocks for each of the 31 liquidity measures. Table 3.19 shows these rankings. An entry of "1" in the table denotes, that this stock is the most liquid according to the specific liquidity measure. If it has an "18" it is the least liquid.

According to the rankings, Swiss Re is, on average, the most liquid stock as the last line of table 3.19 shows. Its average rank is 2.81. Swiss Re is followed by Adecco with an average rank of 4.00 and Richemont with 4.90. Swisscom, Ciba, Syngenta, Holcim, Clariant, Lonza, Baer, Givaudan, Kudelski, Swatch registered share, Serono and Swatch bearer share are set in the middle with average ranks between 6.35 and 12.65. Finally, Unaxis, Surveillance and Sulzer are the least liquid stocks, on average.

The different rankings of the 31 liquidity measures are investigated for their correlation using the Spearman rank correlation, rk:

$$rk = 1 - \frac{6 \cdot R}{n \cdot (n^2 - 1)} \tag{3.2}$$

R denotes the sum of the squared differences in ranks: $R = \sum_{i=1}^{n} di_i^2$. n is the number of observations which is eighteen in our case. To determine whether the correlations are different from zero, they are compared to a special table of critical values for the Spearman rank correlation test which can be found e.g. in Kanji (1999), p. 199. The methodology is similar to Wang (2002) for different market impacts along the book.

Table 3.20 shows the rank correlations produced by the 31 liquidity measures for the 18 stocks. There seem to be two different groups of liquidity measures that produce high correlations among the rankings of the different stocks:

Group one consists of: volume, depth and log depth, the number of orders and the number of trades, the absolute and the log absolute spread, the effective spread, the quote slope, the log quote slope and the adjusted log quote slope, the market impact, the depth for price impact and the price impact measures. In general, these are the liquidity measures that depend on the absolute stock price.

The second group which leads to similar rankings of the stocks consists of: turnover, dollar depth, all the relative spread measures, composite liquidity, the liquidity ratio 1, the liquidity ratio 3 and the flow ratio. This group of liquidity measures contains all the relative spread measures. In general, these measures are independent of the stock price.

The ranking based on the order ratio is negatively correlated to about half of the other rankings. With depth, log depth and the depth for price impact on the ask-side, those

	ADEN	BAER	CFR	CIBN	CLN	GIVN	HOL	KUD	LONN	RUKN	SCMN	SEO	SGSN	SUN	SYNN	UHR	UHRN	UNAX
Q	3	16	2	8	4	15	11	5	9	1	12	14	17	18	6	10	7	13
V	2	11	6	8	14	7	5	12	10	1	4	3	15	18	9	13	17	16
D	8	1	3	4	7	11	13	10	6	2	14	18	17	16	9	12	5	15
$Dlog$	8	6	2	3	7	14	12	13	4	1	10	18	17	16	9	11	5	15
$D\$$	8	1	9	4	15	3	7	18	6	2	5	13	11	14	10	12	16	17
N	2	13	5	10	9	12	6	4	14	1	7	3	17	18	8	11	16	15
NO	1	10	7	13	8	15	6	4	16	2	9	3	17	18	5	14	11	12
$Sabs$	5	14	1	7	2	16	13	4	8	9	12	18	17	15	6	10	3	11
$LogSabs$	5	14	1	8	2	17	13	4	7	9	12	18	16	15	6	10	3	11
$SrelM$	4	6	9	8	12	7	3	15	11	2	1	10	13	18	5	16	17	14
$Srelp$	4	6	9	8	12	7	3	15	11	2	1	10	13	18	5	16	17	14
$Srellog$	4	6	9	8	12	7	3	15	11	2	1	10	13	18	5	16	17	14
$LogSrellog$	3	6	8	11	10	9	4	13	12	5	1	7	14	18	2	16	17	15
$Seff$	4	14	1	7	2	15	13	5	9	8	12	18	17	16	6	10	3	11
$Seffrelp$	4	11	7	8	10	6	2	16	12	3	1	9	14	18	5	15	17	13
$SeffrelM$	4	11	7	8	10	6	2	16	12	3	1	9	14	18	5	15	17	13
QS	4	14	1	8	2	15	13	6	9	7	12	18	17	16	5	10	3	11
$LogQS$	3	7	4	5	10	11	8	13	9	1	2	15	17	18	6	14	12	16
$LogQSadj$	3	17	5	4	9	10	6	13	7	2	1	12	16	18	8	11	14	15
CL	8	3	9	4	13	5	7	18	6	1	2	11	14	15	10	12	16	17
$LR1$	2	11	7	9	13	8	6	10	12	1	3	4	15	18	5	14	17	16
$LR3$	4	11	6	7	10	5	2	18	8	3	1	12	13	15	9	16	17	14
FR	2	13	6	7	12	9	5	8	11	1	4	3	15	18	10	14	17	16
OR	6	18	13	15	16	11	3	8	14	10	2	1	4	7	12	5	17	9
MI^{V^*}	3	14	2	4	7	13	11	10	6	1	9	16	15	18	5	12	8	17
MI^{A,V^*}	3	11	1	4	5	14	12	10	8	2	9	17	16	18	6	13	7	15
MI^{B,V^*}	2	14	4	3	7	13	10	9	6	1	8	16	15	17	5	12	11	18
$DI^A(k)$	4	7	2	3	5	13	10	11	6	1	12	18	16	17	8	14	9	15
$DI^B(k)$	3	15	2	4	5	13	10	11	6	1	9	18	17	16	7	12	8	14
$PI^A(q)$	4	11	2	3	5	13	12	10	8	1	9	17	16	18	6	14	7	15
$PI^B(q)$	4	14	2	3	6	13	9	10	7	1	11	17	16	18	5	12	8	15
Average	4.00	10.52	4.90	6.65	8.42	10.74	7.74	10.77	9.06	2.81	6.35	12.13	14.97	16.74	6.71	12.65	11.58	14.26
Rank	2	10	3	5	8	11	7	12	9	1	4	14	17	18	6	15	13	16

Table 3.19: Ranking of the eighteen stocks according to different liquidity measures.

	Q	V	D	Dlog	D$	N	NO	Sabs	LogSabs	SrelM	Srelp
Q	1										
V	0.37*	1									
D	0.61***	0.18	1								
Dlog	0.70***	0.27	0.93***	1							
D$	-0.03	0.62***	0.45**	0.45**	1						
N	0.64***	0.83***	0.20	0.25	0.20	1					
NO	0.64***	0.66***	0.23	0.22	0.02	0.90***	1				
Sabs	0.87***	-0.04	0.62***	0.67***	-0.25	0.28	0.35*	1			
LogSabs	0.86***	-0.06	0.60***	0.67***	-0.27	0.26	0.34*	1.00***	1		
SrelM	0.24	0.85***	0.26	0.33*	0.76***	0.60***	0.52**	-0.08	-0.09	1	
Srelp	0.24	0.85***	0.26	0.33*	0.76***	0.60***	0.52**	-0.08	-0.09	1.00***	1
Srellog	0.24	0.85***	0.26	0.33*	0.76***	0.60***	0.52**	-0.08	-0.09	1.00***	1.00***
LogSrellog	0.29	0.83***	0.19	0.24	0.59***	0.69***	0.67***	0.01	-0.01	0.94***	0.94***
Seff	0.89***	0.02	0.64***	0.69***	-0.20	0.32*	0.39*	0.99***	0.99***	-0.01	-0.01
Seffrelp	0.31*	0.87***	0.16	0.28	0.64***	0.66***	0.54**	-0.01	-0.03	0.96***	0.96***
SeffrelM	0.31*	0.87***	0.16	0.28	0.64***	0.66***	0.54**	-0.01	-0.03	0.96***	0.96***
QS	0.91***	0.04	0.65***	0.71***	-0.18	0.33*	0.41**	0.99***	0.98***	0.02	0.02
LogQS	0.62***	0.73***	0.65***	0.75***	0.68***	0.61***	0.53**	0.42**	0.40*	0.83***	0.83***
LogQSadj	0.63***	0.79***	0.34*	0.56***	0.50**	0.68***	0.48**	0.37*	0.35*	0.73***	0.73***
CL	0.09	0.72***	0.44**	0.50**	0.96***	0.35*	0.16	-0.16	-0.19	0.83***	0.83***
LR1	0.43**	0.97***	0.18	0.25	0.54**	0.87***	0.75***	0.03	0.01	0.87***	0.87***
LR3	0.25	0.80***	0.22	0.37*	0.75***	0.49**	0.32*	-0.03	-0.05	0.91***	0.91***
FR	0.48**	0.97***	0.17	0.26	0.47**	0.92***	0.74***	0.08	0.06	0.78***	0.78***
OR	-0.30	0.31	-0.80	-0.67	-0.14	0.28	0.15	-0.53	-0.51	0.13	0.13
MI^{V^*}	0.89***	0.51**	0.72***	0.85***	0.35*	0.55***	0.48**	0.74***	0.74***	0.47**	0.47**
MI^{A,V^*}	0.89***	0.42**	0.80***	0.89***	0.30	0.51**	0.49**	0.81***	0.80***	0.43**	0.43**
MI^{B,V^*}	0.85***	0.57***	0.66***	0.79***	0.40**	0.61***	0.50**	0.67***	0.66***	0.54**	0.54**
$DI^A(k)$	0.79***	0.40**	0.90***	0.93***	0.45**	0.43**	0.40**	0.70***	0.69***	0.46**	0.46**
$DI^B(k)$	0.89***	0.43**	0.71***	0.86***	0.29	0.49**	0.42**	0.79***	0.77***	0.41**	0.41**
$PI^A(q)$	0.87***	0.43**	0.81***	0.90***	0.34*	0.50**	0.48**	0.78***	0.76***	0.46**	0.46**
$PI^B(q)$	0.91***	0.46**	0.74***	0.85***	0.313	0.53**	0.48**	0.78***	0.76***	0.44**	0.44**

	Srellog	LogSrellog	Seff	Seffrelp	SeffrelM	QS	LogQS	LogQSadj	CL	LR1	LR3
Srellog	1										
LogSrellog	0.94***	1									
Seff	-0.01	0.06	1								
Seffrelp	0.96***	0.92***	0.06	1							
SeffrelM	0.96***	0.92***	0.06	1.00***	1						
QS	0.02	0.09	1.00***	0.10	0.10	1					
LogQS	0.83***	0.78***	0.47**	0.79***	0.79***	0.49**	1				
LogQSadj	0.73***	0.67***	0.42**	0.82***	0.82***	0.43**	0.85***	1			
CL	0.83***	0.68***	-0.11	0.75***	0.75***	-0.09	0.78***	0.66***	1		
LR1	0.87***	0.90***	0.09	0.88***	0.88***	0.12	0.76***	0.78***	0.66***	1	
LR3	0.91***	0.80***	0.03	0.94***	0.94***	0.06	0.79***	0.82***	0.82***	0.76***	1
FR	0.78***	0.78***	0.13	0.81***	0.81***	0.14	0.71***	0.80***	0.60***	0.95***	0.73***
OR	0.13	0.17	-0.53	0.21	0.21	-0.52	-0.22	0.10	-0.09	0.29	0.13
MI^{V^*}	0.47**	0.44**	0.78***	0.50**	0.50**	0.80***	0.82***	0.80***	0.43**	0.54**	0.51**
MI^{A,V^*}	0.43**	0.42**	0.85***	0.45**	0.45**	0.86***	0.83***	0.72***	0.39*	0.46**	0.45**
MI^{B,V^*}	0.54**	0.51**	0.71***	0.56***	0.56***	0.72***	0.85***	0.84***	0.49**	0.61***	0.57***
$DI^A(k)$	0.46**	0.40**	0.74***	0.43**	0.43**	0.75***	0.81***	0.64***	0.50**	0.41**	0.49**
$DI^B(k)$	0.41**	0.36*	0.82***	0.47**	0.47**	0.83***	0.79***	0.79***	0.39*	0.44**	0.51**
$PI^A(q)$	0.46**	0.42**	0.82***	0.47**	0.47**	0.83***	0.83***	0.72***	0.43**	0.47**	0.47**
$PI^B(q)$	0.44**	0.40**	0.81***	0.48**	0.48**	0.82***	0.79***	0.76***	0.39*	0.48**	0.49**

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	0.33*	1							
MI^{V^*}	0.55***	-0.37	1						
MI^{A,V^*}	0.47**	-0.49	0.97***	1					
MI^{B,V^*}	0.62***	-0.27	0.98***	0.93***	1				
$DI^A(k)$	0.43**	-0.60	0.91***	0.95***	0.88***	1			
$DI^B(k)$	0.47**	-0.40	0.97***	0.96***	0.94***	0.91***	1		
$PI^A(q)$	0.48**	-0.51	0.97***	0.99***	0.93***	0.95***	0.96***	1	
$PI^B(q)$	0.50**	-0.42	0.98***	0.97***	0.96***	0.93***	0.98***	0.97***	1

Table 3.20: Spearman rank correlations after different liquidity measures. */**/*** denotes significance on a level of 10%/5%/1%.

negative correlations are even significant, at least, at a 5% level.

3.3 Correlations of the Liquidity Measures

For each stock, the correlations of the liquidity measures were calculated. They can be found in appendix C. The average correlations of the liquidity measures for the eighteen stocks are presented in table 3.21. Liquidity measures that are highly correlated to others and from the analysis are listed below.

- Volume: It is highly correlated with turnover. Turnover is comparable across stocks with different share prices, while volume is not.
- Depth: It has an average correlation of 0.99 to dollar depth and, once again, dollar depth is comparable across different stocks: Therefore, depth is dropped.
- Absolute spread: It is correlated with a variety of liquidity measures. Its correlation to the relative spreads is 0.98, and, therefore, the absolute spread is dropped from the sample.
- Relative spread with last trade: The correlation of the relative spread with the mid price and the last trade is unity. Because the relative spread with the mid price always can be calculated it is retained.
- Relative spread of log prices: It has a correlation of 0.93 to the log relative spread of log prices and to the quote slope. The average correlation to the log quote slope is even higher. The relative spread of log prices is, therefore, dropped from the liquidity measures.
- Effective spread: It is highly correlated with the relative effective spreads and eliminated.
- Relative effective spread with last trade: The relative effective spread with last trade and the mid price have a correlation of unity. The relative effective spread with last trade is dropped.
- Quote slope and log quote slope are correlated with 0.98 and the log quote slope is dropped.

The results are in line with Irvine et al. (2000) which report negative correlations between the market impact measures and depth, too. Also the correlation between the market impact measures and the relative effective spread is confirmed. On the other hand, the correlation between the relative spread and the market impact measures is higher in their paper.

After this section, I conclude that only the following 23 liquidity measures are needed: turnover, log depth, dollar depth, number of trades and number of orders, the log absolute spread, the relative spread with the mid price, the log relative spread of log prices, the relative spread with the mid price, quote slope, adjusted log quote slope, composite liquidity, the liquidity ratios 1 and 3, the flow ratio, order ratio, the market impact measures, the depth for price impact measures and finally, the price impact measures. With these measures I continue.

	Q	V	D	Dlog	D$	N	NO	Sabs	LogSabs	SrelM	Srelp
Q	1										
V	0.99	1									
D	0.04	0.05	1								
Dlog	0.02	0.03	0.62	1							
D$	0.03	0.04	0.99	0.62	1						
N	0.73	0.71	-0.03	-0.07	-0.04	1					
NO	0.50	0.49	-0.05	-0.08	-0.07	0.67	1				
Sabs	0.09	0.07	0.02	0.09	0.01	0.11	0.16	1			
LogSabs	0.07	0.06	0.03	0.11	0.02	0.08	0.13	0.94	1		
SrelM	0.11	0.08	-0.01	0.05	-0.03	0.14	0.20	0.97	0.90	1	
Srelp	0.11	0.08	-0.01	0.05	-0.03	0.14	0.20	0.97	0.90	1.00	1
Srellog	0.11	0.08	-0.01	0.05	-0.03	0.14	0.20	0.97	0.90	1.00	1.00
LogSrellog	0.10	0.07	0.00	0.07	-0.03	0.12	0.18	0.92	0.97	0.92	0.92
Seff	0.03	0.02	-0.03	-0.02	-0.04	0.05	0.12	0.56	0.50	0.56	0.56
Seffrelp	0.05	0.03	-0.05	-0.04	-0.07	0.09	0.16	0.56	0.50	0.61	0.61
SeffrelM	0.05	0.03	-0.05	-0.04	-0.07	0.09	0.16	0.56	0.50	0.61	0.61
QS	0.08	0.07	-0.13	-0.19	-0.14	0.13	0.18	0.94	0.87	0.93	0.93
LogQS	0.10	0.07	-0.14	-0.20	-0.16	0.16	0.22	0.91	0.83	0.95	0.95
LogQSadj	0.09	0.06	-0.07	-0.36	-0.08	0.14	0.17	0.59	0.53	0.62	0.62
CL	0.05	0.03	-0.25	-0.47	-0.25	0.11	0.14	0.30	0.25	0.34	0.34
LR1	0.63	0.65	0.03	0.02	0.04	0.46	0.29	-0.02	-0.02	-0.02	-0.02
LR3	0.02	0.00	-0.04	-0.05	-0.06	0.03	0.13	0.25	0.23	0.29	0.29
FR	0.85	0.85	0.02	0.00	0.01	0.64	0.43	0.06	0.05	0.07	0.07
OR	-0.07	-0.07	0.10	0.07	0.10	-0.08	-0.06	-0.01	0.00	-0.01	-0.01
MI^{V^*}	0.05	0.02	-0.21	-0.29	-0.23	0.14	0.18	0.27	0.23	0.34	0.34
MI^{A,V^*}	0.04	0.01	-0.21	-0.28	-0.23	0.12	0.16	0.24	0.21	0.31	0.31
MI^{B,V^*}	0.04	0.02	-0.16	-0.22	-0.17	0.11	0.14	0.22	0.19	0.27	0.27
$DI^A(k)$	-0.02	0.02	0.34	0.28	0.38	-0.09	-0.15	-0.17	-0.16	-0.24	-0.24
$DI^B(k)$	0.02	0.05	0.32	0.25	0.35	-0.05	-0.10	-0.15	-0.14	-0.21	-0.21
$PI^A(q)$	0.05	0.02	-0.22	-0.29	-0.24	0.12	0.16	0.23	0.20	0.30	0.30
$PI^B(q)$	0.04	0.00	-0.19	-0.24	-0.21	0.11	0.15	0.24	0.20	0.30	0.30

	Srellog	LogSrellog	Seff	Seffrelp	SeffrelM	QS	LogQS	LogQSadj	CL	LR1	LR3
Srellog	1										
LogSrellog	0.92	1									
Seff	0.56	0.51	1								
Seffrelp	0.61	0.54	0.98	1							
SeffrelM	0.61	0.54	0.98	1.00	1						
QS	0.93	0.87	0.55	0.57	0.57	1					
LogQS	0.95	0.87	0.55	0.60	0.60	0.97	1				
LogQSadj	0.62	0.56	0.40	0.43	0.43	0.72	0.74	1			
CL	0.34	0.30	0.23	0.27	0.27	0.52	0.55	0.36	1		
LR1	-0.02	-0.03	-0.05	-0.05	-0.05	-0.02	-0.02	-0.01	-0.01	1	
LR3	0.29	0.28	0.24	0.27	0.27	0.26	0.29	0.21	0.14	-0.04	1
FR	0.07	0.06	0.03	0.04	0.04	0.06	0.07	0.05	0.04	0.47	0.00
OR	-0.01	-0.01	0.01	0.00	0.00	-0.02	-0.02	0.01	-0.03	-0.05	0.07
MI^{V^*}	0.34	0.31	0.20	0.26	0.27	0.36	0.42	0.31	0.33	-0.04	0.19
MI^{A,V^*}	0.31	0.28	0.18	0.23	0.24	0.32	0.38	0.27	0.30	-0.04	0.17
MI^{B,V^*}	0.27	0.24	0.17	0.21	0.21	0.28	0.33	0.24	0.25	-0.03	0.15
$DI^A(k)$	-0.24	-0.25	-0.13	-0.19	-0.19	-0.24	-0.30	-0.20	-0.22	0.06	-0.16
$DI^B(k)$	-0.21	-0.20	-0.12	-0.16	-0.16	-0.21	-0.26	-0.17	-0.19	0.07	-0.13
$PI^A(q)$	0.30	0.28	0.18	0.24	0.24	0.32	0.38	0.27	0.30	-0.04	0.17
$PI^B(q)$	0.30	0.27	0.18	0.23	0.23	0.30	0.36	0.26	0.27	-0.04	0.17

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.03	1							
MI^{V^*}	0.04	-0.03	1						
MI^{A,V^*}	0.02	-0.03	0.63	1					
MI^{B,V^*}	0.03	-0.02	0.86	0.21	1				
$DI^A(k)$	-0.01	0.03	-0.36	-0.45	-0.21	1			
$DI^B(k)$	0.02	0.04	-0.35	-0.21	-0.35	0.26	1		
$PI^A(q)$	0.03	-0.03	0.50	0.70	0.23	-0.49	-0.24	1	
$PI^B(q)$	0.02	-0.02	0.58	0.25	0.64	-0.27	-0.47	0.28	1

Table 3.21: Average correlations of the liquidity measures on the five minute interval.

Chapter 4

Principal Component Analysis of Liquidity Measures

To extract common factors from the 23 remaining liquidity measures, in this chapter a principal component analysis is carried out. Section 4.1 describes briefly the methodology, while the sections 4.2 to 4.19 present the results of the principal component analysis for each of the 18 stocks. Section 4.20 draws some conclusions and determines the liquidity measures necessary to capture all the dimensions of liquidity.

4.1 Principal Component Analysis

Principal component analysis dates back to Pearson (1901) and Hotelling (1933). It is used to examine the relationships among several variables and to reduce the complexity. The number of variables is reduced to a set of a few factors that are able to explain the dynamics of the liquidity measures. It detects linear relationships. The complete factor solution is calculated; this means that the n liquidity measures are explained by n principal components. The principal components are the factors. The first principal component is calculated as the linear combination of the liquidity measures:

$$F_1 = b_{11} \cdot m_1 + b_{12} \cdot m_2 + ... + b_{1n} \cdot m_n \tag{4.1}$$

F_1 must have maximal variance. Because variance rises with rising b, it is limited by the following constraint:

$$b_{11}^2 + b_{12}^2 + ... + b_{1n}^2 = 1 \tag{4.2}$$

F is called factor scores. The solution for b_1 equals the eigenvector with the largest eigenvalue of the variance-covariance matrix. This means that the first principal component accounts for the greatest possible variance. When the first principal component is found, the calculation is repeated for the second principal component with the additional constraint that it is orthogonal to the first principal component. The solution for b_2 now equals the eigenvector with the second largest eigenvalue, which has again the greatest possible variance. This procedure is repeated until the nth principal component is found. Basically, the eigenvectors of the variance-covariance-matrix of the liquidity measures have to be found.

The original liquidity measures now can be calculated from the principal components. We get the first measure as:

$$m_1 = b_{11} \cdot F_1 + b_{21} \cdot F_2 + ... + b_{n1} \cdot F_n \tag{4.3}$$

The liquidity measures are now linear combinations of the factor scores. To reduce the number of factors without loss of information, we take the principal components with the highest eigenvalues. The Kaiser criterion by Kaiser (1958) suggests that only principal components with an eigenvalue larger than unity, which means larger than the average eigenvalue, should be used.

To get standardized factors the correlation matrix can be used as input for the principal components analysis. From the standardized b's and the standardized factors, the backward transformation is possible, but it yields standardized liquidity measures. To facilitate the interpretation of the liquidity measures, the factor scores are standardized to a mean of 0 and a standard deviation of 1.

The b's show the impact of a factor realization of one standard deviation. If n factors are used, 100% of variance is explained. The part that is explained by each factor for each liquidity measure i is calculated as:

$$R_j^2 = \frac{b_{ji}^2}{\sum\limits_{j=1}^{n} b_{ji}^2} \tag{4.4}$$

To improve the distributional properties of the liquidity measures, I use the first differences and, therefore, the changes in liquidity. In the following sections the results of the principal component analysis for the 23 remaining liquidity measures are presented for the eighteen stocks.

4.2 Results of the Principal Component Analysis of Adecco

Table 4.1 shows the first seven eigenvalues of the principal component analysis of the Adecco share with the respective variance that the corresponding eigenvectors explain and the cumulative variance explained. The seven eigenvalues that are larger than unity explain about 75% of total variance.

	b_1	b_2	b_3	b_4	b_5	b_6	b_7
Eigenvalue	5.17	3.04	2.67	2.00	1.79	1.31	1.14
Var. explained	22.46%	13.23%	11.61%	8.72%	7.76%	5.72%	4.95%
Cum. var. explained	22.46%	35.69%	47.30%	56.02%	63.78%	69.50%	74.45%

Table 4.1: Principal component analysis of Adecco based on the differences of 23 liquidity measures.

Figure 4.1 presents the first seven eigenvectors of the principal component analysis for Adecco.

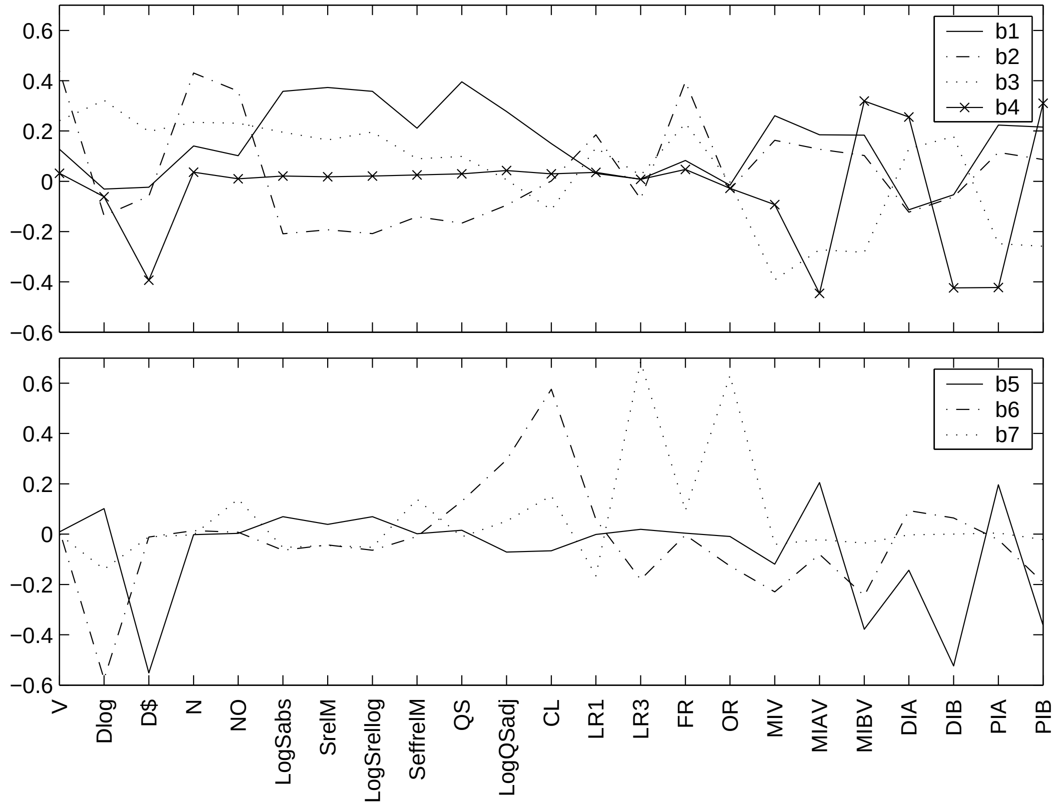

Figure 4.1: First seven eigenvectors of the principal component analysis for Adecco based on the differences of 23 liquidity measures.

The factor with the highest eigenvalue explains about 22.5% of total variance. It captures declining liquidity of all the spread measures as well as of the quotes slope and the adjusted log quote slope. Also, liquidity, as measured by the three market impact and the price impact measures, is captured by this first eigenvector.

Factor two, which explains an additional 13% of variance, captures; turn-over, number of trades and number of orders. Naturally the flow ratio constructed out of turnover and number of trades is influenced in the same direction.

Factor three is responsible for another 11.6% of variance and combines; rising liquidity in turnover, log depth, number of orders, number of trades, the market impact measures, the depth for price impact measures and the price impact measures with declining liquidity of the different spread measures.

The fourth factor separates the bid- and ask-side of the order book since it combines rising liquidity on the ask-side with declining liquidity on the bid-side. Interestingly, declining dollar depth is captured by this factor also.

Factor five takes declining liquidity in dollar depth into account as well as market impact on the ask-side, the depth for price impact measures and the price impact on the ask-side. Rising liquidity is apparent for market impact and price impact on the bid-side.

The sixth factor covers a declining log depth as well as rising quote slope, log quote slope and composite liquidity.

Finally, factor seven, which explains roughly 5% of variance, is responsible for a high liquidity ratio 3 and a high order ratio.

4.3 Results of the Principal Component Analysis of Baer

Table 4.2 shows the results of the principal component analysis for Baer. Six factors have an eigenvalue larger than unity and are, according to the Kaiser criterion, necessary to explain the variation of the variables. These six factors are able to explain more than 70% of total variance of the standardized differences of the liquidity measures. Three factors explain more than 50% of total variance.

	b_1	b_2	b_3	b_4	b_5	b_6
Eigenvalue	5.28	3.37	3.08	1.70	1.58	1.21
Var. explained	22.96%	14.65%	13.38%	7.40%	6.88%	4.87%
Cum. var. explained	22.96%	37.61%	50.98%	58.38%	65.27%	70.14%

Table 4.2: Principal component analysis for Baer based on the differences of 23 liquidity measures.

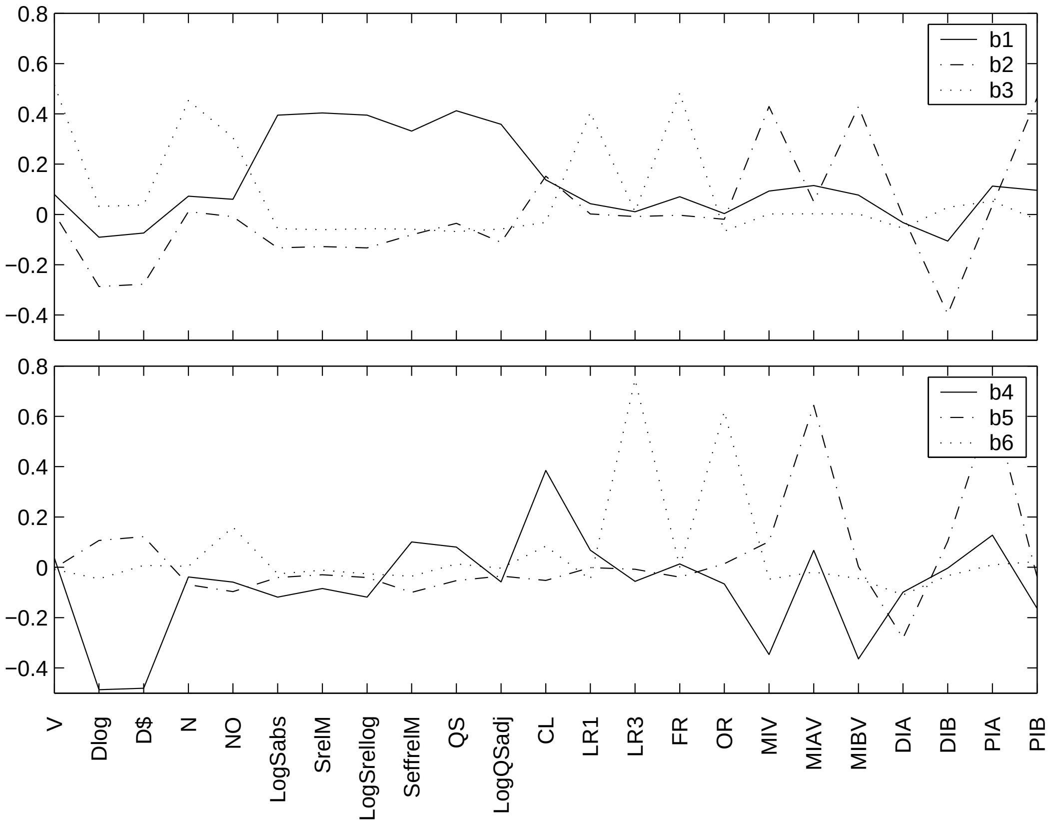

Figure 4.2: First six eigenvectors of the principal component analysis for Baer based on the differences of 23 liquidity measures.

The first factor of Baer in figure 4.2 explains roughly 23% of the variance. It influences positively the spread-related liquidity measures such as; log absolute spread, the relative spread, the log spread of log prices, and the effective spread. Furthermore, the quote slope and the log quote slope are influenced. Therefore, the first factor captures the “tightness” dimension of liquidity and shows declining liquidity in this dimension.

The second factor explains an additional 15% of the variance. It influences negatively the log depth and the dollar depth. Market impact and market impact for the bid-side are influenced positively. The declining liquidity in those four measures goes in line with the declining liquidity in the depth for price impact on the bid-side and the declining liquidity in the price impact on the bid-side. Therefore, the second factor captures the depth dimension of the order book and it also seems to capture a bid-side liquidity dimension.

The third factor explains an additional 13% of the variance. It influences turnover, number of trades and number of orders. Therefore, it captures the time dimension of liquidity. This factor equally influences the liquidity ratio 1 and the flow ratio which depend strongly on turnover.

The fourth factor explains an additional 7% of the variation. It influences again the depth dimension of liquidity. Composite liquidity, which has dollar depth in the denominator, is equally influenced. Interestingly, the declining liquidity of log depth, dollar depth and composite liquidity goes hand in hand with rising liquidity as measured by the market impact and the market impact on the bid-side. At first glance, this is a counterintuitive result, but essentially it is the case that when depth at the best bid is reduced, more depth is added deeper in the order book.

Factor five explains 7% of the variance. It captures an ask-side liquidity since it influences market impact of the ask-side, depth for price impact of the ask-side and price impact on the ask-side of the limit order book and is, therefore, complementary to factor two.

Finally, the sixth factor explains an additional 5%. It shows liquidity changes in the liquidity ratio 3 and the order ratio.

In general, the factors capture clearly the tightness, depth and time dimension of liquidity. The factors show either rising or declining liquidity with exception of factor four which shows rising and declining liquidity at the same time.

4.4 Results of the Principal Component Analysis of Richemont

The results of the principal component analysis of Richemont are presented in table 4.3. In line with the Baer stock, six factors have an eigenvalue larger than unity and are according to the Kaiser criterion necessary to explain the variation of the changes in the liquidity measures.

	b_1	b_2	b_3	b_4	b_5	b_6
Eigenvalue	4.99	2.96	2.58	1.90	1.40	1.08
Var. explained	21.70%	12.86%	11.20%	8.25%	6.07%	4.72%
Cum. var. explained	21.70%	34.56%	45.76%	54.01%	60.08%	64.80%

Table 4.3: Principal component analysis for Richemont based on the differences of 23 liquidity measures.

The six factors explain only 64% of total variance which is less than the first six factors of Baer. Figure 4.3 shows the first six eigenvectors of the principal component analysis.

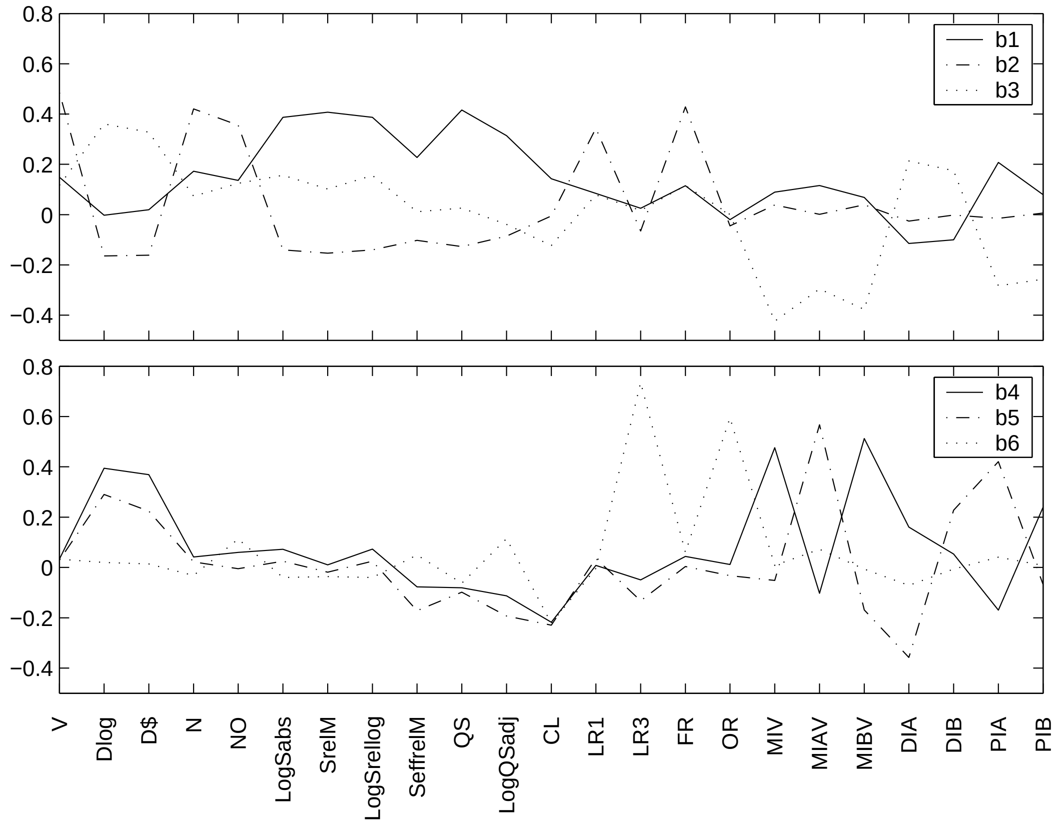

Figure 4.3: First six eigenvectors of the principal component analysis for Richemont based on the differences of 23 liquidity measures.

The first factor captures the tightness dimension of liquidity and is equal the first factor of Baer. It explains also about 22% of the variance. Additionally, and in contrast to Baer it shows a pretty high comovement of spreads and the price impact of the ask-side.

The second factor of Richemont explains 13% of the variance and equals the third factor of Baer. It captures rising liquidity in turnover, number of trades and number of orders as well as in the liquidity ratio 1 and the flow ratio.

The third factor of the Richemont stock, which explains an additional 11%, combines rising liquidity in the depth dimension with the market impact, the price impact and the depth for price impact measures. It is similar to the second factor of the principal component analysis of Baer. In addition, it captures not only the bid-side of market impact, depth for price impact and price impact, but also the ask-side.

The fourth factor is important for the depth dimension as well as for composite liquidity, and in the opposite direction for market impact, market impact on the bid-side, and the price impact of the bid-side. It is similar to the fourth factor of Baer with opposite signs of the coefficients.

The fifth factor explains 6% of variance. It shows rising liquidity in the depth measures, in composite liquidity and the depth for price impact on the bid-side. In addition, it captures declining liquidity on the ask-side as measured by market impact, depth for price impact and price impact.

Finally, the sixth factor, which explains an additional 5%, shows rising liquidity in composite liquidity and declining liquidity in liquidity ratio 3 and the order ratio.

For Richemont the factors four, five and six show rising as well as declining liquidity in different liquidity measures. In general, the first four factors are equal to the first four factors of Baer, but the order is changed and the signs of component three and four change. Only components five and six are slightly different.

4.5 Results of the Principal Component Analysis of Ciba

According to the Kaiser criterion, also for the Ciba stock six principal components are necessary to explain the variance of the liquidity measures, which is in line with Baer and Richemont as table 4.4 shows. The first six factors explain 69% of total variance.

	b_1	b_2	b_3	b_4	b_5	b_6
Eigenvalue	4.76	3.53	2.84	2.25	1.44	1.11
Var. explained	20.71%	15.34%	12.34%	9.77%	6.25%	4.82%
Cum. var. explained	20.71%	36.05%	48.39%	58.17%	64.42%	69.24%

Table 4.4: Principal component analysis of Ciba based on the differences of 23 liquidity measures.

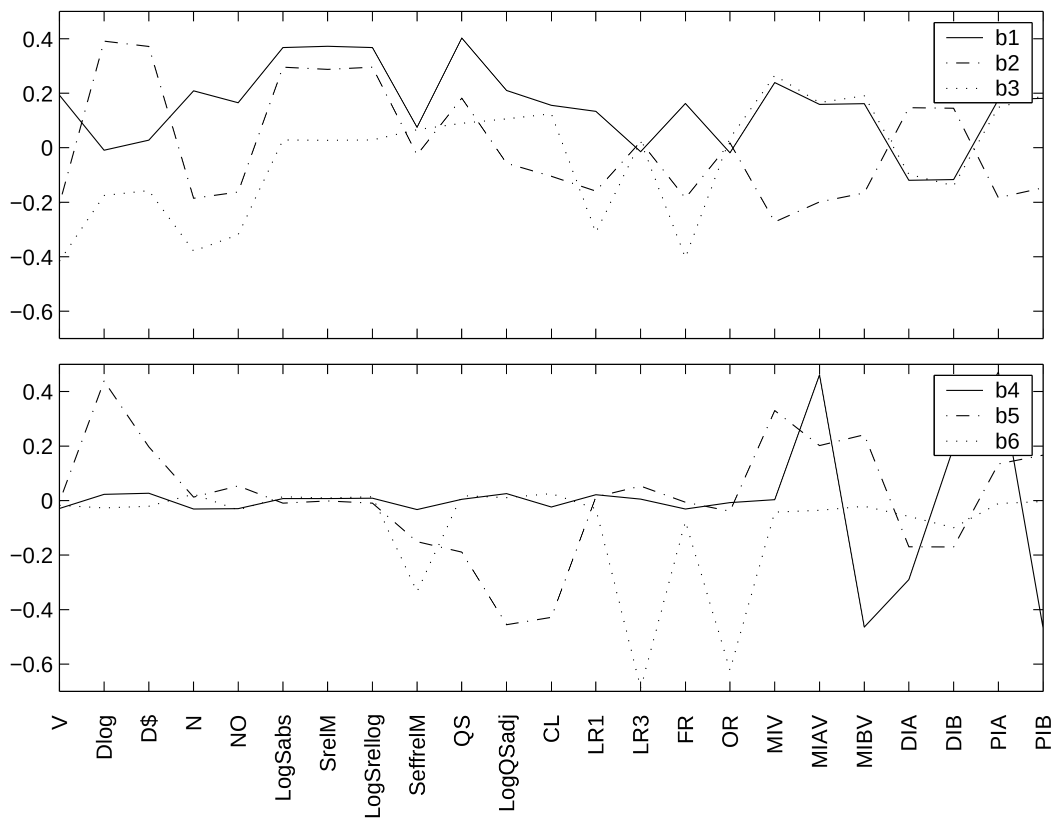

Figure 4.4: First six eigenvectors of the principal component analysis for Ciba based on the differences of 23 liquidity measures.

Figure 4.4 depicts the factor structure of Ciba, which is different from the ones for Baer and Richemont. The first factor explains about 21% of total variance. It captures the spread-related measures with exception of the relative effective spread. It takes quote slope and the adjusted log quote slope into account, as for the first factor of Baer and Richemont. In addition to this declining liquidity in the tightness dimension, this factor shows rising liquidity in turnover, number of trades and orders. The liquidity ratio 1 and the flow ratio rise either. Market impact, depth for price impact and price impact show on the other hand low liquidity. This first principal component of Ciba is difficult to explain from an economic point of view.

The second factor explains 15% of variance. It captures declining liquidity in turnover and spreads but not in the relative effective spread. Rising liquidity is shown in the depth dimension and in market impact, depth for price impact and price impact.

The third factor explains an additional 12% of variance. It is similar to the third factor of Baer and the second factor of Richemont, respectively. In addition, it shows low liquidity as measured by; the market impact, depth for price impact and price impact.

The fourth factor explains another 10% of variance. It separates the ask- and the bid-side of the order book since it captures declining liquidity for the ask-side specific liquidity measures and rising liquidity for the bid-side specific liquidity measures.

Component five, which explains 6% of variance, shows rising liquidity in the depth dimension, the relative effective spread, the quote slope, the adjusted log quote slope and the composite liquidity. On the other hand, with the fifth component, liquidity in market impact, depth for price impact and price impact measures are declining.

Finally, the sixth component explains 5% of variance and is influenced by the effective spread, the liquidity ratio 3, and the order ratio.

The component structure of Ciba is entirely different from Baer and Richemont. One explanation may be that the stock moved during the observation period from one regime of minimum tick sizes to a lower one since the stock price dropped below 100 CHF during the three months investigated.

4.6 Results of the Principal Component Analysis of Clariant

As table 4.5 shows, Clariant requires, like Adecco, seven principal components before the Kaiser criterion reaches the cut off level. The first seven principal components explain 73% of the total variance of the changes in the liquidity measures.

	b_1	b_2	b_3	b_4	b_5	b_6	b_7
Eigenvalue	4.63	3.10	2.55	1.91	1.46	1.16	1.11
Var. explained	20.14%	13.48%	11.10%	8.29%	6.34%	5.02%	4.84%
Cum. var. explained	20.14%	33.62%	44.71%	53.00%	59.35%	64.37%	69.21%

Table 4.5: Principal component analysis of Clariant based on the differences of 23 liquidity measures.

Figure 4.5 shows the first seven eigenvectors of the principal component analysis of Clariant.

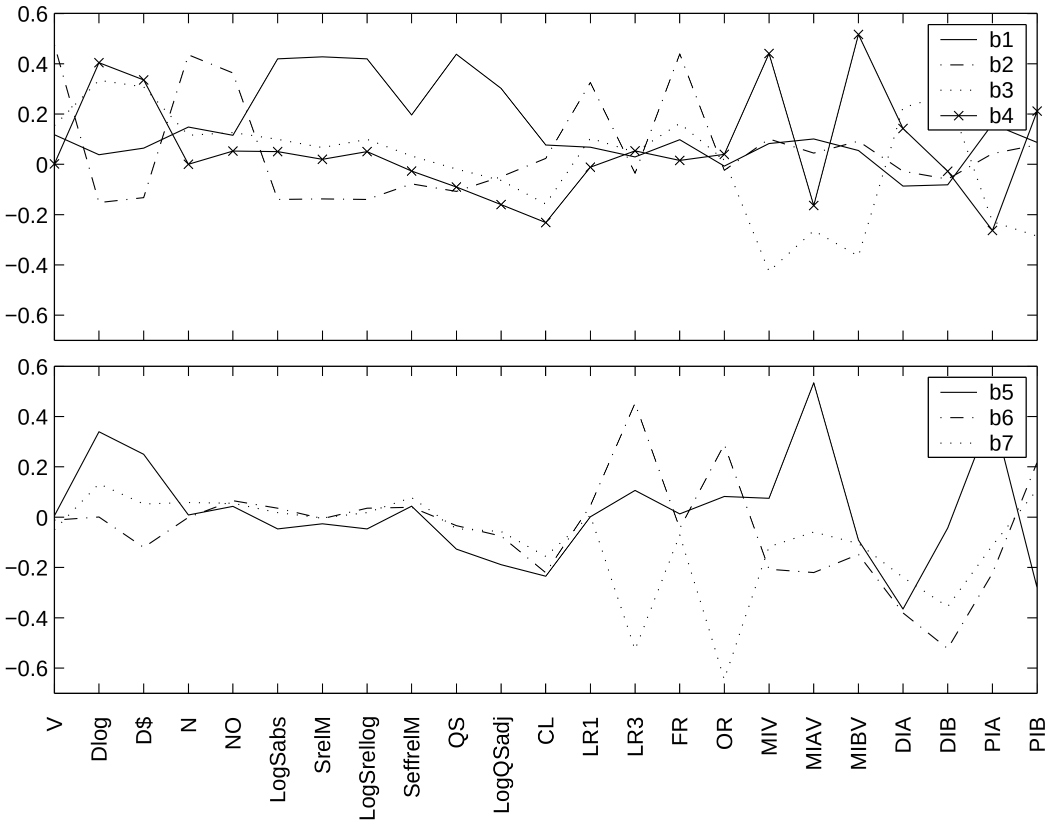

Figure 4.5: First seven eigenvectors of the principal component analysis for Clariant based on the differences of 23 liquidity measures.

The first principal component explains 20% of total variance. Like the first component of Baer and Richemont, it captures the tightness dimension of the limit order book with the spread measures, quote slope and adjusted log quote slope.

The second factor explains an additional 13%. It depicts rising liquidity in turnover, number of trades, number of orders, the liquidity ratio 1 and the flow ratio.

The third principal component of Clariant explains 11% of variance. It influences the depth dimension of the limit order book. Additionally, it captures rising liquidity for the market impact, the depth for price impact and the market impact measures.

Factor four, which explains 8%, separates bid- and ask-side of the order book since it shows rising liquidity in the ask-side related measures and declining liquidity in the bid-side related measures. This is combined with positive changes in the depth dimension and a declining composite liquidity measure.

The fifth factor explains 6%, which again captures rising liquidity in the depth dimension and composite liquidity. As a contrast, this factor show declining liquidity in the ask-side related liquidity measures and rising liquidity in the price impact on the bid-side.

Factor six is responsible for 5% of variance. It is influenced by rising liquidity in the composite liquidity, declining liquidity in the liquidity ratio 3 and the order ratio. Liquidity, as measured by the market impact measures rises, while the depth for price impact measures show declining liquidity. The price impact on the ask-side declines but on the bid-side it rises.

Finally, factor seven, which explains additional 5%, captures rising liquidity in the liquidity ratio 3 and the order ratio. On the other hand, the depth for price impact measures show declining liquidity.

The tightness, time and depth dimensions of liquidity in the limit order book are very well shown by the factor structure of Clariant.

4.7 Results of the Principal Component Analysis of Givaudan

Like the Adecco and Clariant stocks, Givaudan requires seven principal components, as table 4.6 indicates. These seven factors are able to explain roughly 70% of total variance for the changes in the liquidity measures.

	b_1	b_2	b_3	b_4	b_5	b_6	b_7
Eigenvalue	4.92	3.24	2.80	1.57	1.37	1.17	1.09
Var. explained	21.39%	14.08%	12.16%	6.81%	5.96%	5.07%	4.72%
Cum. var. explained	21.39%	35.47%	47.63%	54.48%	60.40%	65.48%	70.20%

Table 4.6: Principal component analysis of Givaudan based on the differences of 23 liquidity measures.

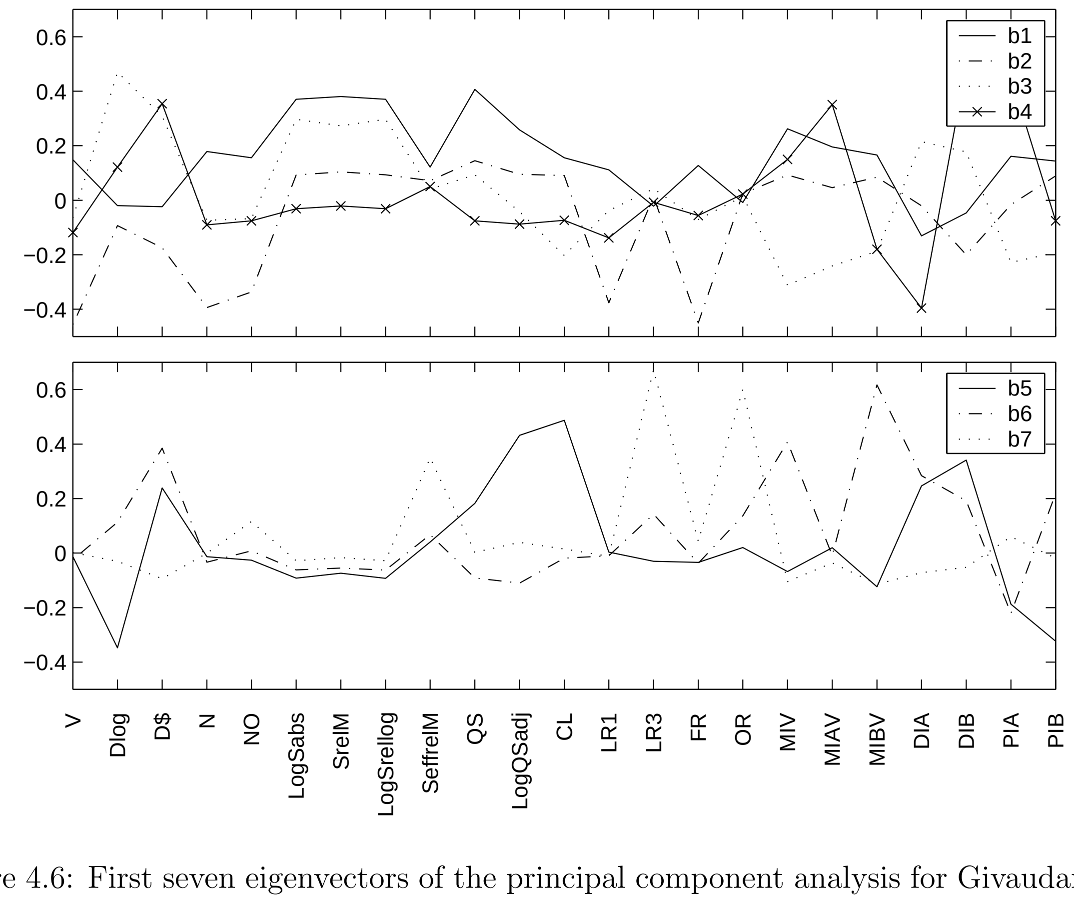

Figure 4.6: First seven eigenvectors of the principal component analysis for Givaudan based on the differences of 23 liquidity measures.

Figure 4.6 shows the first seven eigenvectors of the principal component analysis of Givaudan. Factor one explains 21% of variance. It is very similar to the first factor of Ciba and captures the tightness dimension. It shows declining liquidity in the spread measures with the exception of the relative effective spread. Liquidity is also declining as measured by; the composite liquidity, the market impact, the depth for price impact and the price impact measures. On the other hand, liquidity, as measured by turnover and number of trades and number of orders, is rising.

Factor two – responsible for additional 14% of variance – captures the time dimension of liquidity with the number of trades and the number of orders. Also, it is influenced by turnover, dollar depth but, interestingly, not by the log depth. Liquidity, as measured by liquidity ratio 1 and the flow ratio, is also declining with factor two of Givaudan.

The third eigenvector, with the ability to explain 12% of variance, shows rising liquidity in the depth dimension of the limit order book. With exception of the relative effective spread, the spread measures show declining liquidity. Composite liquidity, market impact, depth for price impact and the price impact measures show, again, rising liquidity.

Principal component four explains 7%. It separates the ask-side and the bid-side related liquidity measures since it shows declining liquidity on the ask-side and rising liquidity on the bid-side. Additionally, it has an impact on dollar depth.

Component five is responsible for 6% of variation and shows different liquidity moves in log depth and dollar depth. This is a hint that prices rise whenever depth declines and vice versa. In line with declining depth are the declining adjusted log quote slope and composite liquidity. The rising dollar depth is supported by the depth for price impact and price impact measures.

Factor six, which explains 5% of variance, shows rising dollar depth, rising depth for price impact measures and rising price impact for the ask-side. This factor depicts, also, declining liquidity in market impact, market impact on the bid-side and price impact on the bid-side, a combination that makes this factor difficult to interpret.

Finally, factor seven adds another 5% to the explanation of variance. It captures the relative effective spread, the liquidity ratio 3 and the order ratio. Factor seven is, therefore, similar to factor six of Ciba.

The component structure of Givaudan is difficult to interpret, in general. Only factors two and six show development of liquidity in one direction.

4.8 Results of the Principal Component Analysis of Holcim

Table 4.7 gives the eigenvalues and the variance for the first seven principal components of Holcim which are larger than unity. In all, they explain 70% of total variance.

	b_1	b_2	b_3	b_4	b_5	b_6	b_7
Eigenvalue	4.68	3.24	2.66	1.97	1.51	1.08	1.00
Var. explained	20.36%	14.09%	11.55%	8.57%	6.55%	4.68%	4.35%
Cum. var. explained	20.36%	34.45%	45.00%	54.57%	61.12%	65.80%	70.15%

Table 4.7: Principal component analysis of Holcim based on the differences of 23 liquidity measures.

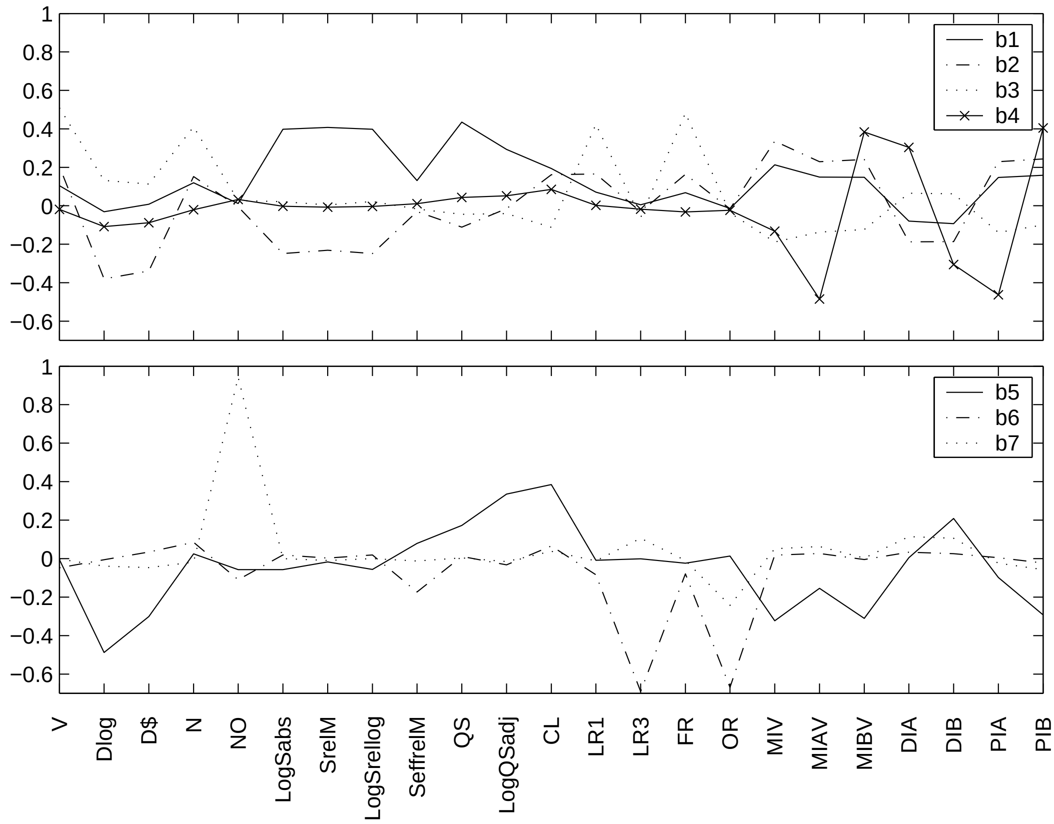

Figure 4.7: First seven eigenvectors of the principal component analysis for Holcim based on the differences of 23 liquidity measures.

Factor one in figure 4.7 explains roughly 20% of variance and captures the tightness dimension of liquidity. It combines declining liquidity of the spread measures with declining liquidity in quote slope, log quote slope, composite liquidity, the market impact measures and the price impact measures.

The second factor explains an additional 14% of variance. It captures rising liquidity in turnover and the spread measures with exception of the relative effective spread. But, with the higher turnover and the smaller spreads, liquidity measured as log depth or dollar depth declines. Also, the market impact, depth for price impact and the price impact measures show declining liquidity.

The third principal component of Holcim is responsible for additional 12% of variation. It captures rising liquidity in turnover, number of trades, the liquidity ratio 1 and the flow ratio. It is similar to the second factor of Givaudan, for example.

Factor four, explaining 9%, separates the bid-side and the ask-side related liquidity measures, since it shows rising liquidity on the ask-side and declining liquidity on the bid-side of the limit order book.

The fifth eigenvector explains 7% of variance and is responsible for the depth dimension as well as the adjusted log quote slope and composite liquidity. In contrast to the declining liquidity in the formerly mentioned measures, liquidity in the market impact measures, the depth for price impact on the bid-side and the price impact on the bid-side is rising.

Factor six is responsible for another 5% of variance. Analogously to the seventh eigenvector of Givaudan, it captures the relative effective spread, the liquidity ratio 3 and the order ratio.

The last principal component with an eigenvalue larger than one explains 4% of variance. It takes the number of orders into account which is, interestingly, not related to the number of trades of the Holcim stock. Furthermore, factor seven influences the order ratio.

4.9 Results of the Principal Component Analysis of Kudelski

For the Kudelski stocks six principal components have an eigenvalue larger than unity as table 4.8 shows and are therefore necessary to explain the factor structure of the liquidity measures. These six factors explain 66% of total variance of the Kudelski stock.

	b_1	b_2	b_3	b_4	b_5	b_6
Eigenvalue	5.23	3.25	2.22	1.91	1.59	1.07
Var. explained	22.72%	14.13%	9.65%	8.32%	6.90%	4.63%
Cum. var. explained	22.72%	36.85%	46.50%	54.82%	61.73%	66.36%

Table 4.8: Principal component analysis of Kudelski based on the differences of 23 liquidity measures.

Figure 4.8 shows the first six eigenvectors of the Kudelski stock.

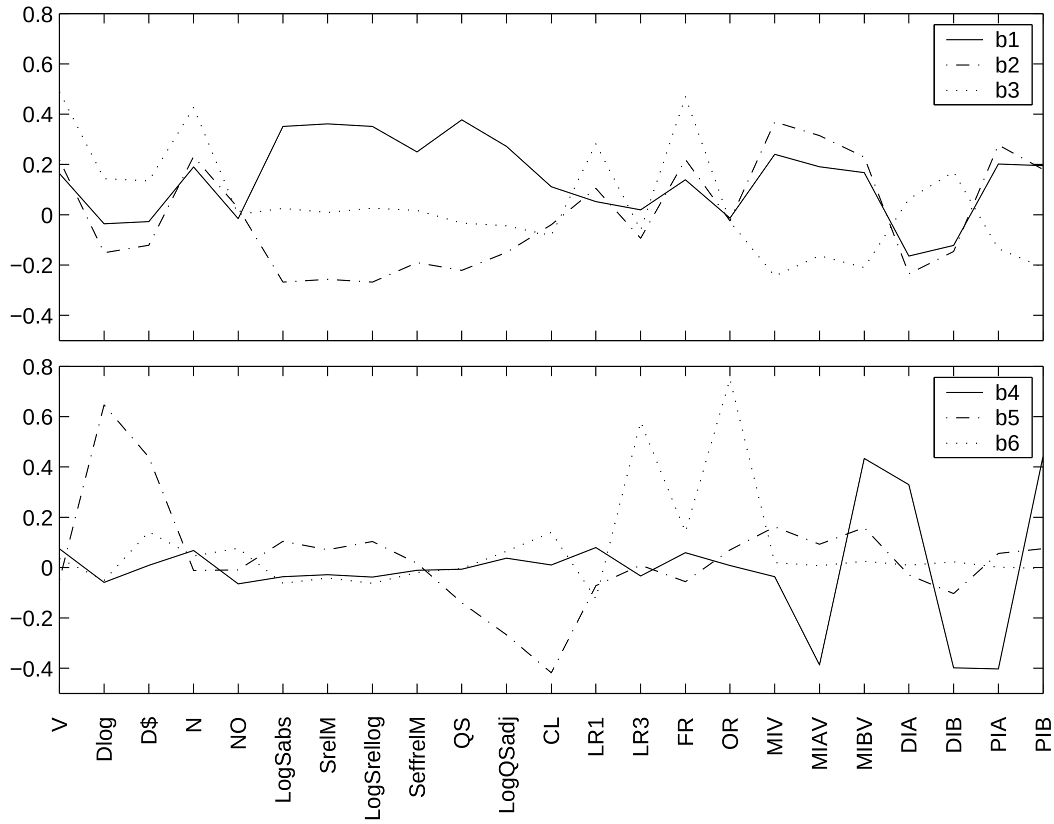

Figure 4.8: First six eigenvectors of the principal component analysis for Kudelski based on the differences of 23 liquidity measures.

Factor one of Kudelski explains 23% of total variance. As for the other stocks, so far, the first principal component captures the tightness dimension of the limit order book since it is influenced by the spread-related measures as well as the quote slope and the adjusted log quote slope. It also shows declining liquidity in the market impact, the depth for price impact and the price impact measures.

The second eigenvector is responsible for an additional 14% of variance. Again, it captures the spread related measures as well as the quote slope and the log quote slope. Furthermore, it shows rising liquidity in turnover, the number of trades and the flow ratio. On the other hand, to this rising liquidity in the formerly mentioned measures it shows declining liquidity in the market impact, the depth for price impact and the price impact measures.

Factor three, explaining an additional 10% of variance, is similar to factor three of Holcim. It takes rising liquidity in turnover, number of orders, the liquidity ratio 1, the flow ratio, the market impact measures and the price impact measures into account.

The fourth eigenvector separates again the bid-side and the ask-side of the limit order book, showing different directions of liquidity change for the buy-side and sell-side specific liquidity measures.

Factor five, which explains 7% of variance, captures the depth dimension of the limit order book. Aside from rising depth, it shows rising liquidity in the quote slope and adjusted log quote slope liquidity measures and the composite liquidity.

Factor six is responsible for another 5% of variance. This factor is almost equal to factor six of Holcim since it takes the liquidity ratio 3 and the order ratio into account.

4.10 Results of the Principal Component Analysis of Lonza

The liquidity measures of the Lonza stock show seven principal components with an eigenvalue larger than unity. They explain 71% of variance, as table 4.9 shows. The respective eigenvectors are depicted in figure 4.9.

	b_1	b_2	b_3	b_4	b_5	b_6	b_7
Eigenvalue	4.59	3.00	2.56	2.10	1.77	1.12	1.08
Var. explained	19.96%	13.06%	11.11%	9.12%	7.70%	4.88%	4.72%
Cum. var. explained	19.96%	33.02%	44.13%	53.25%	60.94%	65.83%	70.54%

Table 4.9: Principal component analysis of Lonza based on the differences of 23 liquidity measures.

Principal component one of Lonza explains 20%. It captures the tightness dimension of the limit order book with the spread-related liquidity measures, the quote slope and the log quote slope.

An additional 13% are explained by principal component two of Lonza which shows rising liquidity in turnover and number of trades as well as in the liquidity ratio 1 and the flow ratio. On the other hand, with factor two liquidity is declining in the depth dimension and in the market impact, depth for price impact and price impact measures.

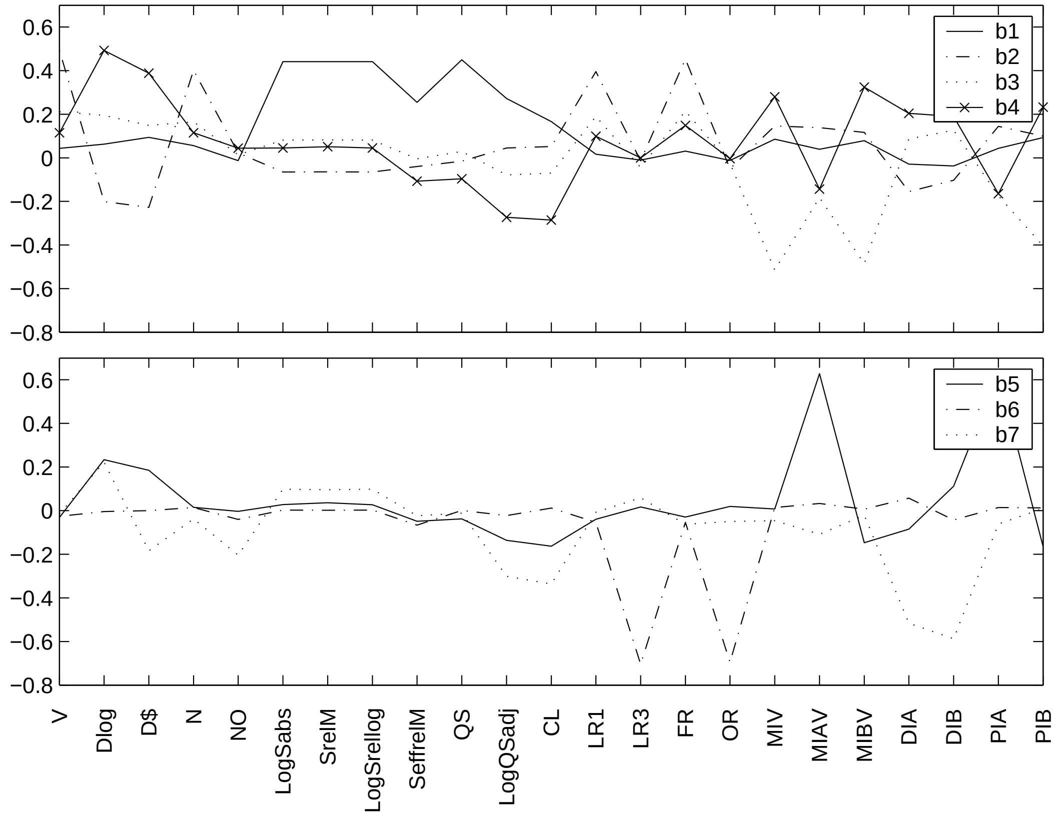

Figure 4.9: First seven eigenvectors of the principal component analysis for Lonza based on the differences of 23 liquidity measures.

Factor three, responsible for an additional 11% of variance, shows only rising liquidity. It influences turnover, the depth measures and the number of trades. Furthermore, the liquidity ratio 1, the flow ratio, the market impact and the price impact measures are captured by factor three.

With factor four, an additional 9% can be explained. Depth is rising with factor four as well as the adjusted log quote slope and composite liquidity. On the other hand, declining liquidity can be found in the market impact, the market impact on the bid-side and the price impact on the bid-side, while liquidity as measured by the market impact on the ask-side, the price impact on the ask-side and the two depth for price impact measures rise.

Factor five, which explains 8% of variance, captures high liquidity in the depth dimension. Furthermore, it separates the ask-side and the bid-side of the limit order book since it shows declining liquidity for the ask-side specific measures and rising liquidity for the bid-side specific ones.

The sixth principal component explains an additional 5% of variance and is equal to the sixth factor of Kudelski since it captures rising liquidity as measured by the liquidity ratio 3 and the order ratio.

Factor seven explains 5% of variance and is responsible for rising liquidity as measured by the adjusted log quote slope and composite liquidity and for declining liquidity as measured by the depth for price impact.

4.11 Results of the Principal Component Analysis of Swiss Re

For the Swiss Re stock six factors are necessary to explain the component structure, as table 4.10 shows. These first six factors explain about 70% of cumulative variance. The respective eigenvectors of Swiss Re can be found in figure 4.10.

	b_1	b_2	b_3	b_4	b_5	b_6
Eigenvalue	5.33	3.64	2.89	2.06	1.10	1.04
Var. explained	23.19%	15.82%	12.56%	8.94%	4.76%	4.53%
Cum. var. explained	23.19%	39.01%	51.57%	60.51%	65.27%	69.80%

Table 4.10: Principal component analysis of Swiss Re based on the differences of 23 liquidity measures.

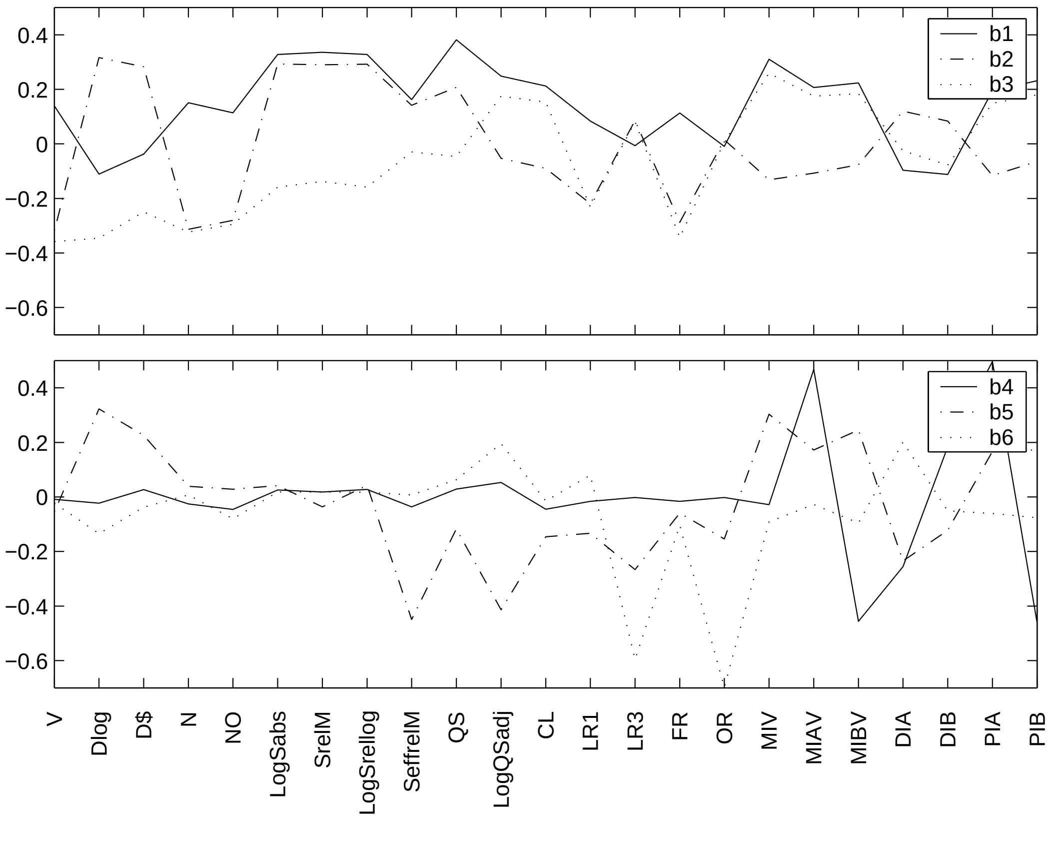

Figure 4.10: First six eigenvectors of the principal component analysis for Swiss Re based on the differences of 23 liquidity measures.

Factor one explains about 23% of total variance. It captures the tightness dimension of liquidity as well as the quote slope, the adjusted log quote slope and the market impact measures. Also, the two price impact measures are included.

Factor two, which explains an additional 15.8% of variance, shows declining liquidity in turnover, number of orders and number of trades as well as in the liquidity ratio 1 and the flow ratio. Additionally, declining liquidity in the tightness dimension and rising liquidity in the depth dimension is captured.

The third factor is responsible for declining liquidity in the depth and time dimension of liquidity. Also, declining liquidity as measured by the market impact and price impact is covered similarly to factor one.

The fourth eigenvector captures roughly another 9% of total variance. It shows declining liquidity for the ask-side related liquidity measures and rising liquidity for the bid-side related liquidity measures.

Factor five shows rising liquidity in the depth dimension and in the relative effective spread, the quote slope, the adjusted log quote slope and in the market impact and price impact measures.

Factor six explains another 4.5% of liquidity. It is responsible for the liquidity ratio 3 and the order ratio where rising liquidity is captured.

4.12 Results of the Principal Component Analysis of Swisscom

Also the Swisscom stock requires six principal components to explain the factor structure according to the Kaiser criterion. As can be seen in table 4.11 these six factors explain 67% of variance. The corresponding eigenvectors are depicted in figure 4.11.

	b_1	b_2	b_3	b_4	b_5	b_6
Eigenvalue	5.13	3.38	2.88	1.65	1.31	1.07
Var. explained	22.34%	14.68%	12.51%	7.17%	5.71%	4.67%
Cum. var. explained	22.34%	37.02%	49.53%	56.70%	62.42%	67.09%

Table 4.11: Principal component analysis of Swisscom based on the differences of 23 liquidity measures.

Eigenvector one of Swisscom is responsible for about 22% of variation. It captures rising liquidity in the time dimension and declining liquidity in the tightness dimension. Also, a rising market impact is captured by this factor.

Factor two explains an additional 14.7% of variance and shows, also, an exposure to rising turnover, number of trades and number of orders. Furthermore, declining depth and a declining tightness including quote slope and adjusted log quotes slope is explained by this second factor.

The third eigenvector captures highs of turnover, log depth, dollar depth, the number of trades and the number of orders. Also, liquidity ratio 1 and flow ratio are large. On the other side, composite liquidity and the three market impact measures are low.

Factor four, explaining 7%, is the factor to separate bid- and ask-side of the limit order book.

Also, the fifth factor shows differences on the bid- and the ask-side: Market impact on the bid-side and price impact on the bid-side are low, while depth for price impact on the bid-side is high. The ask-side related measures are around zero. Also, this factor is responsible for low depth and a high adjusted log quotes slope as well as a high composite liquidity.

Factor six explains 4.7% of variance and captures a rising relative effective spread, a rising liquidity ratio 3 and a rising order ratio.

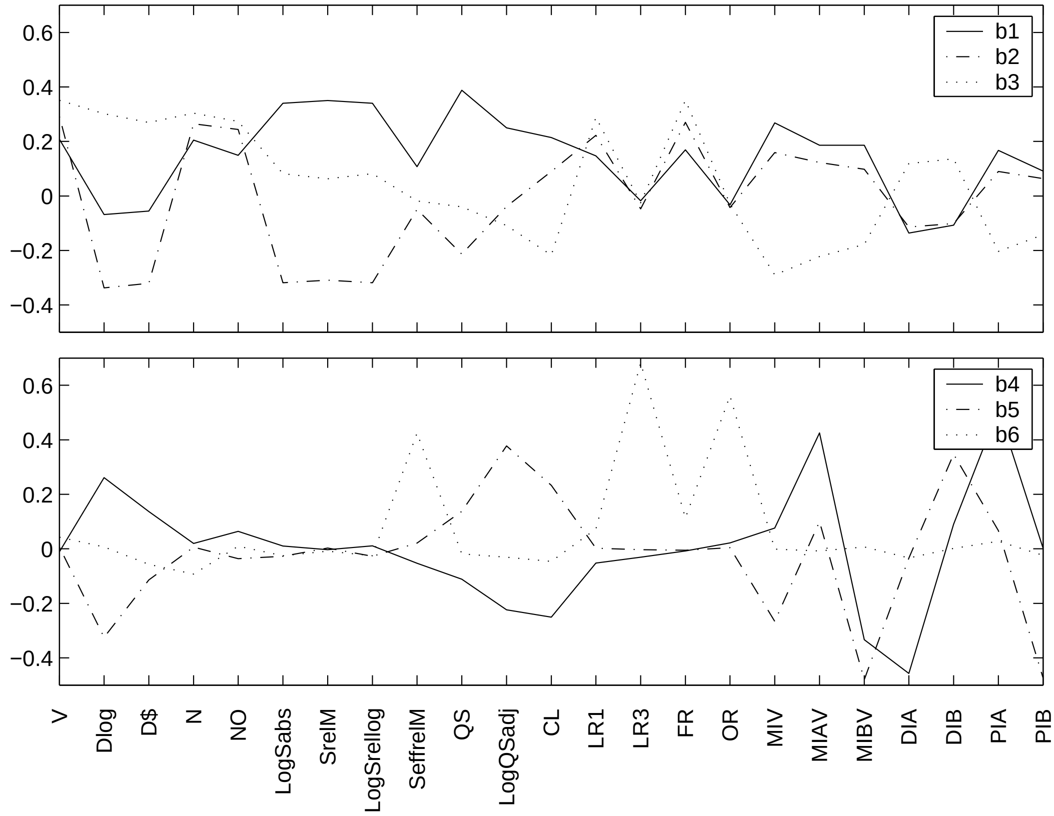

Figure 4.11: First six eigenvectors of the principal component analysis for Swisscom based on the differences of 23 liquidity measures.

4.13 Results of the Principal Component Analysis of Serono

For the Serono stock seven principal components have an eigenvalue larger than unity and are necessary to explain the factor structure as table 4.12 shows. These seven factors explain 74% of variance.

	b_1	b_2	b_3	b_4	b_5	b_6	b_7
Eigenvalue	5.18	3.22	2.52	2.12	1.69	1.23	1.11
Var. explained	22.53%	13.98%	10.96%	9.22%	7.36%	5.33%	4.83%
Cum. var. explained	22.53%	36.52%	47.47%	56.70%	64.06%	69.39%	74.22%

Table 4.12: Principal component analysis of Serono based on the differences of 23 liquidity measures.

The first eigenvector of Serono in figure 4.12 explains about 22.5% of variance and covers the tightness dimension of liquidity with all the spread measures, the quote slope and the adjusted log quote slope.

Factor two explains an additional 14% of total variance and is responsible for rising liquidity in turnover, number of trades, number of orders and the flow ratio.

The third factor shows declining depth, a high in composite liquidity and differences in the ask- and bid-side specific liquidity measures.

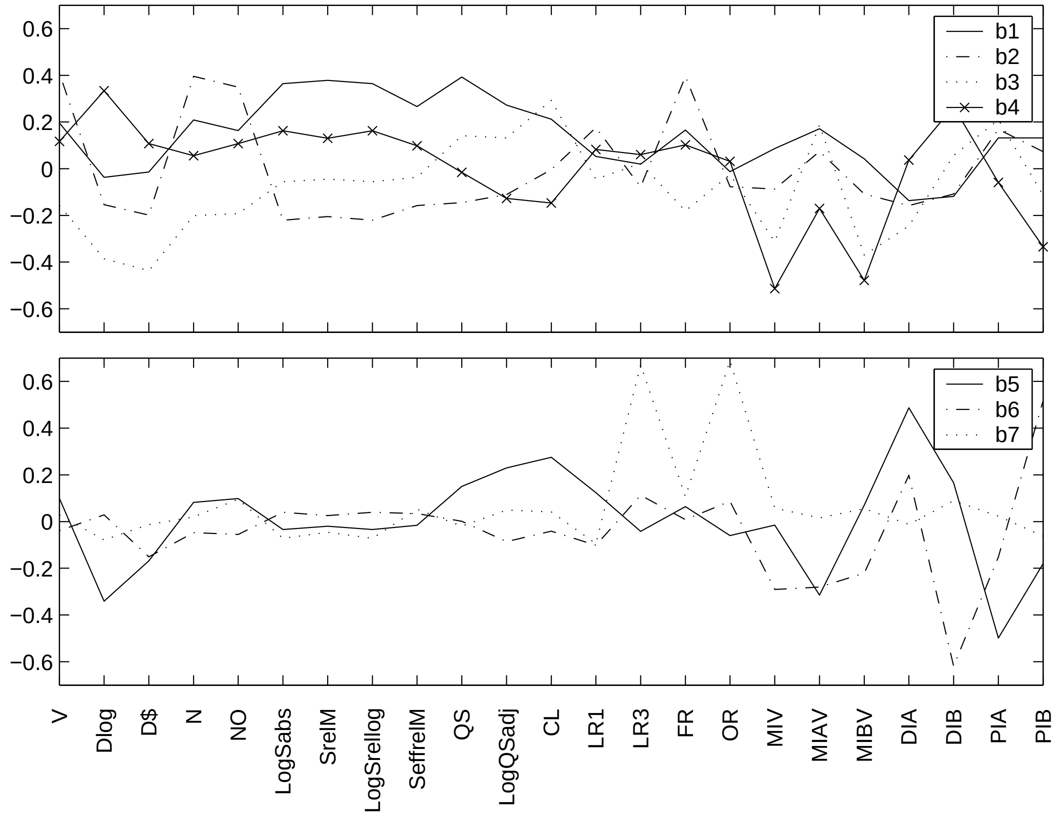

Figure 4.12: First seven eigenvectors of the principal component analysis of Serono based on the differences of 23 liquidity measures.

Factor four, which is responsible for 9.2% of variance, shows rising liquidity in log depth, the three market impact measures, the depth for price impact measures and the price impact on the bid-side.

The fifth eigenvector captures declining depth, shows a high in composite liquidity and rising liquidity in all the ask-side specific measures.

Eigenvector six, on the other hand, has a low with depth for price impact on the bid-side and a high with respect to the price impact on the bid-side. For the Serono stock, there is one clear factor that unwinds bid- and ask-side but, this factor is separated among different eigenvectors.

Factor seven explains 4.8% and is influenced by the liquidity ratio 3 and the order ratio.

4.14 Results of the Principal Component Analysis of Surveillance

Surveillance is the only stock in this study, that requires eight principal components before the Kaiser criterion reaches the cut off level. The results are presented in table 4.13. With these eight factors, 75% of variation can be explained. Figure 4.13 shows the first eight eigenvectors of the liquidity measures for Surveillance.

The first eigenvector of the principal component analysis of Surveillance, which covers 21% of variance, captures declining liquidity in the tightness dimension with the spread

	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8
Eigenvalue	4.89	3.03	2.45	2.03	1.50	1.31	1.08	1.06
Var. explained	21.26%	13.17%	10.66%	8.83%	6.51%	5.69%	4.71%	4.60%
Cum. var. explained	21.26%	34.43%	45.09%	53.91%	60.43%	66.12%	70.82%	75.43%

Table 4.13: Principal component analysis of the differences of 23 liquidity measures for Surveillance.

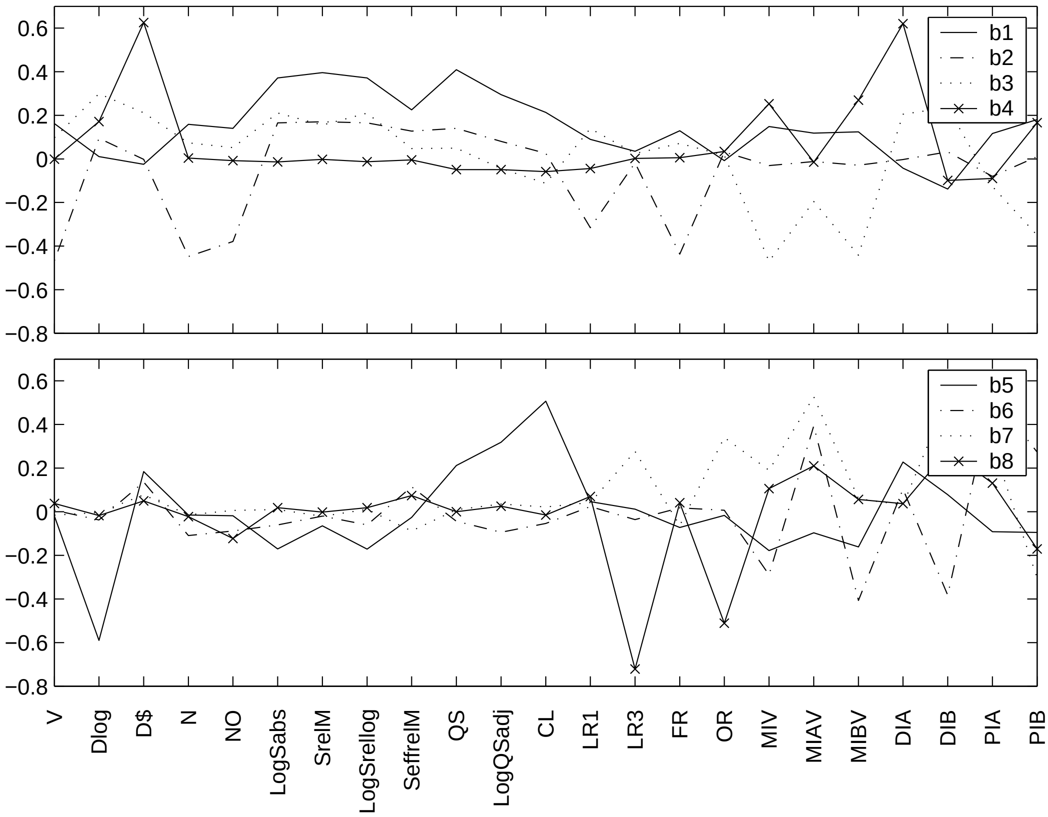

Figure 4.13: First eight eigenvectors of the principal component analysis for Surveillance based on the differences of 23 liquidity measures.

measures, the quote slope, the adjusted log quote slope and the composite liquidity.

Eigenvector two explains an additional 13% of variance and has an exposure to the time dimension since it shows declining turnover, number of orders and number of trades. Also, the liquidity ratio 1 and the flow ratio are included.

The third component adds 11% of variance and shows rising depth and rising liquidity as measured with the market impact, the depth for price impact and the price impact measures. On the other hand, the spread-related measures show declining liquidity with rising depth.

Factor four explains 9% of variance and is difficult to interpret: With factor four, liquidity is rising with dollar depth (and to a lesser extent log depth) and depth for price impact on the ask-side. Liquidity declines with the market impact, the market impact for the bid-side and the price impact for the bid-side.

Factor five explains 6% of variance and captures declining liquidity in log depth but not in dollar depth. Liquidity also declines with the quote slope, the adjusted log quote slope and composite liquidity. On the other hand, liquidity as measured by the depth for price impact for the ask-side is rising with factor five.

The sixth eigenvector takes another 6% of variance into account. It explains rising liquidity with the market impact and the market impact for the bid-side. Declining liquidity is supported by the market impact on the ask-side, the depth for price impact on the bid-side and the two price impact measures.

Principal component seven explains 5% of variance. Liquidity declines with the liquidity ratio 3, the order ratio, the market impact for the ask-side and the price impact for the ask-side. Contrary to this, the depth for price impact for the bid-side and the price impact on the bid-side show rising liquidity.

The eighth principal component is unique in this study and explains 5% of variance. Like factor seven, it shows rising liquidity for the depth for price impact on the bid-side and the price impact on the bid-side while the market impact on the ask-side and the price impact on the ask-side show declining liquidity. It, also, has an impact on the liquidity ratio 3 and on the order ratio, but this time the impact is negative, showing declining liquidity.

4.15 Results of the Principal Component Analysis of Sulzer

The Kaiser criterion tells to cut off after seven principal components, as table 4.14 indicates. These seven principal components, with an eigenvector larger than unity, explain 72% of total variance. Figure 4.14 depicts the first seven eigenvectors of the principal component analysis of Sulzer.

	b_1	b_2	b_3	b_4	b_5	b_6	b_7
Eigenvalue	5.11	3.04	2.74	1.94	1.50	1.23	1.06
Var. explained	22.20%	13.21%	11.90%	8.44%	6.53%	5.37%	4.59%
Cum. var. explained	22.20%	35.41%	47.31%	55.75%	62.27%	67.64%	72.23%

Table 4.14: Principal component analysis of Sulzer based on the differences of 23 liquidity measures.

The first eigenvector of Sulzer explains 22% of total variation and captures, like most of the other first factors, the tightness dimension of liquidity.

Eigenvector two, which is responsible for an additional 13% of variance, covers the time dimension with turnover, number of trades, number of orders and the flow ratio. It shows an additional high at the liquidity ratio 1.

The third factor is influenced by the depth dimension and the market impact, the depth for price impact and the price impact measures.

Factor four covers log depth and dollar depth. In addition to this, it shows rising liquidity as measured by the adjusted log quote slope, composite liquidity, the market impact and the market impact on the bid-side.

Factor five explains 6.5% of total variance and shows declining log depth and rising composite liquidity. Market impact is high, market impact on the ask-side is low and market impact on the bid-side is, again, high as well as depth for price impact on the ask-side. Depth for price impact on the bid-side and price impact on the bid,side are only slightly influenced,

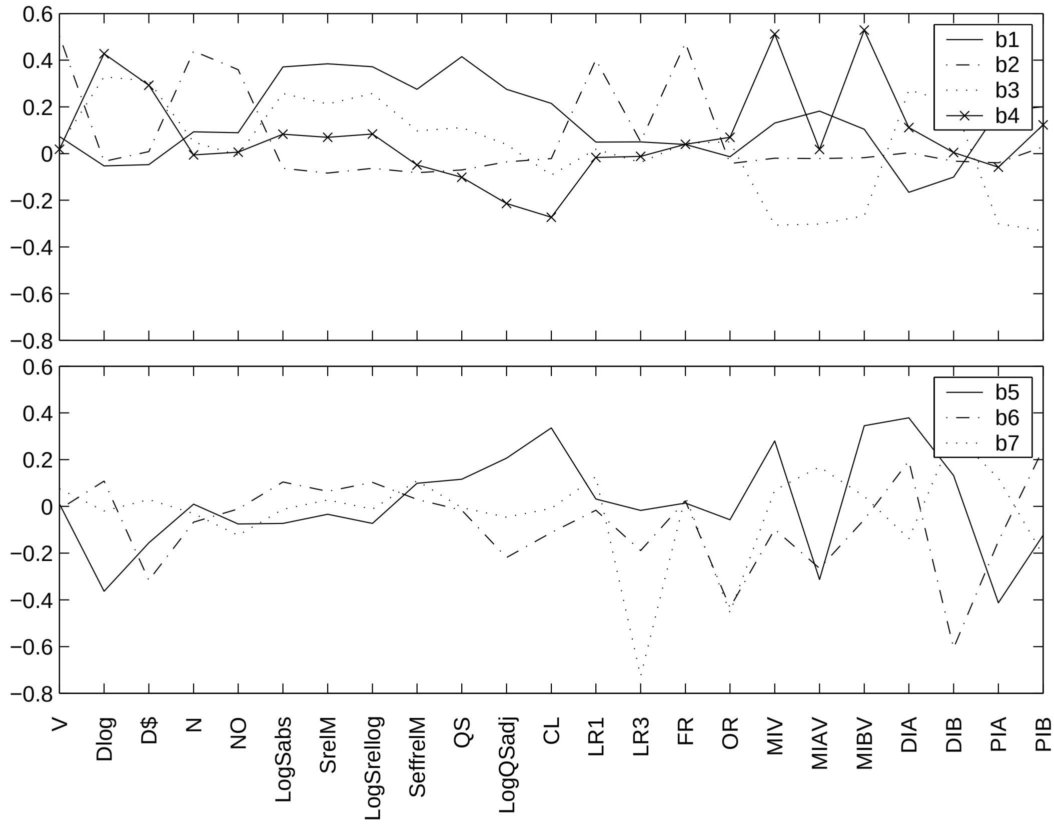

Figure 4.14: First seven eigenvectors of the principal component analysis for Sulzer based on the differences of 23 liquidity measures

while price impact on the ask-side shows rising liquidity. Factor five separates liquidity of the two sides of the order book.

Eigenvector six is responsible for dollar depth, order ratio and depth for price impact on the bid-side.

The seventh eigenvector of Sulzer is influenced, primarily, by the liquidity ratio 3. Also, it has a slight exposure to the depth for price impact on the bid-side.

4.16 Results of the Principal Component Analysis of Syngenta

Also, the Syngenta stock requires seven principal components before the Kaiser criterion tells to cut off, as table 4.15 shows. The first seven eigenvectors are able to explain more than 70% of total variance.

	b_1	b_2	b_3	b_4	b_5	b_6	b_7
Eigenvalue	4.92	3.09	2.77	1.86	1.82	1.44	1.04
Var. explained	21.39%	13.44%	12.05%	8.09%	7.92%	6.24%	4.54%
Cum. var. explained	21.39%	34.83%	46.88%	54.97%	62.89%	69.13%	73.67%

Table 4.15: Principal component analysis of the differences of 23 liquidity measures for Syngenta.

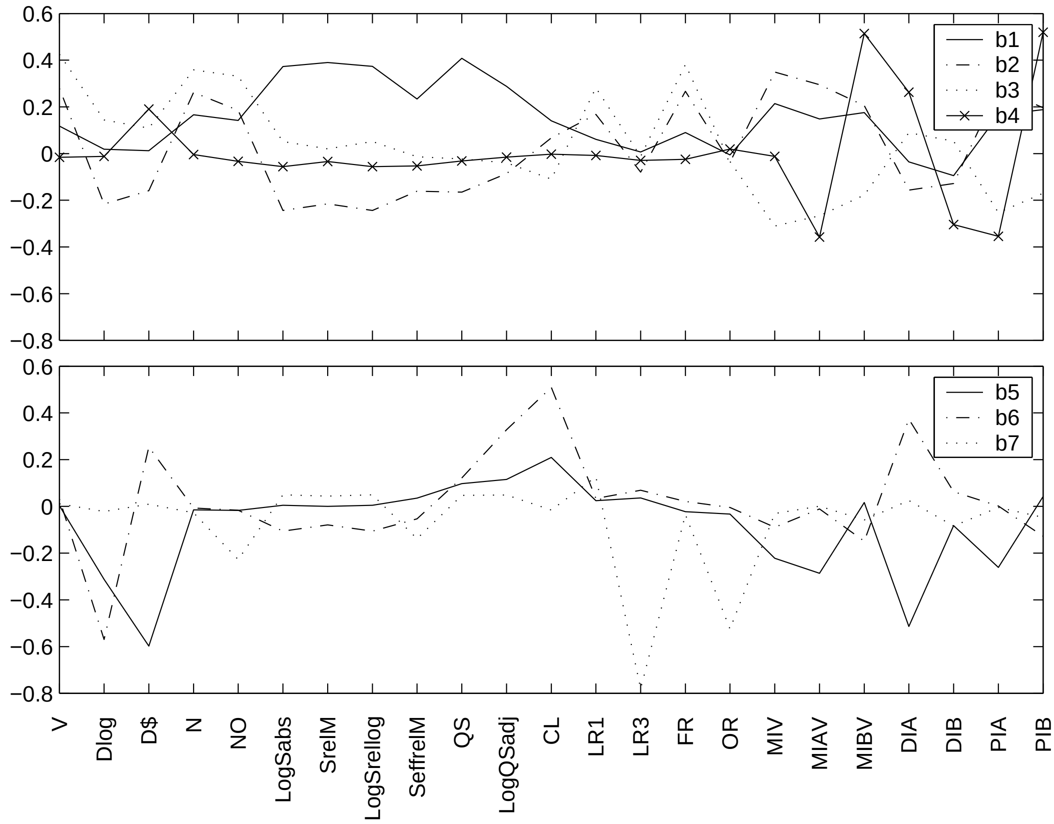

Figure 4.15: First seven eigenvectors of the principal component analysis of Syngenta based on the differences of 23 liquidity measures.

The first eigenvector in figure 4.15, which explains about 21% of total variance, captures, again, the tightness dimension of liquidity since it is influenced by the spread measures as well as the quote slope and the adjusted log quote slope.

Another 13% of variance are explained by factor two. It combines rising liquidity in the time dimension with turnover, number of trades, number of orders and flow ratio and in the tightness dimension with declining liquidity in the depth dimension and the market impact measures.

Factor three is responsible for 12% of variance and has a positive exposure to the time dimension. There is an additional high at the liquidity ratio 1 and lows at the market impact measures and price impact measures.

The fourth principal component separates ask-side and bid-side of the order book since it shows rising liquidity on the ask-side and declining liquidity on the bid-side.

Factor five has a negative influence on the depth dimension and has, like the precedent factor, not the same impact on the bid-side and ask-side related liquidity measures.

The sixth factor shows highs for dollar depth, composite liquidity and depth for price impact and a low at log depth.

Factor seven explains 4.5% of variance and captures rising liquidity as measured by the liquidity ratio 3 and the order ratio.

4.17 Results of the Principal Component Analysis of Swatch Bearer Share

The six principal components with an eigenvector larger than unity are presented in table 4.16. They explain more than 65% of total variance. Figure 4.16 shows the first six eigenvectors of Swatch bearer share.

	b_1	b_2	b_3	b_4	b_5	b_6
Eigenvalue	5.01	3.11	2.81	1.61	1.51	1.07
Var. explained	21.78%	13.51%	12.23%	6.99%	6.57%	4.66%
Cum. var. explained	21.78%	35.28%	47.52%	54.50%	61.07%	65.74%

Table 4.16: Principal component analysis of the differences of 23 liquidity measures for Swatch bearer share.

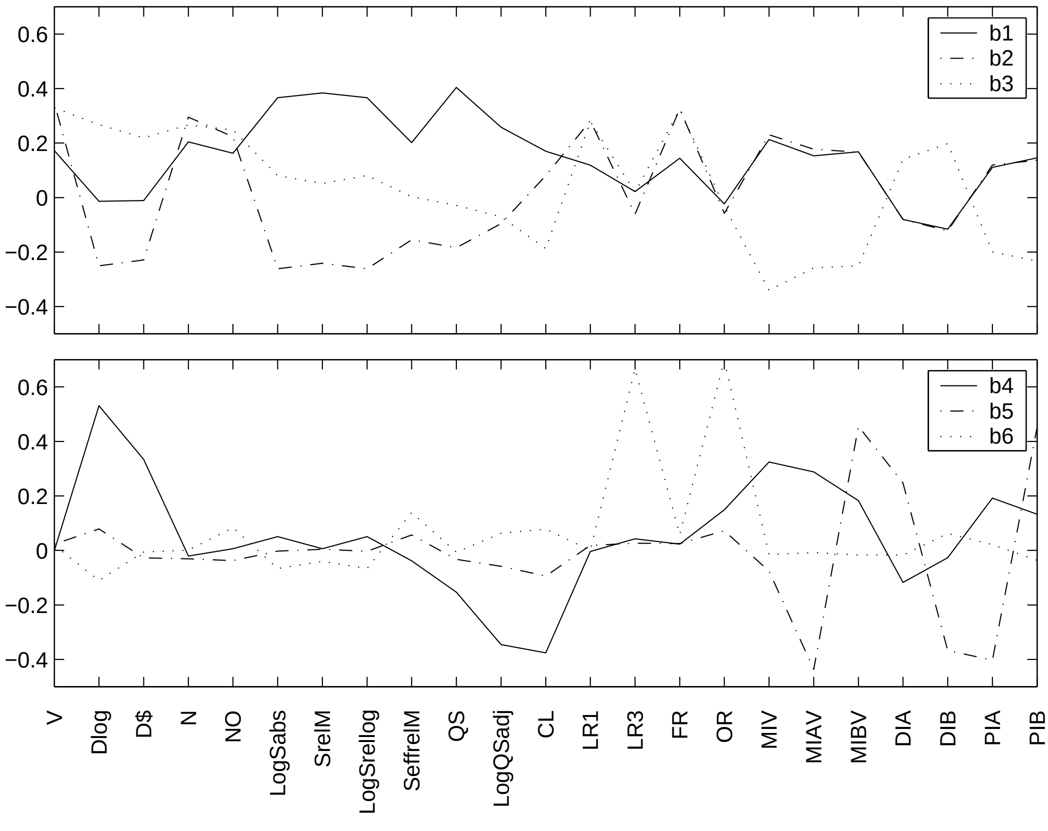

Figure 4.16: First six eigenvectors of the principal component analysis of Swatch bearer share based on the differences of 23 liquidity measures.

Similar to the other stocks, the first eigenvector of Swatch bearer share explains more than 21% of total variance and influences the tightness dimension of liquidity.

The second factor captures 13.5% of variance. It is influenced by turnover, number of trades and number of orders as well as by the liquidity ratio 1 and the flow ratio. Also, it covers declining depth measures.

Factor three explains 12% and covers, again, turnover, depth, number of trades, number of orders, the liquidity ratio 1 and the flow ratio, but this time in the same direction. Furthermore, with this factor, composite liquidity and the market impact measures are low.

Eigenvector four, responsible for an additional 7% of variation, shows rising liquidity in the depth measures as well as in quote slope, log quotes slope and composite liquidity. Liquidity, as measured by the market impact, is declining.

The fifth eigenvector combines rising liquidity on the ask-side of the limit order book with declining liquidity on the bid-side and explains 6.8% of variance.

Factor six shows two peaks at the liquidity ratio 3 and the order ratio.

4.18 Results of the Principal Component Analysis of Swatch Registered Share

Like the Swatch bearer share, the registered share requires six principal components before the Kaiser criterion cuts off, as table 4.17 shows. With 68% these six factors explain slightly more variance than the six factors of the bearer share. The first six principal components of Swatch registered share are depicted in figure 4.17.

	b_1	b_2	b_3	b_4	b_5	b_6
Eigenvalue	4.70	3.15	3.08	2.07	1.56	1.09
Var. explained	20.44%	13.69%	13.38%	9.01%	6.79%	4.75%
Cum. var. explained	20.44%	34.13%	47.51%	56.52%	63.31%	68.06%

Table 4.17: Principal component analysis of the differences of 23 liquidity measures for Swatch registered share.

The tightness dimension is captured by eigenvector one which explains slightly more than 20% of variance.

Factor two is responsible for another 13.7% of variance and is influenced by turnover, number of trades, number of orders, the liquidity ratio 1 and the flow ratio.

The third eigenvector captures an additional 13.4% of variance. It shows declining liquidity in the depth dimension, the market impact, depth for price impact and the price impact measures.

Eigenvector four explains 9% of variance and it is the factor to separate the bid- and the ask-side of the limit order book. Liquidity on the bid-side is declining as well as the market impact measure.

The fifth eigenvector shows rising depth, a declining composite liquidity, a rising market impact on the ask-side and a declining depth for price impact on the ask-side.

The last eigenvector explains 4.75% of variance in the changes of the liquidity measures and has lows at the liquidity ratio 3 and the order ratio.

4.19 Results of the Principal Component Analysis of Unaxis

The results of the principal component analysis of Unaxis are shown in table 4.18. For Unaxis, the Kaiser criterion cut off comes after seven eigenvectors. These seven eigenvectors

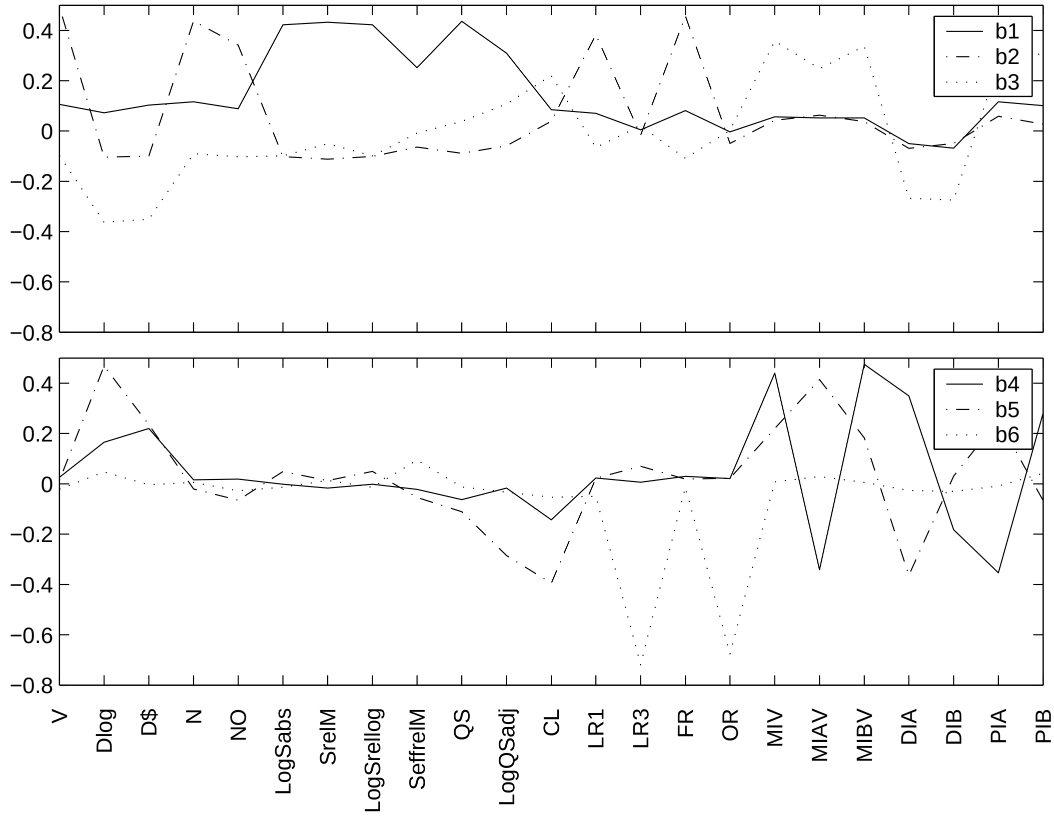

Figure 4.17: First six eigenvectors of the principal component analysis of Swatch registered share based on the differences of 23 liquidity measures.

explain about 71% of total variance. Figure 4.18 shows the factor structure of the Unaxis stock. It is different from the other stocks.

	b_1	b_2	b_3	b_4	b_5	b_6	b_7
Eigenvalue	4.75	3.00	2.94	1.98	1.48	1.06	1.04
Var. explained	20.67%	13.05%	12.80%	8.61%	6.44%	4.60%	4.53%
Cum. var. explained	20.67%	33.72%	46.52%	55.13%	61.57%	66.17%	70.70%

Table 4.18: Principal component analysis of the differences of 23 liquidity measures for Unaxis.

The first factor explains more than 20% of variance and shows no exposure neither to the log absolute spread nor to the relative spread. It captures the log relative spread of log prices, the relative effective spread, the quotes slope, the adjusted log quote slope, composite liquidity and the liquidity ratio 1, the market impact and the market impact on the ask-side.

Factor two explains 13% and shows highs for turnover, log depth and depth for price impact on the bid-side. It is difficult to justify this factor from an economic point of view.

The third and the fourth eigenvectors, which explain 12.8% and 8.61%, respectively, are very similar since one factor looks like a parallel shift of the other. They have peaks at dollar depth, number of trades and number of orders and show minima for the liquidity ratio 1, the flow ratio, the order ratio and the depth for price impact on the ask-side.

The fifth eigenvector, again, shows lows for the liquidity ratio 3, the flow ratio and the order ratio.

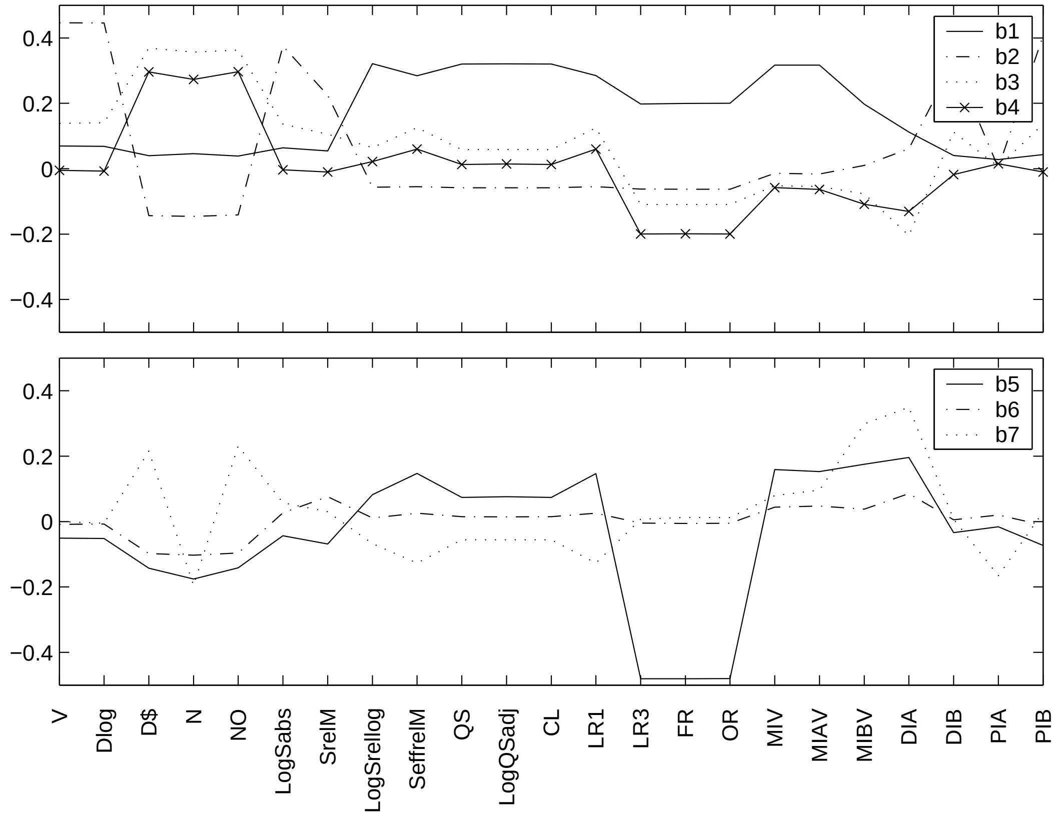

Figure 4.18: First seven eigenvectors of the principal component analysis of Unaxis based on the differences of 23 liquidity measures.

Eigenvector six explains an additional 4.6% of variance, but is almost a horizontal line at zero.

Factor seven shows rising liquidity for the depth for price impact on the ask-side and the price impact on the ask-side. Declining liquidity is found for the market impact on the bid-side. Therefore, this is the factor to separate the bid- and the ask-side of the limit order book.

4.20 General Results of the Principal Component Analysis of the Liquidity Measures

From the principal component analysis of the individual stocks the following general conclusions can be drawn:

One factor explains the spread-related liquidity measures like log absolute spread, relative spread, log relative spread of log prices, relative effective spread as well as quote slope and adjusted log quote slope.

A second factor takes the volume-related liquidity measures like turnover, number of orders and number of trades into account.

Another factor is responsible for the depth dimension, capturing log depth and dollar depth.

Bid- and ask-side of the limit order book do not always move in common but have to be split up in an ask-side specific and a bid-side specific liquidity. This finding is in line with Irvine et al. (2000). In the principal component analysis this phenomenon may show up either in one factor, covering rising liquidity on the ask-side and declining liquidity on the bid-side or in two factors, influencing only the bid- or ask-side.

Somehow on their own stand the liquidity ratio 3 and the order ratio.

The results of the principal component analysis, therefore, suggest six dimensions of liquidity which will be captured in the following chapters by the following liquidity measures:

1. Tightness

   The tightness dimension can be described by the different spread measures. I chose the relative spread with the mid-price in the denominator since it is comparable among different stocks.

2. Time

   The time dimension will be captured by the turnover since it is highly correlated with the number of trades and is, again, comparable across different stocks.

3. Depth

   For the same reason as above, dollar depth will describe the depth dimension of liquidity.

4. Bid-side

   The market impact for the bid-side is used to measure bid-side related liquidity since it is easy to interpret and may be compared across different stocks.

5. Ask-side

   Ask-side specific liquidity is measured by the market impact for the ask-side.

6. Resiliency

   The resiliency dimension will be measured by the liquidity ratio 3 since it is easier to interpret than the order ratio.

The dimensions of liquidity proposed in chapter 1 show up clearly in the results of the principal component analysis. New is the separation of the bid-side and the ask-side of the limit order book.

Part II

Predicting Liquidity

In the second part some ways to predict liquidity are investigated. Starting with the sample of six liquidity measures determined at the end of part I, the next chapter will be devoted to the lead-lag behavior of liquidity. In a vector autoregressive model the six liquidity measures and returns will be included and the structure of these variables is analyzed for the eighteen stocks. The last chapter 6 builds prediction models for the six liquidity measures mentioned above which yield promising results.

Chapter 5

The Lead-Lag Behavior of Liquidity Measures

In this chapter, the question is addressed whether there is a “normal” level of liquidity, and whether there is mean-reversion in liquidity measures. This will yield possibilities to predict liquidity, since a long term mean would be an estimate for liquidity. Coppejans et al. (2003) detect mean-reversion in the measures “depth for price impact” which may be a general result and could be adapted for other liquidity measures.

There may also be persistence in liquidity: A period of high liquidity tends to be followed by another of high liquidity and the same holds for low liquidity. Chan et al. (2002) describe positive autocorrelation among net-trade volumes in the stock market.

Engle & Lange (2001) show the net-directional-volume to be a function of magnitude and timing of current and lagged transaction flows. The spread preceding a price-duration is negatively related to $VNET$.

The lead-lag behavior of liquidity measures is investigated further using a vector autoregressive model as described, for example in Stier (2001). This will yield estimates for the influence of lagged liquidity measures on the liquidity in time t, and is, therefore, an approach that may lead to promising results in predicting liquidity.

5.1 Autocorrelation in Liquidity Measures and Returns

For the theory of autocorrelations see e.g. Hamilton (1994). The autocorrelation τ of the change in the liquidity measure dm at lag k is estimated as

$$\tau_k = \frac{\sum\limits_{t=k+1}^{T} (dm_t - \overline{dm}) \cdot (dm_{t-k} - \overline{dm})}{\sum\limits_{t=1}^{T} (dm_t - \overline{dm})^2}. \tag{5.1}$$

With the Ljung-Box test, the autocorrelations are tested for their significance. The Q-statistic for lag k is calculated as

$$Q_k = T \cdot (T+2) \cdot \sum_{j=1}^{k} \frac{\tau_j^2}{T-j}. \tag{5.2}$$

Under the null hypothesis of no autocorrelation up to lag k, Q is asymptotically distributed as a χ^2 with k degrees of freedom, according to Ljung & Box (1978).

All the differences in liquidity measures show negative and significant autocorrelation at lag 1. Afterwards the autocorrelation drops sharply to about zero which is a sign that the differences in liquidity measures obey a moving-average process of order 1.

The partial autocorrelation ρ at lag k is approximated recursively, in line with Box & Jenkins (1976), by

$$\rho_k = \begin{cases} \tau_1 & \text{for } k = 1 \\ \frac{\tau_k - \sum_{j=1}^{k-1} \rho_{k-1,j} \cdot \tau_{k-j}}{1 - \sum_{j=1}^{k-1} \rho_{k-1,j} \cdot \tau_{k-j}} & \text{for } k > 1 \end{cases}. \tag{5.3}$$

and

$$\rho_{k,j} = \rho_{k-1,j} - \rho_k \cdot \rho_{k-1,k-j}. \tag{5.4}$$

Since the partial autocorrelations of the differences for all liquidity measures gradually approach zero, they follow a moving average process.

For the returns, the picture is similar: seventeen stocks show slightly negative but significant autocorrelations at lag one. The partial autocorrelations are dying out, and the returns follow a moving average process. Only for Adecco is no autocorrelation in returns observed.

5.2 The Vector Autoregressive Model

There are several studies employing the vector autoregressive model in the context of market microstructure: George & Hwang (1998) e.g. use a vector autoregressive model to evaluate daytime and overnight order flows with its respective returns, and Trapletti, Geyer & Leisch (2002) try to forecast exchange rates using a vector autoregressive model. Chung, Han & Tse (1996) examine the interrelation between NYSE, AMEX and NASDAQ markets with a VAR model and describe the methodology extensively.

An n-dimensional vector-autoregressive model of order p (VAR(p)-process) is defined according to Hamilton (1994) or Stier (2001) as:

$$x_t = c + \Phi_1 \cdot x_{t-1} + \Phi_2 \cdot x_{t-2} + ... + \Phi_p \cdot x_{t-p} + \varepsilon_t \tag{5.5}$$

In our case, the vector x_t consists of the changes in the six liquidity measures and returns in time t. n is therefore equal to seven. x_t is regressed upon its own lagged variables. $\Phi_i (i = 1, 2, ..., p)$ denotes the $(n \times n)$-parameter matrices with $\Phi_p \neq 0$. c is an $(n \times 1)$ vector of constants which may be a vector of zeros. ε_t is a vector of white noise.

To determine the appropriate number of lags (p) to include, the Schwarz information criterion (SIC) by Schwarz (1978) was employed. It is given by:

$$SIC = -2 \cdot (\frac{l}{T}) + k \cdot \frac{\log(T)}{T} \tag{5.6}$$

l is the value of the log likelihood function with the k parameters estimated from the T observations. l is given by

$$l = -\frac{T \cdot M}{2} \cdot (1 + \ln(2 \cdot \pi)) - \frac{T}{2} \cdot \ln |\hat{\Omega}| \tag{5.7}$$

M is the number of equations and

$$|\hat{\Omega}| = det(\sum_i \frac{\hat{\varepsilon}\hat{\epsilon}'}{T}). \tag{5.8}$$

The Schwarz information criterion reaches its maximum for all stocks at seven lags. Therefore, seven lags are included in the vector autoregressive model.

5.3 Results of the VAR model for Adecco

Table 5.1 presents the results of the vector autoregressive model for Adecco. As described above, the first differences of six liquidity measures are included as well as returns. The model includes seven lags since there the Schwarz information criterion reaches its maximum.

The relative spread depends on all its own lagged expressions negatively and the coefficients are highly significant. Therefore, rising spreads are followed by declining ones. This result holds for all liquidity measures: The vector autoregressive model shows a significantly negative impact of the changes in $t-7$ until $t-1$ on the liquidity measure in t. The relative spread is positively influenced by changes in turnover. There is significance for lags one to three, and seven. Rising liquidity, as measured by turnover, leads to lower liquidity measured by the spread. Between dollar depth and the spread there is no significant relation. The relative spread is positively influenced by the market impacts on the bid- and the ask-side. For the ask-side the impact is significant up to lag five (at a level of at least 5%), whereas on the bid-side only the first two lags are significant. The liquidity ratio 3 has only a slightly significant impact on the lag seven which is negative. The first lag of the returns influences the relative spread significantly: A declining stock price inflates the spread. At the lag seven this relation is significantly positive. The constant is not significantly different from zero which holds for the whole VAR system.

Turnover is not significantly influenced by the relative spread. For dollar depth there is a slightly positive relation for the first lag. Turnover depends strongly on the lagged market impacts: A negative significance on a level of at least 5% is recognized for lags up to five on the ask-side and up to six on the bid-side. The liquidity ratio 3 influences only slightly turnover on lag two. The returns are negatively related on lags one to five but significant are only the values for lag two and five on a level of 10% and 5%, respectively.

Dollar depth in time t is not influenced by the lagged relative spreads. Therefore, there is no interrelation between the tightness and the depth dimension of liquidity. Turnover

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.71***	$-1.06 \cdot 10^7$	2'924'500	–3.75*	2.99	0.11***	0.11***
$SrelM_{t-2}$	–0.59***	$-1.41 \cdot 10^7$	–5'189'125	–2.66	3.70	0.10***	0.07
$SrelM_{t-3}$	–0.48***	$-1.19 \cdot 10^7$	1'046'047	–3.08	0.06	0.08***	0.09*
$SrelM_{t-4}$	–0.38***	–2'856'269	$-1.36 \cdot 10^7$	–3.73	3.63	0.07***	0.01
$SrelM_{t-5}$	–0.30***	–2'876'019	–6'931'810	–0.78	–3.16	0.07***	–0.01
$SrelM_{t-6}$	–0.19***	–8'595'437	3'620'167	–1.27	0.59	0.05***	0.00
$SrelM_{t-7}$	–0.13***	–9'568'984	–3'611'705	–1.85	–1.52	0.02***	–0.01
V_{t-1}	$4.66 \cdot 10^{-11}$**	–0.62***	0.040***	$3.31 \cdot 10^{-9}$	$1.36 \cdot 10^{-8}$***	$1.08 \cdot 10^{-11}$	$-9.12 \cdot 10^{-11}$
V_{t-2}	$5.97 \cdot 10^{-11}$**	–0.49***	0.042**	$2.62 \cdot 10^{-9}$	$9.33 \cdot 10^{-9}$**	$2.64 \cdot 10^{-11}$**	$1.71 \cdot 10^{-11}$
V_{t-3}	$7.19 \cdot 10^{-11}$***	–0.36***	0.027	$4.09 \cdot 10^{-9}$	$7.51 \cdot 10^{-9}$*	$7.37 \cdot 10^{-12}$	$-4.62 \cdot 10^{-11}$
V_{t-4}	$1.84 \cdot 10^{-11}$	–0.25***	0.003	$3.60 \cdot 10^{-9}$	$9.65 \cdot 10^{-9}$**	$1.29 \cdot 10^{-11}$	$-9.98 \cdot 10^{-11}$
V_{t-5}	$1.45 \cdot 10^{-11}$	–0.16***	–0.001	$1.07 \cdot 10^{-8}$***	$9.63 \cdot 10^{-9}$**	$1.71 \cdot 10^{-11}$	$-1.24 \cdot 10^{-10}$
V_{t-6}	$1.64 \cdot 10^{-11}$	–0.11***	0.041**	$9.34 \cdot 10^{-9}$**	$4.27 \cdot 10^{-9}$	$1.09 \cdot 10^{-11}$	$-1.31 \cdot 10^{-10}$*
V_{t-7}	$4.12 \cdot 10^{-11}$**	–0.06***	0.013	$5.69 \cdot 10^{-9}$*	$1.21 \cdot 10^{-9}$	$8.45 \cdot 10^{-12}$	$-1.30 \cdot 10^{-10}$**
$D\$_{t-1}$	$1.49 \cdot 10^{-12}$	0.022*	–0.850***	$4.86 \cdot 10^{-9}$*	$2.58 \cdot 10^{-9}$	$3.68 \cdot 10^{-12}$	$5.60 \cdot 10^{-11}$
$D\$_{t-2}$	$-1.39 \cdot 10^{-11}$	0.008	–0.718***	$3.53 \cdot 10^{-9}$	$-2.97 \cdot 10^{-10}$	$-3.87 \cdot 10^{-13}$	$-4.27 \cdot 10^{-11}$
$D\$_{t-3}$	$-8.63 \cdot 10^{-12}$	0.010	–0.591***	$5.67 \cdot 10^{-9}$	$3.79 \cdot 10^{-9}$	$-5.21 \cdot 10^{-12}$	$7.01 \cdot 10^{-11}$
$D\$_{t-4}$	$4.68 \cdot 10^{-12}$	0.011	–0.471***	$3.09 \cdot 10^{-9}$	$4.27 \cdot 10^{-11}$	$-1.31 \cdot 10^{-12}$	$1.80 \cdot 10^{-11}$
$D\$_{t-5}$	$2.49 \cdot 10^{-11}$	0.002	–0.355***	$2.20 \cdot 10^{-9}$	$-5.55 \cdot 10^{-10}$	$8.71 \cdot 10^{-13}$	$-4.13 \cdot 10^{-12}$
$D\$_{t-6}$	$2.36 \cdot 10^{-11}$	0.021	–0.239***	$1.95 \cdot 10^{-9}$	$-1.76 \cdot 10^{-9}$	$-1.13 \cdot 10^{-12}$	$5.76 \cdot 10^{-11}$
$D\$_{t-7}$	$2.30 \cdot 10^{-11}$	0.006	–0.119***	$2.20 \cdot 10^{-9}$	$-2.00 \cdot 10^{-9}$	$6.81 \cdot 10^{-13}$	$4.96 \cdot 10^{-11}$
MI_{t-1}^{A,V^*}	$2.91 \cdot 10^{-4}$***	–285'910***	–106'923*	–0.482***	0.079***	$1.43 \cdot 10^{-4}$***	$6.30 \cdot 10^{-4}$**
MI_{t-2}^{A,V^*}	$1.98 \cdot 10^{-4}$**	–186'664***	–166'650***	–0.314***	0.066***	$4.82 \cdot 10^{-5}$	$7.69 \cdot 10^{-4}$***
MI_{t-3}^{A,V^*}	$2.94 \cdot 10^{-4}$***	–239'491***	–93'338	–0.215***	0.073***	$1.24 \cdot 10^{-4}$***	$7.46 \cdot 10^{-4}$***
MI_{t-4}^{A,V^*}	$2.87 \cdot 10^{-4}$***	–182'415***	7'866	–0.209***	0.020	$2.82 \cdot 10^{-5}$	$8.37 \cdot 10^{-4}$***
MI_{t-5}^{A,V^*}	$2.92 \cdot 10^{-4}$***	–140'956**	22'496	–0.170***	0.018	$-1.56 \cdot 10^{-5}$	$6.81 \cdot 10^{-4}$**
MI_{t-6}^{A,V^*}	$1.67 \cdot 10^{-4}$*	–95'483*	–92'824	–0.119***	0.017	$-3.08 \cdot 10^{-5}$	$2.20 \cdot 10^{-4}$
MI_{t-7}^{A,V^*}	$7.10 \cdot 10^{-5}$	–56'145	4'829	–0.094***	0.022*	$-9.26 \cdot 10^{-7}$	$6.76 \cdot 10^{-4}$***
MI_{t-1}^{B,V^*}	$2.47 \cdot 10^{-4}$***	–368'166***	–48'963	0.063***	–0.500***	$5.50 \cdot 10^{-5}$	$-1.23 \cdot 10^{-3}$***
MI_{t-2}^{B,V^*}	$2.77 \cdot 10^{-4}$***	–194'161***	–58'271	0.063***	–0.339***	$1.16 \cdot 10^{-4}$***	$-1.11 \cdot 10^{-3}$***
MI_{t-3}^{B,V^*}	$1.25 \cdot 10^{-4}$	–164'918***	52'045	0.050***	–0.274***	$1.26 \cdot 10^{-4}$***	$-6.97 \cdot 10^{-4}$**
MI_{t-4}^{B,V^*}	$6.74 \cdot 10^{-5}$	–137'781**	–63'392	0.032**	–0.235***	$1.22 \cdot 10^{-4}$***	$1.17 \cdot 10^{-4}$
MI_{t-5}^{B,V^*}	$-1.13 \cdot 10^{-4}$	–195'232***	–111'983*	0.004	–0.181***	$8.81 \cdot 10^{-5}$**	$-4.42 \cdot 10^{-4}$
MI_{t-6}^{B,V^*}	$5.00 \cdot 10^{-5}$	–164'263***	74'886	0.009	–0.114***	$7.12 \cdot 10^{-5}$*	$7.61 \cdot 10^{-5}$
MI_{t-7}^{B,V^*}	$8.71 \cdot 10^{-5}$	–94'943*	1'796	0.026*	–0.101***	$1.14 \cdot 10^{-5}$	$-3.70 \cdot 10^{-4}$
$LR3_{t-1}$	0.028	$2.05 \cdot 10^7$	$1.99 \cdot 10^7$	10.75**	–3.08	–0.822***	–0.075
$LR3_{t-2}$	0.026	$4.05 \cdot 10^7$*	$2.76 \cdot 10^7$	24.32***	–5.46	–0.684***	0.099
$LR3_{t-3}$	0.004	$2.06 \cdot 10^7$	$4.52 \cdot 10^7$	16.02**	–6.87	–0.576***	0.180
$LR3_{t-4}$	0.018	$2.16 \cdot 10^7$	$3.47 \cdot 10^7$	10.60	–1.88	–0.442***	0.256**
$LR3_{t-5}$	0.016	$2.94 \cdot 10^7$	$3.47 \cdot 10^7$	15.12**	–4.35	–0.320***	0.150
$LR3_{t-6}$	–0.011	$1.87 \cdot 10^7$	$3.28 \cdot 10^7$	9.52*	–4.76	–0.224***	–0.087
$LR3_{t-7}$	–0.053*	$-1.82 \cdot 10^7$	$2.56 \cdot 10^7$	4.41	–8.29*	–0.100***	0.032
r_{t-1}	–0.015***	–1'233'676	–3'012'040	–2.45***	3.78***	–0.003*	–0.022*
r_{t-2}	–0.006	–4'243'341*	–4'284'932	0.42	1.49**	0.001	0.009
r_{t-3}	–0.006	–1'422'456	–1'671'784	–1.12*	1.04	0.003	–0.035***
r_{t-4}	–0.004	–2'060'627	–1'578'842	–0.19	0.53	–0.003*	–0.001
r_{t-5}	0.007*	–6'156'838**	3'163'491	–0.27	–1.03	–0.003*	0.059***
r_{t-6}	0.001	2'627'962	–2'494'487	–0.01	–2.12***	–0.002	0.037***
r_{t-7}	0.012***	3'125'027	546'365	–1.03	0.82	0.002	–0.011
C	0.00	–397.57	–649.85	0.00	0.00	0.00	0.00
$Adj.R^2$	0.34	0.30	0.42	0.20	0.22	0.42	0.02

Table 5.1: Vector autoregressive model of Adecco based on the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

influences dollar depth significantly positively on lags one, two and six. Most of the market impact measures are negatively related to dollar depth which is an intuitive result. When market impact declines the order book becomes thicker and depth rises. On a 1% significance level the effect shows up for the market impact on the ask-side on lag two and on a 10% significance level for the ask-side on lag one and on the bid-side on lag five. The lagged liquidity ratio 3 and the lagged returns show no explanatory power with respect to dollar depth.

The relative spread on lag 1 influences the market impact on the ask-side only slightly negatively. Turnover and market impact on the ask-side are positively related as for turnover and spread. Higher liquidity as measured by turnover is followed by lower liquidity as measured by market impact, but the effect is only significant for lags five to seven. Dollar depth shows only a positive lagged influence on market impact on the ask-side for lag one. Market impact on the bid-side seems to have a large positive effect on market impact on the ask-side: On a significance level of at least 5% the first four lags are able to predict liquidity on the other side of the order book. Lagged liquidity as measured by the liquidity ratio 3 and market impact are also positively correlated. Significant values show up for lags one to three, five and six. Rising stock prices are mostly followed by declining market impacts as lags one and three show.

The relative spread has no predictive power to market impact on the bid-side. Rising turnover influences the market impact on the bid-side positively. The effect seems to be complementary to the relation of lagged turnover and market impact on the ask-side: The first five lags of turnover have an effect on market impact on the bid-side, while the effect on market impact on the ask-side is significant for lags five to seven. There is no effect of lagged dollar depth on market impact on the bid-side. Market impact on the ask-side on lags one to three influences market impact on the bid-side significantly. The lagged liquidity ratio 3 shows almost no predictive power with respect to market impact on the bid-side. While the impact of returns on market impact on the ask-side was mostly negative, it is mostly positive for market impact on the bid-side. Significantly positive values show up for lags one and two while lag six is significantly negative.

The liquidity ratio 3 is positively influenced by the relative spread for all lags. Turnover has only predictive power on lag two; it is also positive. There is no influence of lagged dollar depth on the liquidity ratio 3. Market impact on the ask-side shows for lags one and three a significantly positive relation to the liquidity ratio 3. In contrast to this, significant lags for the effect to market impact on the bid-side on the liquidity ratio 3 are from two to six. The effect of lagged returns to the liquidity ratio 3 is almost zero. It is only slightly significant on lags one, four and five.

A high spread is usually followed by a high return as the relation between relative spread and log returns show. The impact of turnover on returns is mostly negative, and is significant for lags six and seven. There is no impact of dollar depth on returns. The relation of market impact on the ask-side on returns is always positive and significant for almost all lags. In contrast to this, market impact on the bid-side is negatively related to returns; significantly for lags one to three. This means that low liquidity on the ask-side is usually followed by rising stock prices while low liquidity on the bid-side is followed by declining stock prices – an economically intuitive result. Finally, the interrelation of lagged returns on return in time t is ambiguous: It is significantly negative on lags one and three while it is significantly positive on lags five and six.

The adjusted R^2 values vary between 42% for the explanation of the dollar depth and the liquidity ratio 3 and 2% for the regression of returns.

5.4 Results of the VAR model for Baer

Table 5.2 presents the results of the vector autoregressive model of Baer.

As for the Adecco stock, all the liquidity measures of Baer are strongly negatively influenced by its own changes at all lags.

For the Baer stock the relative spread depends significantly positively on turnover for lags three to five and seven. Turnover on other lags yields no prediction for the relative spread. Dollar depth has a significantly positive impact on the relative spread on lags from two to seven, which is a different result compared to the Adecco stock. The first lag of market impact on the ask-side has a slightly positive impact on the relative spread. Lags four and five have a significantly negative impact on the spread. All the lags of market impact on the bid-side have a positive influence on the relative spread. There is significance for lags one and three to six. Lags one to three of the liquidity ratio 3 have a significantly positive influence on the relative spread while the impact of the seventh lag is significantly negative. The lagged returns are mostly negatively related to the relative spread. The impact is significant for lags three, five and six.

Only the relative spread of lag two influences turnover slightly. Lagged dollar depth is positively related to turnover and is significant on lags two, three, five and six. Similar to the Adecco stock, lagged market impact on the ask-side has a negative impact on turnover; significantly for lags one to three. However, market impact on the bid-side is different: Only the coefficient of lag six of market impact on the bid-side is slightly significant. There is no impact of the lagged liquidity ratio 3 and of lagged returns on turnover.

The first two lags of the relative spread influence dollar depth significantly negatively. Therefore, rising depth leads to higher spreads but, in turn, this effects again lower depth. Higher turnover leads to lower depth, sometimes significantly, as the results in table 5.2 show. Of the lagged differences of the market impact measures, only market impact on the ask-side for lag five and market impact on the bid-side for lag four influence dollar depth significantly negatively. The liquidity ratio 3 shows no impact on dollar depth at all. The significant coefficients of lagged returns all show a positive relation to depth, while for Adecco there was no significance.

As for the Adecco stock, the relative spread for Baer influences market impact on the ask-side negatively. The effect is significant for lags one, three, four and six. Lagged turnover and dollar depth are not related to market impact on the ask-side. Lagged market impact on the bid-side has an ambiguous influence on market impact on the ask-side: For the first two lags it is negative and significant while for lags four to seven it is positive and significant. There is almost no impact of the liquidity ratio 3 on market impact on the ask-side. Lagged returns are negatively correlated to market impact on the ask-side. For Baer there is significance for lags two to five and seven.

While the effect of the lagged spreads was negative on the market impact on the ask-side

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.65***	–2'401'633	$-3.47 \cdot 10^{7}$***	–35.45**	314.97***	0.12***	–0.12***
$SrelM_{t-2}$	–0.52***	5'086'341*	$-2.02 \cdot 10^{6}$**	–2.34	336.24***	0.10***	–0.03
$SrelM_{t-3}$	–0.41***	–3'827'538	$-1.10 \cdot 10^{6}$	–61.83***	11.79	0.09***	–0.10**
$SrelM_{t-4}$	–0.33***	–4'760'847	–9'816'197	–58.69***	101.02	0.07***	–0.07*
$SrelM_{t-5}$	–0.24***	–579'185	–774'423	–19.11	180.85*	0.05***	–0.07*
$SrelM_{t-6}$	–0.14***	–983'488	–4'407'978	–29.66*	–5.68	0.02	0.04
$SrelM_{t-7}$	–0.08***	1'347'119	–653'227	1.68	–14.00	0.02**	0.03
V_{t-1}	$-4.01 \cdot 10^{-11}$	–0.75***	–0.054	$-6.06 \cdot 10^{-8}$	$-1.15 \cdot 10^{-7}$	$6.07 \cdot 10^{-11}$	$5.18 \cdot 10^{-11}$
V_{t-2}	$7.25 \cdot 10^{-11}$	–0.61***	–0.104**	$4.69 \cdot 10^{-8}$	$3.32 \cdot 10^{-7}$	$1.03 \cdot 10^{-10}$*	$2.61 \cdot 10^{-11}$
V_{t-3}	$1.54 \cdot 10^{-10}$*	–0.53***	–0.107**	$2.74 \cdot 10^{-8}$	$4.43 \cdot 10^{-7}$	$1.38 \cdot 10^{-10}$**	$8.87 \cdot 10^{-11}$
V_{t-4}	$1.57 \cdot 10^{-10}$*	–0.42***	–0.08*	$8.97 \cdot 10^{-8}$	$9.61 \cdot 10^{-7}$*	$1.18 \cdot 10^{-10}$*	$4.98 \cdot 10^{-11}$
V_{t-5}	$2.55 \cdot 10^{-10}$***	–0.27***	–0.105**	$7.34 \cdot 10^{-8}$	$2.58 \cdot 10^{-7}$	$1.13 \cdot 10^{-10}$*	$-2.40 \cdot 10^{-10}$
V_{t-6}	$1.14 \cdot 10^{-10}$	–0.20***	–0.055	$-1.74 \cdot 10^{-9}$	$1.92 \cdot 10^{-7}$	$1.34 \cdot 10^{-10}$**	$-3.78 \cdot 10^{-10}$*
V_{t-7}	$1.55 \cdot 10^{-10}$**	–0.12***	–0.008	$-4.43 \cdot 10^{-8}$	$-5.06 \cdot 10^{-8}$	$9.29 \cdot 10^{-11}$**	$-3.95 \cdot 10^{-10}$**
$D\$_{t-1}$	$1.84 \cdot 10^{-11}$	0.006	–0.702***	$9.16 \cdot 10^{-9}$	$1.65 \cdot 10^{-7}$	$-6.10 \cdot 10^{-11}$***	$3.56 \cdot 10^{-10}$***
$D\$_{t-2}$	$9.88 \cdot 10^{-11}$***	0.013**	–0.575***	$4.01 \cdot 10^{-8}$	$-1.04 \cdot 10^{-7}$	$-7.12 \cdot 10^{-11}$***	$1.35 \cdot 10^{-10}$*
$D\$_{t-3}$	$9.33 \cdot 10^{-11}$***	0.013**	–0.405***	$2.39 \cdot 10^{-8}$	$-6.58 \cdot 10^{-8}$	$-5.01 \cdot 10^{-11}$**	$1.63 \cdot 10^{-10}$**
$D\$_{t-4}$	$9.83 \cdot 10^{-11}$***	0.010	–0.358***	$2.37 \cdot 10^{-8}$	$2.80 \cdot 10^{-7}$	$-6.74 \cdot 10^{-11}$***	$2.15 \cdot 10^{-10}$***
$D\$_{t-5}$	$9.12 \cdot 10^{-11}$***	0.016***	–0.280***	$-5.33 \cdot 10^{-9}$	$8.15 \cdot 10^{-8}$	$-5.27 \cdot 10^{-11}$**	$1.93 \cdot 10^{-10}$**
$D\$_{t-6}$	$8.63 \cdot 10^{-11}$***	0.010*	–0.202***	$4.40 \cdot 10^{-8}$	$8.50 \cdot 10^{-8}$	$-2.08 \cdot 10^{-11}$	$1.25 \cdot 10^{-10}$*
$D\$_{t-7}$	$4.20 \cdot 10^{-11}$*	0.002	–0.104***	$2.98 \cdot 10^{-8}$	$1.26 \cdot 10^{-7}$	$-2.83 \cdot 10^{-11}$*	$1.48 \cdot 10^{-10}$**
MI_{t-1}^{A,V^*}	$4.01 \cdot 10^{-6}$*	–4'943**	1'187	–0.401***	–0.362***	$1.49 \cdot 10^{-5}$**	$-3.43 \cdot 10^{-5}$
MI_{t-2}^{A,V^*}	$-7.19 \cdot 10^{-6}$	–4'877**	–6'845	–0.375***	–0.209***	$5.07 \cdot 10^{-6}$	$9.09 \cdot 10^{-6}$
MI_{t-3}^{A,V^*}	$-8.65 \cdot 10^{-6}$	–4'544**	–8'719	–0.109***	–0.248***	$-2.16 \cdot 10^{-5}$***	$8.79 \cdot 10^{-5}$***
MI_{t-4}^{A,V^*}	$-2.63 \cdot 10^{-5}$**	–2'868	–9'343	–0.045***	–0.342***	$-1.36 \cdot 10^{-5}$*	$5.47 \cdot 10^{-5}$*
MI_{t-5}^{A,V^*}	$-2.55 \cdot 10^{-5}$**	–635	–12'937**	–0.171***	–0.155**	$-4.47 \cdot 10^{-5}$***	$6.76 \cdot 10^{-5}$**
MI_{t-6}^{A,V^*}	$4.48 \cdot 10^{-6}$	1'599	–2'104	–0.088***	–0.191***	$-2.30 \cdot 10^{-5}$***	$-9.37 \cdot 10^{-6}$
MI_{t-7}^{A,V^*}	$-1.59 \cdot 10^{-5}$	–1'010	3'949	–0.106***	–0.092	$-3.19 \cdot 10^{-5}$***	$8.32 \cdot 10^{-5}$***
MI_{t-1}^{B,V^*}	$8.51 \cdot 10^{-6}$***	–453	–403	–0.010***	–0.615***	$-1.38 \cdot 10^{-7}$	$-2.73 \cdot 10^{-5}$***
MI_{t-2}^{B,V^*}	$1.65 \cdot 10^{-6}$	–585	1'125	–0.008***	–0.678***	$-4.15 \cdot 10^{-7}$	$-1.58 \cdot 10^{-5}$***
MI_{t-3}^{B,V^*}	$7.59 \cdot 10^{-6}$***	–370	–1'801	–0.001	–0.274***	$-1.05 \cdot 10^{-6}$	$-1.11 \cdot 10^{-5}$*
MI_{t-4}^{B,V^*}	$6.43 \cdot 10^{-6}$**	–681	–2'697**	0.016***	–0.292***	$1.55 \cdot 10^{-6}$	$-3.05 \cdot 10^{-5}$***
MI_{t-5}^{B,V^*}	$9.47 \cdot 10^{-6}$***	–700	–252	0.021***	–0.283***	$-2.74 \cdot 10^{-6}$	$-2.07 \cdot 10^{-5}$***
MI_{t-6}^{B,V^*}	$4.76 \cdot 10^{-6}$**	–822*	–476	0.013***	–0.107***	$-2.61 \cdot 10^{-6}$	$-2.98 \cdot 10^{-6}$
MI_{t-7}^{B,V^*}	$1.69 \cdot 10^{-6}$	12	281	0.011***	–0.073***	$-2.58 \cdot 10^{-6}$*	$-4.17 \cdot 10^{-6}$
$LR3_{t-1}$	0.055***	–3'424'323	–3'405'868	3.76	162.76	–0.802***	0.045
$LR3_{t-2}$	0.074***	–4'067'550	5'630'355	–3.30	260.30*	–0.671***	0.045
$LR3_{t-3}$	0.089***	238'646	12'191'050	–19.60	239.18	–0.566***	0.101
$LR3_{t-4}$	0.032	–2'028'177	17'179'725	–54.95*	133.64	–0.440***	0.012
$LR3_{t-5}$	0.023	–1'503'998	8'328'166	–26.92	–89.29	–0.322***	0.022
$LR3_{t-6}$	0.018	–5'478'076	–14'546'619	27.29	7.08	–0.236***	0.016
$LR3_{t-7}$	–0.036**	–4'883'236	944'011	1.67	84.83	–0.131***	0.100**
r_{t-1}	–0.007	–897'918	4'790'081*	4.36	–107.30***	–0.016***	–0.104***
r_{t-2}	0.008	–274'434	–482'820	–19.21***	67.52**	–0.010***	–0.016
r_{t-3}	–0.016***	224'218	–1'359'923	–27.45***	–93.28***	0.002	–0.048***
r_{t-4}	–0.006	28'061	1'746'888	–15.07**	173.26***	0.001	0.018
r_{t-5}	–0.011**	380'678	9'209'289***	–15.53**	–70.72**	–0.004	–0.004
r_{t-6}	–0.014***	220'484	5'362'879**	–3.21	40.46	0.006*	0.010
r_{t-7}	0.005	1'431	2'601'376	–15.88***	72.98**	0.008**	0.007
C	0.00	423.94	–6'192.18	0.00	0.00	0.00	0.00
$Adj.R^2$	0.31	0.37	0.34	0.22	0.42	0.41	0.05

Table 5.2: Vector autoregressive model of Baer with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

it is positive on the market impact on the bid-side. There is significance for lags one, two and five. Turnover shows almost no influence on market impact on the bid-side and the impact of lagged dollar depth cannot be distinguished from zero. Market impact on the ask-side has a significantly negative influence on market impact on the bid-side for lags one to six. This effect was positive for the Adecco stock. The influence of the liquidity ratio 3 on market impact on the bid-side is negligible. The impact of lagged returns on the market impact on the bid-side is difficult to interpret: It is significantly negative for lags one, three and five while it is significantly positive for lags two and seven.

The impact of the lagged relative spread on the liquidity ratio 3 is similar to Adecco and significantly positive on almost all lags. Also, turnover has a positive impact on the liquidity ratio 3, and is significant for lags two to seven. While there was no impact of dollar depth on the liquidity ratio 3 for Adecco, it is clearly negative for Baer. There is significance for lags one to five and seven. Market impact on the ask-side leads to a larger liquidity ratio 3 in the next five minute time space while there is negative significance on lags three to seven. There is almost no influence of the market impact on the bid-side on the liquidity ratio 3. Lagged returns have a negative impact on the liquidity ratio 3; the effect is for Baer more pronounced than for Adecco.

There is a negative and significant influence of lagged spreads on returns on lags one and three to five for the Baer stock. As for Adecco, the influence of lagged turnover on returns only shows up significantly for lags six and seven. The effect is again negative. For Baer the effect of lagged dollar depth on returns is positive and significant on all lags. The effect of the lagged market impact measures on returns shows the same pattern as for Adecco. The significant values are positive for the market impact on the ask-side and negative for the market impact on the bid-side. The liquidity ratio 3 shows significant impact on return on lag seven. Finally, lagged returns show significantly negative impacts on the return in time t on lags one and three.

All the constants of the model are not significantly different from zero. The adjusted R^2 value is lowest for the explanation of the returns with 5% and highest for the market impact on the bid-side with 42%.

5.5 Results of the VAR model for Richemont

The results of the vector autoregressive model for the Richemont stocks are presented in table 5.3. It shows again significantly negative impacts of all liquidity measures on its own changes in time t.

As for the previous stocks, lagged turnovers lead to higher spreads. For Richemont the effect is significant on all lags. On the other hand, smaller dollar depth leads to higher relative spreads with significance for lags one, three, five and seven. The significant lagged impacts of the market impact measures are all positive: For the ask-side related liquidity there is significance for lags one, two, five and seven, while on the bid-side lags one and five to seven are important. The liquidity ratio 3 shows only an impact of lag seven on the relative spread. The return in $t-2$ leads to a smaller relative spread while the return in $t-3$ leads to a higher spread. This result is difficult to justify from an economic point of view.

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.62***	$-1.80\cdot10^{7}$***	–2'544'426**	1.74	–5.42	0.15***	–0.07**
$SrelM_{t-2}$	–0.53***	$-1.99\cdot10^{7}$***	–3'548'365***	2.07	5.13	0.13***	–0.09***
$SrelM_{t-3}$	–0.42***	$-1.32\cdot10^{7}$***	–2'738'683**	2.00	–8.75	0.12***	–0.07*
$SrelM_{t-4}$	–0.35***	$-1.10\cdot10^{7}$**	–1'449'432	–1.37	–23.51**	0.09***	–0.08**
$SrelM_{t-5}$	–0.27***	$-1.50\cdot10^{7}$***	–974'659	–2.83	–15.08	0.08***	–0.11***
$SrelM_{t-6}$	–0.19***	–3'821'619	–394'447	–0.40	18.45*	0.06***	–0.10***
$SrelM_{t-7}$	–0.12***	–4'506'499	–978'574	–0.31	12.60	0.03***	–0.06**
V_{t-1}	$1.61\cdot10^{-10}$***	–0.74***	–0.004	$1.44\cdot10^{-8}$**	$2.74\cdot10^{-8}$	$1.18\cdot10^{-11}$	$-6.70\cdot10^{-11}$
V_{t-2}	$3.15\cdot10^{-10}$***	–0.61***	–0.006	$1.38\cdot10^{-8}$	$1.70\cdot10^{-8}$	$2.79\cdot10^{-11}$	$-1.29\cdot10^{-10}$
V_{t-3}	$3.47\cdot10^{-10}$***	–0.48***	–0.014***	$1.55\cdot10^{-8}$*	$2.59\cdot10^{-8}$	$4.29\cdot10^{-11}$	$-3.94\cdot10^{-11}$
V_{t-4}	$3.93\cdot10^{-10}$***	–0.38***	–0.021***	$1.58\cdot10^{-8}$*	$4.09\cdot10^{-8}$	$1.41\cdot10^{-10}$***	$-1.27\cdot10^{-10}$
V_{t-5}	$2.10\cdot10^{-10}$***	–0.27***	–0.026***	$2.43\cdot10^{-9}$	$2.47\cdot10^{-8}$	$7.61\cdot10^{-11}$**	$9.64\cdot10^{-11}$
V_{t-6}	$2.18\cdot10^{-10}$***	–0.17***	–0.036***	$2.82\cdot10^{-9}$	$1.24\cdot10^{-8}$	$3.75\cdot10^{-11}$	$-4.12\cdot10^{-12}$
V_{t-7}	$9.38\cdot10^{-11}$*	–0.07***	–0.008**	$4.02\cdot10^{-9}$	$1.30\cdot10^{-8}$	$7.41\cdot10^{-12}$	$1.17\cdot10^{-11}$
$D\$_{t-1}$	$-3.30\cdot10^{-10}$**	0.329***	–0.558***	$1.26\cdot10^{-8}$	$1.37\cdot10^{-7}$	$-2.42\cdot10^{-10}$***	$-3.22\cdot10^{-10}$
$D\$_{t-2}$	$-2.07\cdot10^{-10}$	0.285***	–0.438***	$4.02\cdot10^{-8}$	$-2.17\cdot10^{-8}$	$-5.26\cdot10^{-11}$	$-9.67\cdot10^{-11}$
$D\$_{t-3}$	$-3.52\cdot10^{-10}$*	0.289***	–0.325***	$2.90\cdot10^{-8}$	$-3.46\cdot10^{-9}$	$-8.21\cdot10^{-11}$	$-2.19\cdot10^{-10}$
$D\$_{t-4}$	$-2.81\cdot10^{-10}$	0.261***	–0.284***	$1.24\cdot10^{-8}$	$1.12\cdot10^{-7}$	$1.60\cdot10^{-11}$	$2.26\cdot10^{-10}$
$D\$_{t-5}$	$-3.47\cdot10^{-10}$*	0.190***	–0.213***	$1.36\cdot10^{-8}$	$-6.68\cdot10^{-8}$	$1.29\cdot10^{-12}$	$5.62\cdot10^{-10}$
$D\$_{t-6}$	$-2.46\cdot10^{-10}$	0.134***	–0.132***	$-6.80\cdot10^{-9}$	$-6.35\cdot10^{-8}$	$3.41\cdot10^{-11}$	$6.94\cdot10^{-10}$*
$D\$_{t-7}$	$-2.57\cdot10^{-10}$*	0.067*	–0.073***	$-1.03\cdot10^{-8}$	$1.66\cdot10^{-8}$	$8.80\cdot10^{-11}$	$4.89\cdot10^{-10}$
MI_{t-1}^{A,V^*}	$1.83\cdot10^{-4}$**	–62'285***	–7317	–0.401***	0.116*	$9.77\cdot10^{-5}$**	$4.88\cdot10^{-4}$***
MI_{t-2}^{A,V^*}	$4.87\cdot10^{-4}$***	–9'153	–1274	–0.250***	–0.014	$8.70\cdot10^{-5}$*	$5.67\cdot10^{-4}$***
MI_{t-3}^{A,V^*}	$1.45\cdot10^{-4}$	–26'150	–767	–0.261***	–0.065	$6.70\cdot10^{-5}$	$3.75\cdot10^{-4}$*
MI_{t-4}^{A,V^*}	$-9.48\cdot10^{-5}$	7'323	–1611	–0.258***	–0.035	$7.07\cdot10^{-6}$	$-1.03\cdot10^{-4}$
MI_{t-5}^{A,V^*}	$2.84\cdot10^{-4}$***	–27'537	–1555	–0.129***	0.015	$2.32\cdot10^{-5}$	$9.09\cdot10^{-5}$
MI_{t-6}^{A,V^*}	$7.66\cdot10^{-5}$	–847	–6852	–0.127***	–0.036	$-1.68\cdot10^{-6}$	$-1.09\cdot10^{-5}$
MI_{t-7}^{A,V^*}	$2.66\cdot10^{-4}$***	–34'191	–6482	–0.052***	–0.036	$5.02\cdot10^{-5}$	$3.43\cdot10^{-4}$*
MI_{t-1}^{B,V^*}	$4.55\cdot10^{-5}$**	–2'104	–32	–0.005*	–0.465***	$1.81\cdot10^{-5}$**	$-1.09\cdot10^{-4}$***
MI_{t-2}^{B,V^*}	$-3.06\cdot10^{-6}$	2'489	–1430	–0.008***	–0.283***	$1.54\cdot10^{-5}$	$3.59\cdot10^{-5}$
MI_{t-3}^{B,V^*}	$3.40\cdot10^{-5}$	1'469	1634	–0.008***	–0.225***	$1.14\cdot10^{-5}$	$-5.56\cdot10^{-6}$
MI_{t-4}^{B,V^*}	$3.89\cdot10^{-6}$	4'754	–821	–0.010***	–0.035**	$2.12\cdot10^{-5}$**	$-1.32\cdot10^{-4}$***
MI_{t-5}^{B,V^*}	$3.94\cdot10^{-5}$*	2'716	–81	0.008***	–0.101***	$2.02\cdot10^{-5}$**	$2.55\cdot10^{-5}$
MI_{t-6}^{B,V^*}	$8.40\cdot10^{-5}$***	4'812	–977	0.015***	–0.059***	$2.14\cdot10^{-5}$**	$-4.62\cdot10^{-5}$
MI_{t-7}^{B,V^*}	$4.12\cdot10^{-5}$**	5'916	–241	–0.005**	–0.101***	$4.97\cdot10^{-6}$	$-7.66\cdot10^{-5}$**
$LR3_{t-1}$	–0.002	–3'227'039	–3'884'565*	0.98	3.61	–0.870***	–0.118**
$LR3_{t-2}$	–0.038	1'724'013	–3'362'765	5.59	–4.58	–0.746***	–0.112
$LR3_{t-3}$	–0.028	–7'130'493	–5'260'592*	12.73**	24.58	–0.624***	–0.053
$LR3_{t-4}$	–0.033	–5'457'532	–4'988'842	14.51**	49.40*	–0.475***	–0.053
$LR3_{t-5}$	–0.032	$-1.71\cdot10^{7}$*	–3'040'514	8.71	–55.83**	–0.359***	–0.048
$LR3_{t-6}$	–0.037	$-1.32\cdot10^{7}$	–889'675	3.83	–59.60**	–0.220***	–0.010
$LR3_{t-7}$	–0.089***	–6'912'484	–3'77'172	–3.72	–41.42**	–0.111***	0.012
r_{t-1}	–0.002	–377'849	12'510	–0.92	3.42	–0.015***	–0.088***
r_{t-2}	–0.014**	–461'744	–78'286	–2.44***	15.15***	–0.002	–0.087***
r_{t-3}	0.014**	1'761'997	773'379	–3.83***	–0.58	0.007**	–0.027**
r_{t-4}	0.001	–3'367'082**	–531'857	–1.95**	1.49	0.002	–0.039***
r_{t-5}	0.009	2'221'510	93'434	–0.78	5.62	0.001	–0.030***
r_{t-6}	0.008	–927'470	–75'947	–4.02***	5.93	–0.004	0.001
r_{t-7}	0.005	582'708	–349'113	0.74	–2.35	0.001	0.030**
C	0.00	369.10	–67.09	0.00	0.00	0.00	0.00
$Adj.R^2$	0.30	0.38	0.26	0.18	0.22	0.46	0.02

Table 5.3: Vector Autoregressive model of Richemont with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

A lower liquidity in the tightness dimension leads to lower turnover for the Richemont stock. The effect is significant for lags one to five. As for Adecco and Baer, a high lagged dollar depth leads to higher turnover. This time there is significance for all lags. A declining market impact on the ask-side leads to a lower turnover in the next five minute time space. There is no interrelation between market impact on the bid-side and turnover. This result holds for the Richemont stock also in the other direction. Similar to the previous stocks, there is almost no impact of the lagged liquidity ratio 3 on turnover. The impact of return on turnover is only significant for lag four; it is negative.

The lagged relative spread has a negative impact on dollar depth which is significant for lags one to three. Also, rising turnover leads to smaller depth but only for lags larger than two. There is no influence of the market impact measures on dollar depth and, vice versa, dollar depth does not influence the market impact measures. Declining liquidity as measured by the liquidity ratio 3 leads to declining depth with slight significance for lags one and three. The lagged returns have no influence on dollar depth.

Market impact on the ask-side is not influenced by the lagged relative spread. Rising turnover leads to lower liquidity on the ask-side with significance for lags one, three and four. All the lags of market impact on the bid-side have a significant influence on market impact on the ask-side, but with different signs: The effect is negative for lags one to four and seven and positive for lags five and six. A rising liquidity ratio 3 leads to declining liquidity as measured by the market impact on the ask-side on lags two and three. As for the Adecco and the Baer stocks, rising stock prices tend to be followed by smaller market impact on the ask-side with significance for lags two, three, four and six.

A rising relative spread leads to a declining market impact on the bid-side on lag four and a rising one on lag six. Market impact on the ask-side shows only a slight impact on market impact on the bid-side on lag one. The lagged liquidity ratio 3 induces lower market impacts on the bid-side on the lags five to seven while the impact of lag four is slightly positive. Rising stock prices lead to lower liquidity on the bid-side since the impact of lag two for the lagged returns is significantly positive.

Similar to the previous two stocks, all the lags of the relative spread influence the liquidity ratio 3 positively. Higher turnovers lead to larger price moves per trade as the relation of lagged turnover to the liquidity ratio 3 on lags four and five suggests. Rising depth leads to a smaller liquidity ratio 3. The lagged market impact measures suggest a rising liquidity ratio 3 for lags one and two on the ask-side and for lags one and four to six on the bid-side. A rising stock price on lag one leads to a lower liquidity ratio 3, but for lag three the effect is reversed.

Higher spreads lead to lower returns on all lags, similar to Adecco and Baer. Lagged turnovers do not influence returns at all. Dollar depth has only a slight impact on lag six. The lagged market impact on the ask-side leads to higher returns on lags one to three and seven while the lagged market impact on the bid-side is followed by lower returns. Here, significance shows up for lags one, four and seven. The liquidity ratio 3 on lag one leads to lower returns. The impact of lagged returns on the return itself is significantly negative for lags one to five and shows on the other hand positive significance for lag seven.

None of the constants can be distinguished from zero. The adjusted R^2 values range from 46% for the liquidity ratio 3 regression to 2% for the return regression.

5.6 Results of the VAR Model for Ciba

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.66***	$-3.13 \cdot 10^{7***}$	$-2.65 \cdot 10^{7***}$	1.10	10.46***	0.08***	0.12***
$SrelM_{t-2}$	–0.54***	$-1.42 \cdot 10^{7*}$	$-2.62 \cdot 10^{7***}$	4.77	8.64**	0.08***	0.01
$SrelM_{t-3}$	–0.42***	$-1.21 \cdot 10^{7}$	$-2.36 \cdot 10^{7***}$	16.47***	11.17***	0.08***	0.08**
$SrelM_{t-4}$	–0.35***	$-1.70 \cdot 10^{7*}$	$-2.10 \cdot 10^{7***}$	6.30	7.03*	0.06***	0.11**
$SrelM_{t-5}$	–0.27***	–4'165'972	$-1.70 \cdot 10^{7***}$	11.92***	–0.66	0.04***	0.05
$SrelM_{t-6}$	–0.22***	–8'293'192	–7'319'901*	1.99	–2.21	0.01	0.01
$SrelM_{t-7}$	–0.11***	–5'122'207	–3'352'302	3.28	–0.01	0.00	–0.01
V_{t-1}	$3.60 \cdot 10^{-11}$	–0.74***	–0.016**	$-1.14 \cdot 10^{-9}$	$1.01 \cdot 10^{-8*}$	$2.85 \cdot 10^{-12}$	$4.29 \cdot 10^{-11}$
V_{t-2}	$7.39 \cdot 10^{-11**}$	–0.60***	0.003	$9.72 \cdot 10^{-9}$	$2.15 \cdot 10^{-8***}$	$-1.30 \cdot 10^{-11}$	$5.52 \cdot 10^{-11}$
V_{t-3}	$1.10 \cdot 10^{-10**}$	–0.48***	–0.008	$2.08 \cdot 10^{-8***}$	$2.20 \cdot 10^{-8***}$	$-1.29 \cdot 10^{-11}$	$8.29 \cdot 10^{-12}$
V_{t-4}	$6.76 \cdot 10^{-11*}$	–0.38***	0.002	$1.86 \cdot 10^{-8**}$	$2.32 \cdot 10^{-8***}$	$1.76 \cdot 10^{-11}$	$-6.04 \cdot 10^{-11}$
V_{t-5}	$4.28 \cdot 10^{-11}$	–0.31***	–0.014	$1.65 \cdot 10^{-8**}$	$2.17 \cdot 10^{-8***}$	$7.56 \cdot 10^{-12}$	$-4.90 \cdot 10^{-11}$
V_{t-6}	$7.34 \cdot 10^{-12}$	–0.19***	–0.017**	$4.50 \cdot 10^{-9}$	$1.51 \cdot 10^{-8**}$	$2.80 \cdot 10^{-11}$	$3.60 \cdot 10^{-11}$
V_{t-7}	$2.27 \cdot 10^{-11}$	–0.13***	–0.010	$1.11 \cdot 10^{-8*}$	$9.60 \cdot 10^{-10}$	$5.73 \cdot 10^{-12}$	$4.63 \cdot 10^{-11}$
$D\$_{t-1}$	$-6.38 \cdot 10^{-11}$	0.135***	–0.388***	$-2.13 \cdot 10^{-8*}$	$-4.08 \cdot 10^{-8***}$	$6.55 \cdot 10^{-11}$	$-1.35 \cdot 10^{-10}$
$D\$_{t-2}$	$-4.17 \cdot 10^{-11}$	0.136***	–0.216***	$-4.33 \cdot 10^{-8***}$	$-1.55 \cdot 10^{-8}$	$5.31 \cdot 10^{-11}$	$2.17 \cdot 10^{-10}$
$D\$_{t-3}$	$-5.04 \cdot 10^{-12}$	0.204***	–0.159***	$-3.11 \cdot 10^{-8**}$	$-2.50 \cdot 10^{-8*}$	$1.08 \cdot 10^{-10**}$	$1.49 \cdot 10^{-10}$
$D\$_{t-4}$	$-4.96 \cdot 10^{-11}$	0.123***	–0.113***	$-3.25 \cdot 10^{-8**}$	$-1.94 \cdot 10^{-8}$	$1.05 \cdot 10^{-10**}$	$-1.31 \cdot 10^{-10}$
$D\$_{t-5}$	$-2.63 \cdot 10^{-11}$	0.061**	–0.101***	$-1.40 \cdot 10^{-8}$	$1.62 \cdot 10^{-8}$	$4.63 \cdot 10^{-11}$	$-2.71 \cdot 10^{-10*}$
$D\$_{t-6}$	$8.55 \cdot 10^{-12}$	0.053*	–0.090***	$8.56 \cdot 10^{-9}$	$1.45 \cdot 10^{-8}$	$9.12 \cdot 10^{-11*}$	$3.45 \cdot 10^{-11}$
$D\$_{t-7}$	$-3.51 \cdot 10^{-11}$	0.035	–0.059***	$4.51 \cdot 10^{-10}$	$1.08 \cdot 10^{-8}$	$2.02 \cdot 10^{-11}$	$1.46 \cdot 10^{-10}$
MI_{t-1}^{A,V^*}	$1.60 \cdot 10^{-4***}$	–64'887**	–3'247	–0.444***	0.024*	$6.32 \cdot 10^{-5}$	$-2.36 \cdot 10^{-4*}$
MI_{t-2}^{A,V^*}	$9.18 \cdot 10^{-5}$	11'682	9'436	–0.315***	0.035**	$7.85 \cdot 10^{-5}$	$3.35 \cdot 10^{-4**}$
MI_{t-3}^{A,V^*}	$6.06 \cdot 10^{-5}$	–19'693	–5'729	–0.270***	0.039***	$8.29 \cdot 10^{-5}$	$1.69 \cdot 10^{-4}$
MI_{t-4}^{A,V^*}	$2.58 \cdot 10^{-5}$	28'222	–9'596	–0.230***	0.026*	$1.19 \cdot 10^{-4**}$	$-2.04 \cdot 10^{-4}$
MI_{t-5}^{A,V^*}	$-6.94 \cdot 10^{-5}$	–26'556	–8'239	–0.135***	0.047***	$7.59 \cdot 10^{-5}$	$7.18 \cdot 10^{-5}$
MI_{t-6}^{A,V^*}	$1.24 \cdot 10^{-4**}$	–56'325*	–6'750	–0.083***	0.034**	$1.10 \cdot 10^{-4**}$	$9.69 \cdot 10^{-5}$
MI_{t-7}^{A,V^*}	$-5.69 \cdot 10^{-5}$	–46'092	–10'823	–0.065***	0.045***	$-6.64 \cdot 10^{-5}$	$3.03 \cdot 10^{-4**}$
MI_{t-1}^{B,V^*}	$8.70 \cdot 10^{-5}$	–131'427***	–891	0.040***	–0.534***	$8.75 \cdot 10^{-5*}$	$-8.15 \cdot 10^{-5}$
MI_{t-2}^{B,V^*}	$2.12 \cdot 10^{-4***}$	–99'042***	26'855	–0.003	–0.370***	$2.55 \cdot 10^{-4***}$	$-5.28 \cdot 10^{-4***}$
MI_{t-3}^{B,V^*}	$1.35 \cdot 10^{-4*}$	–36'294	5'284	0.051***	–0.297***	$2.22 \cdot 10^{-4***}$	$-3.98 \cdot 10^{-4**}$
MI_{t-4}^{B,V^*}	$1.51 \cdot 10^{-4**}$	–89'584**	25'433	0.017	–0.285***	$9.86 \cdot 10^{-5*}$	$-7.75 \cdot 10^{-4***}$
MI_{t-5}^{B,V^*}	$-1.10 \cdot 10^{-4}$	–73'558**	12'040	0.027*	–0.186***	$7.63 \cdot 10^{-5}$	$-5.91 \cdot 10^{-4***}$
MI_{t-6}^{B,V^*}	$2.04 \cdot 10^{-4***}$	–90'128***	–19'872	–0.008	–0.082***	$9.57 \cdot 10^{-5*}$	$-3.46 \cdot 10^{-4**}$
MI_{t-7}^{B,V^*}	$1.96 \cdot 10^{-5}$	–53'843*	1'284	–0.029**	–0.042***	$3.24 \cdot 10^{-5}$	$-8.27 \cdot 10^{-5}$
$LR3_{t-1}$	0.038**	$-1.99 \cdot 10^{7***}$	2'362'906	–2.41	–1.08	–0.837***	–0.072**
$LR3_{t-2}$	0.062***	$-2.27 \cdot 10^{7**}$	5'841'691	–6.92	–1.51	–0.688***	–0.055
$LR3_{t-3}$	0.043*	$-2.53 \cdot 10^{7**}$	2'714'917	–6.14	2.89	–0.561***	–0.050
$LR3_{t-4}$	0.047**	$-2.43 \cdot 10^{7**}$	5'960'854	–7.69	3.75	–0.438***	0.023
$LR3_{t-5}$	0.051**	$-1.78 \cdot 10^{7*}$	2'623'196	–4.73	1.54	–0.330***	–0.031
$LR3_{t-6}$	0.037*	–7'058'033	3'588'415	–4.67	–3.06	–0.219***	–0.043
$LR3_{t-7}$	0.020	–2'408'402	3'778'859	–0.50	–3.51	–0.111***	–0.005
r_{t-1}	0.005	4'627	1'606'515	–3.61***	3.88***	0.008*	–0.205***
r_{t-2}	–0.010*	–1'969'371	224'315	–0.54	0.09	–0.007	–0.044***
r_{t-3}	–0.003	–2'289'101	–654'230	0.65	2.34*	–0.006	0.005
r_{t-4}	–0.006	1'794'355	–545'853	3.18**	1.96	–0.004	0.029**
r_{t-5}	0.003	–127'035	–159'033	4.67***	0.47	0.000	0.024*
r_{t-6}	–0.008	954'446	616'444	2.82**	–2.65**	0.009**	0.025*
r_{t-7}	–0.005	43'124	–668'546	4.04***	–2.35**	–0.001	0.012
C	0.00	307	–77	0.00	0.00	0.00	0.00
$Adj.R^2$	0.31	0.38	0.16	0.19	0.22	0.42	0.05

Table 5.4: Vector autoregressive model of Ciba with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

Table 5.4 presents the results of the vector autoregressive model for the Ciba stock. The effect of the lagged liquidity measures on themselves in time t is always significant and negative.

For Ciba, rising turnover leads to higher spreads with significance for lags two to four.

Lagged dollar depth, in turn, does not change the relative spread significantly. Declining liquidity as measured by the market impact on the ask-side leads to declining liquidity in the tightness dimension as lags one and six show. The same holds for the market impact on the bid-side for lags two to four and six. The lagged liquidity ratio 3 influences the relative spread more strongly than for the three previously discussed stocks. There is significance for lags one to six. The lagged returns show almost no impact on the relative spread.

Rising spreads lead to lower turnover, which is in line with Baer and Richemont, and is significant for lags one, two and four. A higher liquidity in the depth dimension is followed by a higher turnover as the coefficients for lags one to six of dollar depth show. Rising market impacts lead to lower turnovers. For the ask-side there is significance for lags one and six; for the bid-side the effect is more pronounced and significant for lags one, two and four to seven. Lower liquidity in the resiliency dimension has a negative effect on turnover according to the liquidity ratio 3. This effect was not visible for the three previous stocks, but it is significant for lags one to five. Lagged returns of Ciba do not influence turnover and vice versa.

In line with the previous stocks, higher spreads make depth at the best bid and ask prices decline significantly for lags one to six. Turnover on lags one and six leads to a lower depth. The lagged market impact measures, as well as the liquidity ratio 3 and the returns do not influence dollar depth.

A rising spread leads to higher market impacts with significance for lags three and five on the ask-side and lags one to four on the bid-side of the order book. Also, the relation between lagged turnover and the market impact measures is positive: It is significant for lags three to five and seven on the ask-side and up to lag six on the bid-side. In contrast to the previous stocks, a pronounced relation between the lagged dollar depth and the market impact measures can be observed for Ciba. As economically expected it is negative. There is significance on the ask-side for lags one to four and on the bid-side for lags one and three. A rising market impact on the bid-side is followed by rising market impact on the ask-side on lags one, three and five, while on lag seven it declines significantly. The lagged liquidity ratio 3 has neither an effect on the market impact on the ask-side nor on the market impact on the bid-side. The influence of lagged returns on market impact on the ask-side is ambiguous. Return on lag one leads to a significant decline of market impact on the ask-side, while on lags four to seven it makes market impact on the ask-side rise.

A rising market impact on the ask-side leads to a significantly higher market impact on the bid-side on all lags. This result is entirely different from the Richemont stock. Also, for the market impact on the bid-side the influence of lagged returns is difficult to interpret: There is a significantly positive relation for lags one and three while the effect is negative for lags six and seven.

In line with the previous stocks, a rising spread causes the liquidity ratio 3 to rise as well. There is significance for lags one to five. Lagged turnover does not change the liquidity ratio 3. A rising lagged depth leads to lower liquidity, as measured by the liquidity ratio 3, since the relation is positive and significant for lags three, four and six. This result is different for Ciba with respect to the previous three stocks. The lagged market impact measures are followed by a higher liquidity ratio 3. For the ask-side for lags four and six and for the bid-side for lags one to four and six. Lagged returns are slightly positively related to the liquidity ratio 3 as there is significance for lags one and six.

Higher spreads lead to higher returns for the Ciba stock on lags one, three and four. This result is similar to Adecco but different from Baer and Richemont. There is only a slight influence of lagged depth on returns on lag five. Market impact on the ask-side has mainly a positive influence on returns as the significant coefficients for lags two and seven show. The coefficient of lag one is slightly negative. The lagged market impact on the bid-side of the order book is negatively related to returns since lags two to six are significant. A rising liquidity ratio 3 in $t-1$ leads to a negative return. Finally, the lagged returns of lag one and two are followed by lower returns while lags four to six show significantly positive coefficients.

None of the constants is different from zero. The highest adjusted R^2 shows, again, the liquidity ratio 3 regression, the lowest R^2 is for the return regression with only 5%.

5.7 Results of the VAR Model for Clariant

For the Clariant stock the changes in the liquidity measures depend again on its own lagged changes, as table 5.5 shows. The only exception is the market impact on the bid-side on lag four.

As seen above for Richemont, the lagged turnover of Clariant influences the relative spread on all lags significantly positively. Lagged dollar depth has no impact on the relative spread. Declining liquidity as measured by the market impact measures leads to declining tightness of the order book: There is significance on the ask-side for lags one, two and five to seven while on the bid-side lags two to five are significant. There is a slightly negative influence of the lagged liquidity ratio 3 on the relative spread with lags one and six. Only the return on lag three shows a significantly positive impact on the spread.

The lagged relative spread of Clariant influences turnover negatively, which is in line with the Richemont stock. There is significance for lags one to four, six and seven. Increasing depth leads to a rising turnover with significance on all lags. The lagged market impact measures have almost no impact on turnover and also the influence of lagged turnover on the market impacts is, with slight exceptions, zero. The lagged liquidity ratio 3 shows only a small impact with lag five on turnover. The influence of returns on turnover is positive and significant on the first two lags.

As for the previous stocks, lagged liquidity in the tightness dimension leads to lower depth. For Clariant, it is significant for lags up to six. Rising turnover is followed by lower depth in the order book, since the coefficients are significantly negative for lags three to seven. There is virtually no impact of the market impact measures on dollar depth. The relation holds, also, in the opposite direction. A higher liquidity ratio 3 on lag two leads, for Clariant, to a higher dollar depth and, also, for the lagged returns it is the second coefficient which is slightly positive.

A rising spread on lags two, three and seven leads to a smaller market impact on the ask-side. For the market impact on the bid-side the relative spread has the same effect on lags two to four, six and seven. The lagged market impact on the bid-side leads to smaller market impacts on the ask-side with significance for all lags. The liquidity ratio 3 has only on lag six a significant negative impact on the market impact on the ask-side. Higher returns

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.66***	–7'069'374***	–2'012'339***	0.57	2.00	0.10***	–0.08***
$SrelM_{t-2}$	–0.51***	–5'445'191***	–2'760'742***	–11.94***	–18.45*	0.12***	–0.01
$SrelM_{t-3}$	–0.39***	–4'552'762**	–2'070'278***	–12.89***	–31.49***	0.10***	–0.01
$SrelM_{t-4}$	–0.33***	–5'394'821**	–1'834'441**	–5.63	–39.66***	0.08***	–0.06*
$SrelM_{t-5}$	–0.23***	–3'003'786	–1'358'422*	–6.43	–15.27	0.06***	–0.05
$SrelM_{t-6}$	–0.17***	–4'816'675**	–1'645'523**	–1.42	–32.76***	0.04***	0.05
$SrelM_{t-7}$	–0.11***	–2'960'587*	–447'833	–16.67***	–41.44***	0.03***	0.04
V_{t-1}	$2.44 \cdot 10^{-10}$**	–0.66***	–0.005	$8.13 \cdot 10^{-9}$	$-3.05 \cdot 10^{-8}$	$2.38 \cdot 10^{-11}$	$-2.54 \cdot 10^{-10}$
V_{t-2}	$7.41 \cdot 10^{-10}$***	–0.51***	–0.007	$3.68 \cdot 10^{-8}$	$-6.50 \cdot 10^{-8}$	$6.36 \cdot 10^{-11}$	$-2.07 \cdot 10^{-10}$
V_{t-3}	$5.97 \cdot 10^{-10}$***	–0.42***	–0.010*	$6.16 \cdot 10^{-8}$*	$-3.37 \cdot 10^{-8}$	$6.89 \cdot 10^{-11}$	$3.43 \cdot 10^{-10}$
V_{t-4}	$6.20 \cdot 10^{-10}$***	–0.32***	–0.014**	$4.54 \cdot 10^{-8}$	$-2.84 \cdot 10^{-9}$	$1.36 \cdot 10^{-10}$**	$1.24 \cdot 10^{-10}$
V_{t-5}	$5.09 \cdot 10^{-10}$***	–0.27***	–0.017***	$3.42 \cdot 10^{-8}$	$4.07 \cdot 10^{-8}$	$1.01 \cdot 10^{-10}$	$-8.51 \cdot 10^{-12}$
V_{t-6}	$4.54 \cdot 10^{-10}$***	–0.17***	–0.010*	$2.22 \cdot 10^{-8}$	$1.59 \cdot 10^{-7}$*	$1.11 \cdot 10^{-10}$*	$2.68 \cdot 10^{-10}$
V_{t-7}	$2.82 \cdot 10^{-10}$***	–0.07***	–0.011**	$3.68 \cdot 10^{-8}$	$-1.22 \cdot 10^{-8}$	$8.69 \cdot 10^{-11}$	$2.50 \cdot 10^{-10}$
$D\$_{t-1}$	$-2.22 \cdot 10^{-10}$	0.240***	–0.510***	$-1.16 \cdot 10^{-8}$	$4.87 \cdot 10^{-8}$	$-5.07 \cdot 10^{-11}$	$6.86 \cdot 10^{-11}$
$D\$_{t-2}$	$-4.78 \cdot 10^{-10}$	0.192***	–0.375***	$8.00 \cdot 10^{-8}$	$3.56 \cdot 10^{-8}$	$-6.87 \cdot 10^{-11}$	$-5.01 \cdot 10^{-10}$
$D\$_{t-3}$	$-3.29 \cdot 10^{-10}$	0.203***	–0.272***	$5.57 \cdot 10^{-8}$	$7.64 \cdot 10^{-8}$	$-3.35 \cdot 10^{-10}$**	$-1.01 \cdot 10^{-9}$
$D\$_{t-4}$	$-5.27 \cdot 10^{-10}$	0.152***	–0.219***	$-2.95 \cdot 10^{-8}$	$1.48 \cdot 10^{-7}$	$-1.24 \cdot 10^{-10}$	$-3.11 \cdot 10^{-10}$
$D\$_{t-5}$	$-1.74 \cdot 10^{-10}$	0.120***	–0.168***	$2.41 \cdot 10^{-8}$	$-1.28 \cdot 10^{-7}$	$-2.02 \cdot 10^{-10}$	$-6.48 \cdot 10^{-10}$
$D\$_{t-6}$	$-2.56 \cdot 10^{-10}$	0.106***	–0.099***	$-4.20 \cdot 10^{-10}$	$7.82 \cdot 10^{-8}$	$-2.98 \cdot 10^{-11}$	$-8.55 \cdot 10^{-10}$
$D\$_{t-7}$	$-7.12 \cdot 10^{-11}$	0.133***	–0.041***	$5.65 \cdot 10^{-8}$	$2.86 \cdot 10^{-7}$	$-2.01 \cdot 10^{-10}$	$-1.95 \cdot 10^{-10}$
MI_{t-1}^{A,V^*}	$1.12 \cdot 10^{-4}$**	–7'441	–286	–0.363***	0.101***	$1.47 \cdot 10^{-4}$***	$3.44 \cdot 10^{-4}$***
MI_{t-2}^{A,V^*}	$2.45 \cdot 10^{-4}$***	–11'866*	–749	–0.160***	0.168***	$1.07 \cdot 10^{-4}$***	$7.66 \cdot 10^{-5}$
MI_{t-3}^{A,V^*}	$6.15 \cdot 10^{-6}$	–4'882	–599	–0.159***	0.158***	$7.51 \cdot 10^{-6}$	$2.28 \cdot 10^{-4}$**
MI_{t-4}^{A,V^*}	$-6.20 \cdot 10^{-5}$	3'843	2'067	–0.174***	0.326***	$3.91 \cdot 10^{-5}$	$-1.23 \cdot 10^{-4}$
MI_{t-5}^{A,V^*}	$1.82 \cdot 10^{-4}$***	–2'877	1'203	–0.113***	0.260***	$5.07 \cdot 10^{-5}$*	$-4.88 \cdot 10^{-5}$
MI_{t-6}^{A,V^*}	$1.43 \cdot 10^{-4}$***	2'370	2'487	–0.100***	0.225***	$1.01 \cdot 10^{-5}$	$1.10 \cdot 10^{-5}$
MI_{t-7}^{A,V^*}	$1.38 \cdot 10^{-4}$***	336	4'074*	–0.042***	0.205***	$3.75 \cdot 10^{-5}$	$3.60 \cdot 10^{-4}$***
MI_{t-1}^{B,V^*}	$1.89 \cdot 10^{-5}$	–2'164	–59	–0.010**	–0.584***	$-6.72 \cdot 10^{-6}$	$-7.19 \cdot 10^{-5}$**
MI_{t-2}^{B,V^*}	$4.16 \cdot 10^{-5}$**	411	442	–0.035***	–0.213***	$-1.07 \cdot 10^{-6}$	$-2.06 \cdot 10^{-4}$***
MI_{t-3}^{B,V^*}	$1.05 \cdot 10^{-4}$***	1'401	291	–0.034***	–0.160***	$1.89 \cdot 10^{-5}$*	$-3.00 \cdot 10^{-4}$***
MI_{t-4}^{B,V^*}	$7.40 \cdot 10^{-5}$***	–2'440	552	–0.045***	0.003	$1.91 \cdot 10^{-5}$*	$-2.16 \cdot 10^{-4}$***
MI_{t-5}^{B,V^*}	$8.56 \cdot 10^{-5}$***	450	672	–0.037***	–0.059***	$2.87 \cdot 10^{-5}$***	$-1.06 \cdot 10^{-4}$***
MI_{t-6}^{B,V^*}	$8.45 \cdot 10^{-6}$	–2'332	270	–0.025***	–0.031**	$1.56 \cdot 10^{-5}$	$-7.62 \cdot 10^{-5}$*
MI_{t-7}^{B,V^*}	$-2.06 \cdot 10^{-5}$	–1'997	324	–0.018***	–0.024*	$1.87 \cdot 10^{-6}$	$-7.44 \cdot 10^{-6}$
$LR3_{t-1}$	–0.055**	–4'096'761	1'462'171	5.21	–0.94	–0.869***	0.027
$LR3_{t-2}$	–0.049	–1'562'316	2'970'608**	–1.48	16.60	–0.721***	0.024
$LR3_{t-3}$	–0.012	–4'657'542	2'418'213	–3.34	39.47	–0.565***	–0.024
$LR3_{t-4}$	0.026	–4'323'134	1'165'447	–4.60	37.95	–0.438***	0.107
$LR3_{t-5}$	–0.025	–7'153'495*	1'400'059	–11.72	21.26	–0.350***	0.029
$LR3_{t-6}$	–0.058*	–5'940'254	340'966	–16.21**	–3.02	–0.224***	–0.007
$LR3_{t-7}$	–0.009	–3'380'424	821'043	–4.63	8.73	–0.096***	–0.045
r_{t-1}	–0.003	1'290'733*	349'666	–3.94***	–13.31***	0.005	–0.091***
r_{t-2}	0.001	1'716'914**	499'210*	–0.07	–5.81	–0.002	–0.043***
r_{t-3}	0.013**	–561'119	184'471	–5.62***	–3.92	0.006*	–0.030***
r_{t-4}	–0.003	820'155	–219'762	2.27	25.98***	–0.002	–0.015
r_{t-5}	0.008	–692'771	114'680	–2.84*	4.03	–0.001	0.014
r_{t-6}	0.005	200'210	47'446	–6.29***	3.76	–0.002	–0.009
r_{t-7}	–0.005	–954'783	–215'263	0.81	1.36	–0.005*	0.038***
C	0.00	38.22	8.56	0.00	0.00	0.00	0.00
$Adj.R^2$	0.32	0.32	0.22	0.15	0.30	0.44	0.02

Table 5.5: Vector autoregressive model of Clariant with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

are followed by smaller market impacts on the ask-side with significance for lags one, three, five and six.

The market impact on the bid-side is significantly positively influenced by the lagged market impact on the ask-side for all lags, while the liquidity ratio 3 has no influence at all. Rising returns in lag one are followed by declining market impacts on the bid-side. In contrast to this, the returns of lag four lead to higher market impacts on the bid-side.

Higher relative spreads lead to higher liquidity ratios 3 with significance for all lags. Lagged turnover has only little influence on the liquidity ratio 3 for the Clariant stock on lags four and six. This in contrast to Baer, for example. Higher dollar depth on lag three is followed by a smaller liquidity ratio 3. The significant lagged values of the market impact measures on the ask- and on the bid-side lead to rising liquidity ratios 3. There is significance on the ask-side for lags one, two and five while on the bid-side lags three to five are significant. There is only a slight impact of returns at lags three and seven on the liquidity ratio 3.

The lagged relative spread has a significantly negative impact on returns with lags one and four. Lagged turnover and lagged depth do not influence returns. The market impact on the ask-side leads to higher returns on lags one, three and seven. The market impact on the bid-side is followed by lower returns. There is significance for lags one to six. The lagged liquidity ratio 3 does not influence returns. Finally, rising returns on lags one to three lead to smaller returns in time t while on lag seven the effect is reversed.

The constants of the vector autoregressions are all zero and the adjusted R^2 is again highest for the liquidity ratio 3 regression and lowest for the returns regression.

5.8 Results of the VAR Model for Givaudan

The results of the vector autoregressive model for Givaudan are presented in table 5.6. As for the previous stocks, Givaudan shows significantly negative impacts of the liquidity measures' own lags on the respective liquidity measures in time t.

Rising turnover on lags two and three leads to a rising relative spread. Dollar depth has for the Givaudan stock no influence on the spread. All the significant values of the market impact measures are followed by rising relative spreads. For the market impact on the ask-side there is significance for all lags, for the market impact on the bid-side lags one to four are significant. The lagged liquidity ratio 3 has only a slight impact on the relative spread on lags six and seven. The return on lag three has a negative effect on the spread.

A rising spread leads to a declining turnover. Lags one to four and six show a significantly negative relation of lagged relative spread to turnover. Also, rising depth leads to a rising turnover for lags one and two. Declining liquidity as measured by the market impact measures leads, in general, to a declining turnover. On the ask-side there is significance for lags one to six and on the bid-side for lags one and two. Only the market impact on the bid-side shows a slightly negative impact on returns. The lagged liquidity ratio 3 has no impact at all on turnover. A higher return in time $t-1$ leads to a higher turnover in time t. On the other hand, on lags four, five and seven this interrelation is reversed.

There is no significant impact of lagged relative spread on dollar depth. Neither does lagged turnover influence dollar depth. Market impact on the ask-side shows some positive significance on lag seven for an impact on dollar depth, while the market impact on the bid-

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.65***	$-2.84 \cdot 10^{7}$***	2'907'323	–10.91	–19.58*	0.11***	–0.03
$SrelM_{t-2}$	–0.54***	$-1.76 \cdot 10^{7}$**	$-1.48 \cdot 10^{7}$	–22.68	–13.68	0.14***	–0.03
$SrelM_{t-3}$	–0.43***	$-1.91 \cdot 10^{7}$**	$-1.06 \cdot 10^{7}$	3.06	0.39	0.11***	0.02
$SrelM_{t-4}$	–0.35***	$-1.74 \cdot 10^{7}$*	–8'605'413	–18.03	–13.26	0.08***	0.00
$SrelM_{t-5}$	–0.27***	$-1.39 \cdot 10^{7}$	$-1.48 \cdot 10^{7}$	–10.83	–26.06*	0.07***	0.00
$SrelM_{t-6}$	–0.17***	$-1.64 \cdot 10^{7}$*	–7'615'014	–5.32	–23.50*	0.03***	0.00
$SrelM_{t-7}$	–0.10***	–3'350'232	–8'295'135	–5.78	1.16	0.03***	0.02
V_{t-1}	$3.08 \cdot 10^{-11}$	–0.70***	–0.026	$2.55 \cdot 10^{-8}$	$3.19 \cdot 10^{-8}$	$-1.34 \cdot 10^{-11}$	$-7.53 \cdot 10^{-12}$
V_{t-2}	$8.68 \cdot 10^{-11}$***	–0.56***	0.031	$4.77 \cdot 10^{-8}$*	$1.29 \cdot 10^{-8}$	$4.78 \cdot 10^{-12}$	$-7.44 \cdot 10^{-11}$
V_{t-3}	$7.61 \cdot 10^{-11}$**	–0.43***	–0.008	$8.12 \cdot 10^{-8}$***	$1.09 \cdot 10^{-8}$	$-3.54 \cdot 10^{-11}$*	$-3.91 \cdot 10^{-11}$
V_{t-4}	$4.83 \cdot 10^{-11}$	–0.34***	0.008	$5.63 \cdot 10^{-8}$*	$2.76 \cdot 10^{-9}$	$-1.27 \cdot 10^{-12}$	$4.24 \cdot 10^{-11}$
V_{t-5}	$4.12 \cdot 10^{-11}$	–0.26***	–0.006	$3.92 \cdot 10^{-8}$	$-1.42 \cdot 10^{-9}$	$-1.14 \cdot 10^{-11}$	$2.13 \cdot 10^{-11}$
V_{t-6}	$1.74 \cdot 10^{-11}$	–0.19***	0.009	$1.42 \cdot 10^{-8}$	$2.92 \cdot 10^{-8}$	$5.92 \cdot 10^{-12}$	$-1.59 \cdot 10^{-11}$
V_{t-7}	$2.41 \cdot 10^{-11}$	–0.13***	–0.016	$1.49 \cdot 10^{-8}$	$1.75 \cdot 10^{-8}$	$5.11 \cdot 10^{-12}$	$1.71 \cdot 10^{-11}$
$D\$_{t-1}$	$1.95 \cdot 10^{-11}$	0.036***	–0.426***	$-9.29 \cdot 10^{-9}$	$-2.33 \cdot 10^{-9}$	$-3.84 \cdot 10^{-12}$	$4.88 \cdot 10^{-12}$
$D\$_{t-2}$	$1.63 \cdot 10^{-12}$	0.019**	–0.234***	$-2.12 \cdot 10^{-8}$	$-9.30 \cdot 10^{-9}$	$9.67 \cdot 10^{-12}$	$4.61 \cdot 10^{-11}$
$D\$_{t-3}$	$3.76 \cdot 10^{-12}$	$-4.74 \cdot 10^{-4}$	–0.171***	$-1.84 \cdot 10^{-8}$	$7.39 \cdot 10^{-9}$	$2.95 \cdot 10^{-11}$**	$1.66 \cdot 10^{-12}$
$D\$_{t-4}$	$1.05 \cdot 10^{-11}$	–0.004	–0.152***	$-1.10 \cdot 10^{-8}$	$-1.30 \cdot 10^{-8}$	$3.90 \cdot 10^{-11}$***	$-1.95 \cdot 10^{-11}$
$D\$_{t-5}$	$9.66 \cdot 10^{-12}$	–0.013	–0.058***	$-1.96 \cdot 10^{-8}$	$-5.58 \cdot 10^{-9}$	$1.21 \cdot 10^{-11}$	$-1.95 \cdot 10^{-11}$
$D\$_{t-6}$	$-1.07 \cdot 10^{-11}$	–0.003	–0.061***	$-2.62 \cdot 10^{-8}$	$4.72 \cdot 10^{-9}$	$1.22 \cdot 10^{-11}$	$-1.15 \cdot 10^{-12}$
$D\$_{t-7}$	$-1.26 \cdot 10^{-11}$	$-2.30 \cdot 10^{-4}$	–0.063***	$-2.24 \cdot 10^{-8}$	$3.58 \cdot 10^{-10}$	$-3.69 \cdot 10^{-12}$	$-8.40 \cdot 10^{-12}$
MI_{t-1}^{A,V^*}	$5.80 \cdot 10^{-5}$***	–19'325***	–6'707	–0.434***	0.051***	$8.91 \cdot 10^{-6}$	$5.26 \cdot 10^{-5}$*
MI_{t-2}^{A,V^*}	$8.39 \cdot 10^{-5}$***	–18'047**	–13'903	–0.368***	0.058***	$3.37 \cdot 10^{-6}$	$7.94 \cdot 10^{-5}$***
MI_{t-3}^{A,V^*}	$7.39 \cdot 10^{-5}$***	–24'524***	15'868	–0.276***	0.018	$2.39 \cdot 10^{-5}$**	$2.24 \cdot 10^{-5}$
MI_{t-4}^{A,V^*}	$5.67 \cdot 10^{-5}$***	–20'841**	9'922	–0.241***	0.016	$8.94 \cdot 10^{-6}$	$-4.51 \cdot 10^{-5}$
MI_{t-5}^{A,V^*}	$4.83 \cdot 10^{-5}$***	–15'571*	11'957	–0.192***	0.014	$4.06 \cdot 10^{-6}$	$-1.69 \cdot 10^{-5}$
MI_{t-6}^{A,V^*}	$3.80 \cdot 10^{-5}$***	–15'752**	17'968	–0.125***	0.007	$-1.03 \cdot 10^{-6}$	$1.43 \cdot 10^{-5}$
MI_{t-7}^{A,V^*}	$3.09 \cdot 10^{-5}$**	–10'348	19'196*	–0.057***	–0.013	$-8.41 \cdot 10^{-6}$	$1.85 \cdot 10^{-5}$
MI_{t-1}^{B,V^*}	$4.48 \cdot 10^{-5}$***	–40'929***	4'238	0.023	–0.436***	$1.79 \cdot 10^{-5}$*	$-9.03 \cdot 10^{-5}$***
MI_{t-2}^{B,V^*}	$7.78 \cdot 10^{-5}$***	–20'605**	–7'635	0.088***	–0.261***	$-1.76 \cdot 10^{-6}$	$1.02 \cdot 10^{-5}$
MI_{t-3}^{B,V^*}	$4.07 \cdot 10^{-5}$**	–7'560	13'565	0.069***	–0.249***	$2.74 \cdot 10^{-5}$**	$-7.16 \cdot 10^{-5}$**
MI_{t-4}^{B,V^*}	$3.44 \cdot 10^{-5}$**	–7'177	6'240	0.091***	–0.218***	$3.50 \cdot 10^{-5}$***	$-1.03 \cdot 10^{-4}$***
MI_{t-5}^{B,V^*}	$3.86 \cdot 10^{-6}$	754	835	0.055***	–0.130***	$2.49 \cdot 10^{-5}$**	$-7.83 \cdot 10^{-5}$**
MI_{t-6}^{B,V^*}	$1.06 \cdot 10^{-5}$	5'483	–4'931	–0.023	–0.076***	$3.32 \cdot 10^{-5}$***	$-3.99 \cdot 10^{-5}$
MI_{t-7}^{B,V^*}	$-4.88 \cdot 10^{-6}$	14'899*	5'180	0.009	–0.079***	$1.13 \cdot 10^{-6}$	$-5.90 \cdot 10^{-5}$*
$LR3_{t-1}$	0.016	4'603'852	$-1.67 \cdot 10^{7}$	29.99*	14.74	–0.806***	0.029
$LR3_{t-2}$	0.033	3'630'612	$-1.87 \cdot 10^{7}$	26.29	4.31	–0.693***	0.025
$LR3_{t-3}$	–0.020	–1'605'923	$-2.11 \cdot 10^{7}$	20.59	8.78	–0.577***	0.060
$LR3_{t-4}$	–0.023	1'044'338	$-3.82 \cdot 10^{7}$*	–9.64	0.26	–0.470***	0.024
$LR3_{t-5}$	–0.026	1'272'149	$-4.00 \cdot 10^{7}$**	–12.86	–4.97	–0.342***	–0.021
$LR3_{t-6}$	–0.056**	$-1.01 \cdot 10^{7}$	$-2.16 \cdot 10^{7}$	–40.63*	–27.84	–0.235***	0.017
$LR3_{t-7}$	–0.033*	1'127'015	–455'200	–13.38	1.57	–0.142***	0.017
r_{t-1}	0.001	6'960'275**	–9'653'070*	–22.67***	21.81***	0.008*	–0.197***
r_{t-2}	0.009	4'155'498	–1'679'368	–9.13	5.01	–0.007	–0.087***
r_{t-3}	–0.013**	–5'173'846	979'592	–9.45	0.68	–0.001	–0.072***
r_{t-4}	0.000	$-1.23 \cdot 10^{7}$***	$-1.05 \cdot 10^{7}$*	–9.57	–3.22	–0.010**	–0.028**
r_{t-5}	0.005	–7'012'391**	–4'188'615	–4.94	0.19	–0.005	$-2.95 \cdot 10^{-4}$
r_{t-6}	–0.010	325'132	7'050'196	13.33**	–23.53***	$1.88 \cdot 10^{-4}$	–0.004
r_{t-7}	–0.009	–7'640'510**	–429'148	14.52**	–2.35	$-4.66 \cdot 10^{-4}$	0.014
C	0.00	186.22	–24.43	0.00	0.00	0.00	0.00
$Adj.R^2$	0.30	0.34	0.16	0.19	0.18	0.41	0.05

Table 5.6: Vector autoregressive model of Givaudan with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

side has no influence on dollar depth at all. Declining liquidity as measured by the liquidity ratio 3 leads also to declining liquidity in the depth dimension for lags four and five. The lagged return has only a slightly negative influence on dollar depth with lags one and four.

The market impact on the ask-side is neither influenced by the lagged relative spread nor by lagged dollar depth. Rising market impact on the bid-side leads to a higher market impact on the ask-side on lags two to five. The liquidity ratio 3 has with lag one a slightly positive impact on the market impact on the ask-side, in addition, there is a slightly negative impact of lag six. The rising turnover in lag one makes market impact on the ask-side decline. For lags six and seven, this effect is inverted.

Market impact on the bid-side of the limit order book is slightly negatively influenced by the relative spread on lags one, five and six. Lagged turnover and dollar depth do not have any significant influence on market impact on the bid-side. The first two lags of market impact on the ask-side make market impact on the bid-side rise, while the lagged liquidity ratio 3 has no significant impact at all. The effect of lagged returns on the market impact on the bid-side is almost the opposite of its effect on the ask-side: There is positive significance of lag one and negative significance of lag six.

The relative spread leads to a significantly higher liquidity ratio 3 on all lags. The impact of turnover is only slightly significant for lag three. Rising depth makes the liquidity ratio 3 rise on lags three and four. The third lag of the market impact on the ask-side leads to a higher liquidity ratio 3. For the market impact on the bid-side this relation holds for lags one and three to six. The effect of returns on the liquidity ratio 3 is for lag one slightly positive and for lag four significantly negative.

The relative spread, turnover, dollar depth and the liquidity ratio 3 do not influence returns of Givaudan. Market impact on the ask-side has on lags one and two a significantly positive influence on return. As for the other stocks, so far, the impact of market impact on the bid-side on returns is negative. For the Givaudan stock there is significance for lags one, three to five and seven. Finally, turnover depends negatively on its own lagged realizations with lags one to four.

All the constants of the vector autoregressive model are zero. The adjusted R^2 is highest for the liquidity ratio 3 regression and, with 5%, lowest for the returns regression.

5.9 Results of the VAR Model for Holcim

The vector autoregressive model of the six liquidity measures and the returns for Holcim is presented in table 5.7. It shows, as for the other stocks so far, the significantly negative dependence of the liquidity measures on its own lags.

As for the Richemont and the Clariant stocks, the relative spread depends on all lags of turnover positively. Dollar depth has only a slightly negative effect on lag five on the relative spread. The market impact on the ask-side has a significant influence on lag two on the spread. For the bid-side the significant values show up at lags two to four. The liquidity ratio 3 leads to a rising relative spread as the significant coefficients of lags one to three show. Rising stock prices let the spread decline since the coefficients are significantly negative for lags one and three for the influence of returns on spreads.

Similar to the other stocks so far, a rising spread lets turnover decline with significance for

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.71***	$-2.64 \cdot 10^7$***	$-1.78 \cdot 10^7$***	1.86	–6.89	0.10***	–0.06**
$SrelM_{t-2}$	–0.59***	$-3.17 \cdot 10^7$***	$-1.95 \cdot 10^7$***	28.07***	–5.57	0.12***	–0.10***
$SrelM_{t-3}$	–0.50***	$-1.78 \cdot 10^7$*	$-1.44 \cdot 10^7$***	23.23*	–17.63	0.11***	–0.14***
$SrelM_{t-4}$	–0.41***	$-2.39 \cdot 10^7$**	–9'991'002**	6.92	–10.78	0.09***	–0.08*
$SrelM_{t-5}$	–0.30***	$-1.23 \cdot 10^7$	$-1.03 \cdot 10^7$***	–5.94	–22.10*	0.06***	–0.09**
$SrelM_{t-6}$	–0.22***	–5'316'281	–4'480'681	–16.51	–1.12	0.03***	0.01
$SrelM_{t-7}$	–0.14***	899'583	–2'172'127	–16.00	8.55	0.02***	–0.03
V_{t-1}	$6.43 \cdot 10^{-11}$***	–0.68***	–0.005	$1.65 \cdot 10^{-8}$	$3.10 \cdot 10^{-8}$**	$3.54 \cdot 10^{-11}$***	$-3.03 \cdot 10^{-11}$
V_{t-2}	$1.01 \cdot 10^{-10}$***	–0.57***	0.005	$4.70 \cdot 10^{-8}$**	$3.70 \cdot 10^{-8}$**	$3.87 \cdot 10^{-11}$**	$-1.39 \cdot 10^{-11}$
V_{t-3}	$8.03 \cdot 10^{-11}$***	–0.47***	–0.011	$5.07 \cdot 10^{-8}$**	$3.14 \cdot 10^{-8}$	$3.22 \cdot 10^{-11}$*	$1.01 \cdot 10^{-12}$
V_{t-4}	$1.01 \cdot 10^{-10}$***	–0.31***	–0.006	$4.56 \cdot 10^{-8}$*	$4.30 \cdot 10^{-8}$**	$2.67 \cdot 10^{-11}$	$7.35 \cdot 10^{-12}$
V_{t-5}	$6.59 \cdot 10^{-11}$**	–0.25***	–0.009	$4.61 \cdot 10^{-8}$*	$2.28 \cdot 10^{-8}$	$2.17 \cdot 10^{-11}$	$3.55 \cdot 10^{-11}$
V_{t-6}	$8.52 \cdot 10^{-11}$***	–0.17***	–0.003	$3.06 \cdot 10^{-8}$	$2.74 \cdot 10^{-8}$	$2.69 \cdot 10^{-11}$*	$4.70 \cdot 10^{-12}$
V_{t-7}	$7.15 \cdot 10^{-11}$***	–0.09***	–0.006	$3.02 \cdot 10^{-8}$	$3.08 \cdot 10^{-8}$**	$1.55 \cdot 10^{-11}$	$2.26 \cdot 10^{-11}$
$D\$_{t-1}$	$-8.61 \cdot 10^{-11}$	0.194***	–0.422***	$-5.18 \cdot 10^{-8}$	$4.65 \cdot 10^{-8}$	$1.67 \cdot 10^{-11}$	$1.60 \cdot 10^{-10}$
$D\$_{t-2}$	$-7.35 \cdot 10^{-11}$	0.235***	–0.293***	$-1.69 \cdot 10^{-8}$	$-5.76 \cdot 10^{-8}$	$1.80 \cdot 10^{-11}$	$1.29 \cdot 10^{-10}$
$D\$_{t-3}$	$-9.03 \cdot 10^{-11}$	0.146***	–0.245***	$-9.34 \cdot 10^{-9}$	$1.49 \cdot 10^{-8}$	$-2.21 \cdot 10^{-11}$	$4.59 \cdot 10^{-11}$
$D\$_{t-4}$	$-8.91 \cdot 10^{-11}$	0.095***	–0.172***	$-1.70 \cdot 10^{-8}$	$-1.05 \cdot 10^{-8}$	$-5.35 \cdot 10^{-12}$	$5.02 \cdot 10^{-11}$
$D\$_{t-5}$	$-1.67 \cdot 10^{-10}$**	0.175***	–0.104***	$-3.83 \cdot 10^{-8}$	$-3.22 \cdot 10^{-8}$	$5.31 \cdot 10^{-11}$	$1.38 \cdot 10^{-10}$
$D\$_{t-6}$	$-3.81 \cdot 10^{-11}$	0.032	–0.097***	$-4.88 \cdot 10^{-8}$	$-5.87 \cdot 10^{-8}$	$2.78 \cdot 10^{-11}$	$-4.95 \cdot 10^{-11}$
$D\$_{t-7}$	$-9.35 \cdot 10^{-11}$	–0.071**	–0.044***	$-6.07 \cdot 10^{-8}$	$-5.47 \cdot 10^{-8}$	$-1.44 \cdot 10^{-11}$	$1.00 \cdot 10^{-10}$
MI_{t-1}^{A,V^*}	$1.15 \cdot 10^{-5}$	–25'981***	–6'991*	–0.430***	0.020*	$2.69 \cdot 10^{-5}$***	$2.86 \cdot 10^{-6}$
MI_{t-2}^{A,V^*}	$4.33 \cdot 10^{-5}$**	–19'154**	–3'132	–0.311***	0.027**	$5.45 \cdot 10^{-5}$***	$7.85 \cdot 10^{-5}$**
MI_{t-3}^{A,V^*}	$1.12 \cdot 10^{-5}$	–12'967	–1'991	–0.251***	0.010	$2.34 \cdot 10^{-5}$**	$1.34 \cdot 10^{-4}$***
MI_{t-4}^{A,V^*}	$-6.76 \cdot 10^{-6}$	–15'694	–3'094	–0.168***	0.002	$2.03 \cdot 10^{-5}$**	$6.80 \cdot 10^{-5}$*
MI_{t-5}^{A,V^*}	$1.14 \cdot 10^{-5}$	–13'884	–370	–0.156***	–0.004	$1.79 \cdot 10^{-5}$*	$1.55 \cdot 10^{-4}$***
MI_{t-6}^{A,V^*}	$1.52 \cdot 10^{-5}$	–12'157	–4'358	–0.115***	0.010	$2.18 \cdot 10^{-5}$**	$7.84 \cdot 10^{-5}$*
MI_{t-7}^{A,V^*}	$-1.15 \cdot 10^{-5}$	–25'184***	149	–0.054***	–0.006	$5.43 \cdot 10^{-6}$	$8.55 \cdot 10^{-5}$*
MI_{t-1}^{B,V^*}	$9.82 \cdot 10^{-6}$	–47'544***	467	0.023	–0.449***	$4.49 \cdot 10^{-5}$***	$-3.07 \cdot 10^{-5}$
MI_{t-2}^{B,V^*}	$8.59 \cdot 10^{-5}$***	–28'267**	–1'934	0.014	–0.342***	$4.53 \cdot 10^{-5}$***	$-9.02 \cdot 10^{-6}$
MI_{t-3}^{B,V^*}	$7.93 \cdot 10^{-5}$***	–27'561**	–2'597	0.025	–0.209***	$2.73 \cdot 10^{-5}$**	$-6.97 \cdot 10^{-5}$
MI_{t-4}^{B,V^*}	$4.64 \cdot 10^{-5}$**	–7'423	2'884	–0.002	–0.184***	$2.98 \cdot 10^{-5}$**	$-1.01 \cdot 10^{-4}$**
MI_{t-5}^{B,V^*}	$-3.87 \cdot 10^{-6}$	12'434	1'635	0.013	–0.157***	$2.24 \cdot 10^{-5}$*	$-2.78 \cdot 10^{-5}$
MI_{t-6}^{B,V^*}	$-2.46 \cdot 10^{-6}$	–154	2'258	0.014	–0.118***	$1.40 \cdot 10^{-5}$	$-1.02 \cdot 10^{-4}$**
MI_{t-7}^{B,V^*}	$-2.85 \cdot 10^{-5}$	–14'435	1'717	–0.011	–0.063***	$-1.38 \cdot 10^{-6}$	$1.77 \cdot 10^{-6}$
$LR3_{t-1}$	0.088***	$1.62 \cdot 10^7$	2'930'593	4.88	–6.47	–0.857***	–0.012
$LR3_{t-2}$	0.075***	$1.43 \cdot 10^7$	691'185	–32.27	22.89	–0.716***	0.014
$LR3_{t-3}$	0.072**	662'465	–418'773	–14.77	41.14**	–0.613***	–0.008
$LR3_{t-4}$	0.050	991'834	–1'714'004	–0.88	48.08**	–0.514***	0.036
$LR3_{t-5}$	0.014	5'170'802	–3'329'099	25.75	14.30	–0.365***	0.026
$LR3_{t-6}$	0.024	–8'842'102	–4'822'882	33.61	2.35	–0.239***	0.066
$LR3_{t-7}$	–0.023	–8'488'475	–4'795'353	–5.41	10.72	–0.134***	–0.015
r_{t-1}	–0.017***	3'169'054	–2'479'149*	–9.86**	24.65***	–0.003	–0.168***
r_{t-2}	–0.009	–2'132'963	–142'965	–10.80**	10.07**	–0.002	–0.067***
r_{t-3}	–0.015**	1'489'101	911'206	–18.44***	16.24***	0.001	–0.042***
r_{t-4}	–0.009	5'607'410*	–430'241	–3.47	–2.35	0.001	–0.041***
r_{t-5}	0.002	–551'572	382'552	–2.86	12.05***	–0.001	0.024*
r_{t-6}	0.001	–2'427'816	–677'678	–6.17	–3.64	0.001	–0.009
r_{t-7}	0.009	–398'041	–169'139	9.53**	0.34	$-1.52 \cdot 10^{-4}$	0.031**
C	0.00	–209.59	–462.88	0.00	0.00	0.00	0.00*
$Adj.R^2$	0.34	0.34	0.17	0.17	0.19	0.43	0.04

Table 5.7: Vector autoregressive model of Holcim with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

lags one to four. Rising depth leads in general to a higher turnover. A rising market impact is related to lower turnover with significance for lags one, two and seven on the ask-side and one to three on the bid-side. The lagged liquidity ratio 3 does not influence turnover and the stock price has only a very slight positive impact on turnover.

Declining liquidity in the tightness dimension of the order book leads to declining depth. There is significance for lags one to five. On the other hand, there is no impact of turnover on depth. Market impact on the ask-side has only a slightly significant effect on depth with lag one while market impact on the bid-side shows no significance at all. Also the opposite holds: Dollar depth does not influence market impact on the bid-side on any lag. The lagged liquidity ratio 3 has no impact on dollar depth and vice versa. A rising stock price leads to lower dollar depth but this effect shows up only at lag one with significance on the 10% level.

A higher relative spread leads to a significantly higher market impact on the ask-side on lags two and three. Also rising turnover is related to a higher market impact on the ask-side with significance for lags two to five. Lagged dollar depth, lagged market impact on the bid-side and the lagged liquidity ratio 3 do not have any impact on the market impact on the ask-side. For the first three lags, rising stock prices lead to a lower market impact on the ask-side. On lag seven, the effect is positive.

There is only a slightly negative relation of the relative spread to the market impact on the bid-side on lag five. Also, rising turnover leads to higher market impacts on the bid-side, with significance for lags one, two, four and seven. The market impact on the ask-side makes the market impact on the bid-side rise on the first two lags. While the liquidity ratio 3 had no impact on the market impact on the ask-side, it makes the market impact on the bid-side rise significantly on lags three and four. Lagged returns lead to a higher market impact on the bid-side on lags one to three and five.

As for the previous stocks, a rising spread makes the liquidity ratio 3 rise as well with significance on all lags. Also, the turnover leads to a higher liquidity ratio three with significance on the lags one to three and six. The lagged market impact on the ask-side, as well as on the bid-side, is related to a higher liquidity ratio 3. For the ask-side lags up to six and for the bid-side up to five are significant. Price changes do not influence the liquidity ratio 3 and also in the other direction there is no significant connection.

Higher relative spreads lead to lower returns. There is significance for lags one to five. Turnover and dollar depth have no significant impact on returns. The market impact on the ask-side is followed by rising stock prices with significance for lags two to seven. The market impact on the bid-side has a significantly negative impact on lags four and six . Finally, the first four lagged returns make stock prices in time t decline while on lag seven it leads to higher stock prices.

In contrast to the previous stocks so far, the constant for the return regression is not zero on the 10% significance level; it is slightly negative. The other constants cannot be distinguished from zero. The liquidity ratio 3 regression shows with 43% the highest adjusted R^2 while the lowest R^2 is for the return regression.

5.10 Results of the VAR Model for Kudelski

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.71***	–3'426'882***	–1'000'033*	2.79	–0.39	0.11***	–0.12***
$SrelM_{t-2}$	–0.58***	–3'700'027**	–933'837	–4.29	–0.08	0.11***	–0.15***
$SrelM_{t-3}$	–0.46***	–3'483'009**	–478'658	–8.81**	0.21	0.08***	–0.15***
$SrelM_{t-4}$	–0.36***	–3'379'538**	664'385	–11.60***	1.48	0.07***	–0.18***
$SrelM_{t-5}$	–0.28***	–2'553'724	1'025'428	–4.06	–0.56	0.05***	–0.17***
$SrelM_{t-6}$	–0.21***	–3'222'954**	985'065	–0.53	–1.66	0.04***	–0.06
$SrelM_{t-7}$	–0.12***	–2'165'798*	851'664	–7.53***	0.57	0.03***	–0.08**
V_{t-1}	$1.17 \cdot 10^{-10}$	–0.66***	–0.007	$1.54 \cdot 10^{-9}$	$-1.52 \cdot 10^{-8}$	$1.07 \cdot 10^{-10}$	$1.08 \cdot 10^{-10}$
V_{t-2}	$-9.18 \cdot 10^{-11}$	–0.53***	–0.009	$1.64 \cdot 10^{-8}$	$8.11 \cdot 10^{-9}$	$1.39 \cdot 10^{-10}$*	$3.22 \cdot 10^{-10}$
V_{t-3}	$3.39 \cdot 10^{-10}$*	–0.39***	–0.013*	$4.08 \cdot 10^{-8}$	$6.50 \cdot 10^{-8}$**	$1.39 \cdot 10^{-10}$	$8.75 \cdot 10^{-11}$
V_{t-4}	$2.82 \cdot 10^{-10}$	–0.27***	–0.012*	$4.83 \cdot 10^{-8}$	$5.85 \cdot 10^{-8}$**	$1.56 \cdot 10^{-10}$*	$-6.04 \cdot 10^{-10}$
V_{t-5}	$5.08 \cdot 10^{-10}$***	–0.18***	–0.011	$6.20 \cdot 10^{-8}$*	$5.57 \cdot 10^{-8}$**	$3.33 \cdot 10^{-10}$***	$-3.62 \cdot 10^{-10}$
V_{t-6}	$5.44 \cdot 10^{-10}$***	–0.11***	–0.010	$-5.20 \cdot 10^{-9}$	$3.07 \cdot 10^{-8}$	$2.40 \cdot 10^{-10}$***	$5.31 \cdot 10^{-11}$
V_{t-7}	$3.36 \cdot 10^{-10}$**	–0.08***	–0.009*	$4.30 \cdot 10^{-8}$	$4.32 \cdot 10^{-8}$**	$6.87 \cdot 10^{-11}$	$2.28 \cdot 10^{-10}$
$D\$_{t-1}$	$-2.64 \cdot 10^{-10}$	0.118***	–0.534***	$7.78 \cdot 10^{-8}$	$-2.11 \cdot 10^{-9}$	$1.92 \cdot 10^{-12}$	$-2.35 \cdot 10^{-10}$
$D\$_{t-2}$	$-4.71 \cdot 10^{-10}$	0.146***	–0.499***	$1.34 \cdot 10^{-7}$*	$1.35 \cdot 10^{-8}$	$-2.59 \cdot 10^{-10}$	$-8.66 \cdot 10^{-10}$
$D\$_{t-3}$	$-3.85 \cdot 10^{-10}$	0.081**	–0.283***	$-3.87 \cdot 10^{-8}$	$4.20 \cdot 10^{-9}$	$-2.49 \cdot 10^{-10}$	$-3.97 \cdot 10^{-11}$
$D\$_{t-4}$	$-1.99 \cdot 10^{-10}$	0.149***	–0.215***	$1.04 \cdot 10^{-8}$	$7.36 \cdot 10^{-9}$	$-1.96 \cdot 10^{-10}$	$-1.28 \cdot 10^{-10}$
$D\$_{t-5}$	$-3.95 \cdot 10^{-10}$	0.069**	–0.343***	$-6.98 \cdot 10^{-8}$	$4.34 \cdot 10^{-8}$	$-1.59 \cdot 10^{-10}$	$-2.52 \cdot 10^{-10}$
$D\$_{t-6}$	$-3.45 \cdot 10^{-10}$	0.060*	–0.078***	$-1.55 \cdot 10^{-8}$	$2.67 \cdot 10^{-8}$	$-6.62 \cdot 10^{-11}$	$4.09 \cdot 10^{-10}$
$D\$_{t-7}$	$-1.17 \cdot 10^{-10}$	0.017	–0.053***	$1.12 \cdot 10^{-8}$	$-2.24 \cdot 10^{-8}$	$1.17 \cdot 10^{-11}$	$-5.75 \cdot 10^{-10}$
MI_{t-1}^{A,V^*}	$4.09 \cdot 10^{-4}$***	–35'628***	3'436	–0.288***	0.018*	$2.25 \cdot 10^{-4}$***	$5.10 \cdot 10^{-4}$***
MI_{t-2}^{A,V^*}	$3.04 \cdot 10^{-4}$***	–18'633***	–7'108**	–0.150***	0.012	$1.71 \cdot 10^{-4}$***	$3.61 \cdot 10^{-4}$**
MI_{t-3}^{A,V^*}	$2.09 \cdot 10^{-4}$***	–18'903***	–1'735	–0.127***	0.012	$6.23 \cdot 10^{-5}$*	$7.23 \cdot 10^{-4}$***
MI_{t-4}^{A,V^*}	$1.87 \cdot 10^{-4}$***	–5'714	–3'707	–0.107***	0.020*	$7.00 \cdot 10^{-5}$**	$5.06 \cdot 10^{-4}$***
MI_{t-5}^{A,V^*}	$4.28 \cdot 10^{-5}$	–15'151**	–3'526	–0.118***	0.025**	$2.83 \cdot 10^{-5}$	$2.69 \cdot 10^{-4}$
MI_{t-6}^{A,V^*}	$1.05 \cdot 10^{-4}$	–5'452	326	–0.081***	0.035***	$6.83 \cdot 10^{-5}$**	$-2.14 \cdot 10^{-4}$
MI_{t-7}^{A,V^*}	$1.31 \cdot 10^{-4}$**	–8'383	–801	–0.071***	0.005	$-2.81 \cdot 10^{-5}$	$-1.36 \cdot 10^{-4}$
MI_{t-1}^{B,V^*}	$1.91 \cdot 10^{-4}$**	–47'567***	–3'802	–0.054***	–0.357***	$1.47 \cdot 10^{-4}$***	$-6.13 \cdot 10^{-4}$***
MI_{t-2}^{B,V^*}	$1.87 \cdot 10^{-4}$**	–24'113***	–7'198**	–0.025	–0.196***	$1.22 \cdot 10^{-4}$***	$-3.72 \cdot 10^{-4}$
MI_{t-3}^{B,V^*}	$2.71 \cdot 10^{-4}$***	–30'737***	1'179	–0.035**	–0.148***	$1.32 \cdot 10^{-4}$***	$-8.62 \cdot 10^{-4}$***
MI_{t-4}^{B,V^*}	$2.98 \cdot 10^{-5}$	–11'758	–3'517	–0.002	–0.135***	$1.10 \cdot 10^{-4}$**	$-1.64 \cdot 10^{-4}$
MI_{t-5}^{B,V^*}	$-1.39 \cdot 10^{-4}$	–23'959***	–3'226	–0.023	–0.112***	$7.63 \cdot 10^{-5}$*	$-8.16 \cdot 10^{-4}$***
MI_{t-6}^{B,V^*}	$-2.20 \cdot 10^{-4}$**	–12'407	–3'259	–0.001	–0.086***	$4.39 \cdot 10^{-5}$	$-6.08 \cdot 10^{-4}$**
MI_{t-7}^{B,V^*}	$1.19 \cdot 10^{-4}$	–3'038	–1'028	–0.011	–0.029**	$1.51 \cdot 10^{-4}$***	$-2.90 \cdot 10^{-4}$
$LR3_{t-1}$	0.095***	–3'254'162	–622'610	–1.03	–4.25	–0.795***	0.156**
$LR3_{t-2}$	0.095***	–6'974'192**	583'841	5.19	–0.14	–0.631***	0.239***
$LR3_{t-3}$	0.096***	–6'481'489*	–774'634	14.48**	–1.98	–0.523***	0.256***
$LR3_{t-4}$	0.043	–6'158'112*	–1'728'839	11.39	–9.73*	–0.422***	0.416***
$LR3_{t-5}$	0.028	–6'827'555**	–1'945'646	12.40*	–12.14**	–0.292***	0.389***
$LR3_{t-6}$	–0.025	–5'326'712*	–1'471'172	6.00	–3.43	–0.221***	0.288***
$LR3_{t-7}$	–0.015	–2'743'259	–1'152'491	–5.65	–1.97	–0.099***	0.226***
r_{t-1}	–0.002	663'488	–92'760	–4.40***	3.41***	–0.006***	–0.088***
r_{t-2}	–0.001	–551'511	–101'863	–3.67***	2.35***	–0.004*	–0.034***
r_{t-3}	–0.011**	–883'634**	–221'907	–2.39**	0.57	–0.003	–0.012
r_{t-4}	–0.008*	802'978*	29'840	–2.96**	0.74	–0.004	–0.011
r_{t-5}	0.005	–220'587	–258'148	0.87	0.68	0.004	–0.010
r_{t-6}	–0.005	543'601	211'689	–2.59***	1.63**	$1.60cdot10^{-5}$	–0.017
r_{t-7}	0.009*	–182'194	184'386	–1.72*	–0.15	$1.17cdot10^{-5}$	0.002
C	0.00	–74.90	–43.43	0.00	0.00	0.00	0.00
$Adj.R^2$	0.34	0.33	0.31	0.10	0.12	0.40	0.02

Table 5.8: Vector autoregressive model of Kudelski with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

Table 5.8 presents the results of the vector autoregressive model for the Kudelski stock. The liquidity measures all show a significantly negative impact of the lagged realizations on the value in time t. The return regression for the first two lags also has this significantly negative impact.

The interrelation of lagged turnover and the relative spread is positive but only significant for lags three and five to seven. Lagged dollar depth does not influence the relative spread, and the opposite regression of dollar depth on lagged spreads shows a slightly negative significance at lag one. The relative spread is positively influenced by the market impact on the ask-side on lags one to four and seven. For lags up to three the market impact on the bid-side has a positive impact on the relative spread. Also the coefficient of lag six is negative and significant. As for the Holcim stock, Kudelski shows a significantly positive impact of the first three lagged liquidity ratios 3 on the relative spread. The impact of lagged returns on the relative spread is negative and significant for lags three and four. There is a slightly positive impact of the coefficient at lag seven.

Rising spreads lead to smaller turnovers with significance on all lags, with exception of lag five which cannot be distinguished from zero. Dollar depth of lags up to six is followed by rising turnover. The market impact measures let turnover decline with significance for lags one to three and five. Also, declining liquidity, as measured by the liquidity ratio 3, leads to a declining turnover. There is significance for lags two to six. The impact of returns on turnover is ambiguous: return in $t-3$ has a significantly negative impact on turnover while on lag four the connection is positive and significant on the 10% level.

Dollar depth is slightly negatively influenced by turnovers of lags three, four and seven. The market impact measures (both on lag two) have a negative impact on dollar depth. The lagged liquidity ratios 3 and the lagged returns do not influence dollar depth. The opposite also holds: Lagged dollar depth does not significantly change the liquidity ratio 3 and returns.

The lagged relative spread is followed by a declining market impact on the ask-side. The significantly negative coefficients show up at lags three, four and seven. Turnover and depth lead to positive changes of the market impact on the ask-side with only slight significance on lags five and two. The significant coefficients of market impact on the bid-side have a negative effect on market impact on the ask-side. Lags three and five of the liquidity ratio 3 lead to a rise in the market impact on the ask-side. Almost all lagged returns significantly reduce the market impact on the ask-side.

Market impact on the bid-side is not changed by the lagged relative spread. As for the ask-side, turnover leads to a rising market impact on the bid-side, since the coefficients of lags three to five and seven are significantly different from zero. Dollar depth has no influence on market impact on the ask-side. The market impact on the ask-side of the order book leads to a declining market impact on the bid-side as lags one and four to six show. The impact of the liquidity ratio 3 with respect to the market impact on the bid-side is negative for Kudelski on lags four and five. The lagged returns lead to higher market impacts on the bid-side, as expected, with significance on lags one, two and six.

The liquidity ratio 3 is significantly positively influenced by the relative spread on all lags. Turnover leads to a higher liquidity ratio 3 on lags two and four to six. Market impact on the ask-side and market impact on the bid-side lead both to a higher liquidity ratio 3 with significance for almost all lags. Declining stock prices of lags one and two are followed by a rising liquidity ratio 3.

Almost all lags of the relative spread lead to lower stock prices, while lagged turnover does not influence returns. The significant market impact on the ask-side coefficients are followed by higher returns, while the market impact on the bid-side leads to smaller returns. In contrast to the other stocks so far, all the lagged coefficients of the liquidity ratio 3 are significantly positive.

None of the constants of the model is significantly different from zero and the adjusted R^2-values are in the range of the previous stocks.

5.11 Results of the VAR Model for Lonza

Table 5.9 presents the results of the vector autoregressive model for Lonza. Also for this stock, the liquidity measures depend on all their own lags significantly negatively.

Rising turnover of lags up to six lead to larger relative spreads. Lagged dollar depth does not influence the relative spread. The influence of lagged market impacts on the ask-side on returns is ambiguous: for lags one and two it is significantly positive while for lags five to seven it is significantly negative. The market impact on the bid-side is followed on lags two, four and five by a rising relative spread. The liquidity ratio 3 has a positive impact on the relative spread. The first two lags are significant. Rising stock prices in $t-1$ and $t-2$ lead to a rising relative spread. On lags four and seven the impact is significantly negative.

The relative spread on lags up to three makes turnover decline. Rising dollar depth leads to higher turnover with significance for all lags. The influence of the market impact measures on turnover is negative, but only lags one and two on the ask-side and lag seven on the bid-side are significantly different from zero. The lagged liquidity ratio 3 does not change turnover significantly and, also, in the other direction from lagged turnovers to the liquidity ratio 3 no interrelation is found. Lagged returns on lag three and seven lead to significantly lower turnovers.

A rising spread of lags up to six leads to a significantly lower dollar depth. Lagged turnover does not influence dollar depth. For the market impact measures there is no connection to dollar depth and, also, the opposite holds: lagged dollar depth does not influence the market impact measures. The lagged liquidity ratio 3 and lagged return do not have any impact on dollar depth. Again, dollar depth neither influences the liquidity ratio 3 nor the return.

The market impact on the ask-side is positively influenced by the lagged relative spread. Almost all coefficients are significant. Turnover does not influence the market impact measures, neither on the bid- nor on the ask-side. The market impact on the bid-side leads to a higher market impact on the ask-side with significance for lags four and five. This in contrast to the Kudelski stock, for example. The lagged liquidity ratio 3 in time $t-1$ and $t-2$ leads to a significantly lower market impact on the ask-side. Rising stock prices of lags one, five and six are followed by a declining market impact on the ask-side while on lag three there is a slightly positive impact.

The significant coefficients of the lagged relative spread show a negative relation to market impact on the bid-side. Market impact on the ask-side does not lead to any significant changes in market impact on the bid-side. Lag five of the liquidity ratio 3 shows a significantly positive impact on the market impact on the bid-side. The coefficients of the lagged returns are significantly positive on lags three to five. The return of lag two is negative on a significance level of 10%.

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.64***	$-1.86 \cdot 10^{7}$***	$-1.39 \cdot 10^{7}$***	19.54**	–41.42	0.10***	$1.61 \cdot 10^{-3}$
$SrelM_{t-2}$	–0.53***	–9’298’494*	$-1.58 \cdot 10^{7}$***	35.17***	–147.21***	0.09***	0.04
$SrelM_{t-3}$	–0.45***	–8’918’169*	$-1.64 \cdot 10^{7}$***	23.14**	11.21	0.08***	0.06
$SrelM_{t-4}$	–0.37***	–7’810’030	$-1.26 \cdot 10^{7}$***	44.69***	–85.87**	0.06***	–0.02
$SrelM_{t-5}$	–0.25***	–2’284’029	$-1.16 \cdot 10^{7}$***	14.64	–64.87*	0.04***	0.02
$SrelM_{t-6}$	–0.17***	–2’207’760	–6’160’660**	51.51***	–88.05**	0.03***	0.05
$SrelM_{t-7}$	–0.07***	–4’831’415	–2’570’554	32.05***	–21.32	0.01	0.08***
V_{t-1}	$1.23 \cdot 10^{-10}$***	–0.70***	–0.001	$-6.31 \cdot 10^{-9}$	$-2.22 \cdot 10^{-8}$	$-1.98 \cdot 10^{-11}$	$5.11 \cdot 10^{-11}$
V_{t-2}	$1.62 \cdot 10^{-10}$***	–0.57***	0.006	$-1.95 \cdot 10^{-8}$	$1.03 \cdot 10^{-7}$	$-4.49 \cdot 10^{-11}$	$3.07 \cdot 10^{-11}$
V_{t-3}	$1.30 \cdot 10^{-10}$**	–0.49***	0.008	$-1.50 \cdot 10^{-8}$	$6.63 \cdot 10^{-8}$	$-3.73 \cdot 10^{-11}$	$-4.02 \cdot 10^{-11}$
V_{t-4}	$1.28 \cdot 10^{-10}$**	–0.37***	–0.004	$-1.25 \cdot 10^{-8}$	$3.39 \cdot 10^{-8}$	$-3.10 \cdot 10^{-11}$	$6.05 \cdot 10^{-11}$
V_{t-5}	$1.17 \cdot 10^{-10}$**	–0.27***	0.005	$3.28 \cdot 10^{-9}$	$1.83 \cdot 10^{-8}$	$-1.21 \cdot 10^{-11}$	$8.18 \cdot 10^{-11}$
V_{t-6}	$9.22 \cdot 10^{-11}$**	–0.16***	0.001	$6.11 \cdot 10^{-9}$	$2.12 \cdot 10^{-8}$	$-8.25 \cdot 10^{-12}$	$6.46 \cdot 10^{-11}$
V_{t-7}	$5.96 \cdot 10^{-11}$	–0.10***	0.007	$-3.60 \cdot 10^{-9}$	$4.81 \cdot 10^{-8}$	$-3.05 \cdot 10^{-11}$	$8.17 \cdot 10^{-11}$
$D\$_{t-1}$	$-1.22 \cdot 10^{-11}$	0.196***	–0.386***	$-4.68 \cdot 10^{-8}$	$-1.10 \cdot 10^{-7}$	$-6.75 \cdot 10^{-11}$	$6.34 \cdot 10^{-11}$
$D\$_{t-2}$	$5.91 \cdot 10^{-11}$	0.163***	–0.207***	$-2.64 \cdot 10^{-8}$	$2.11 \cdot 10^{-7}$	$4.28 \cdot 10^{-11}$	$-3.36 \cdot 10^{-11}$
$D\$_{t-3}$	$-5.11 \cdot 10^{-12}$	0.128***	–0.174***	$-4.40 \cdot 10^{-8}$	$-1.56 \cdot 10^{-7}$	$2.73 \cdot 10^{-11}$	$-3.68 \cdot 10^{-11}$
$D\$_{t-4}$	$-1.03 \cdot 10^{-11}$	0.105***	–0.121***	$-4.45 \cdot 10^{-8}$	$-1.79 \cdot 10^{-8}$	$-2.49 \cdot 10^{-11}$	$1.34 \cdot 10^{-10}$
$D\$_{t-5}$	$9.85 \cdot 10^{-12}$	0.063**	–0.078***	$7.53 \cdot 10^{-9}$	$2.70 \cdot 10^{-8}$	$5.33 \cdot 10^{-11}$	$-1.20 \cdot 10^{-10}$
$D\$_{t-6}$	$-1.18 \cdot 10^{-11}$	0.114***	–0.073***	$-7.72 \cdot 10^{-8}$	$1.17 \cdot 10^{-7}$	$-8.10 \cdot 10^{-11}$	$-1.15 \cdot 10^{-10}$
$D\$_{t-7}$	$-5.20 \cdot 10^{-11}$	0.059**	–0.057***	$-6.97 \cdot 10^{-8}$	$4.27 \cdot 10^{-8}$	$-3.21 \cdot 10^{-11}$	$-9.33 \cdot 10^{-11}$
MI_{t-1}^{A,V^*}	$9.11 \cdot 10^{-5}$***	–12’739**	456	–0.559***	–0.035	$2.14 \cdot 10^{-5}$	$9.30 \cdot 10^{-5}$**
MI_{t-2}^{A,V^*}	$1.04 \cdot 10^{-4}$***	–13’851*	3’270	–0.350***	–0.002	$-3.01 \cdot 10^{-5}$*	$2.28 \cdot 10^{-4}$***
MI_{t-3}^{A,V^*}	$1.43 \cdot 10^{-5}$	–3’883	3’140	–0.337***	0.022	$-2.82 \cdot 10^{-5}$	$1.17 \cdot 10^{-4}$**
MI_{t-4}^{A,V^*}	$-1.45 \cdot 10^{-5}$	–7’957	2’240	–0.248***	–0.054	$-3.96 \cdot 10^{-6}$	$8.13 \cdot 10^{-5}$
MI_{t-5}^{A,V^*}	$-9.01 \cdot 10^{-5}$***	–7’454	2’023	–0.261***	–0.031	$1.86 \cdot 10^{-5}$	$3.88 \cdot 10^{-5}$
MI_{t-6}^{A,V^*}	$-8.50 \cdot 10^{-5}$***	–6’895	241	–0.122***	–0.012	$9.46 \cdot 10^{-6}$	$-8.84 \cdot 10^{-5}$*
MI_{t-7}^{A,V^*}	$-3.64 \cdot 10^{-5}$*	–6’029	–48	–0.099***	–0.036	$-3.14 \cdot 10^{-5}$**	$-4.78 \cdot 10^{-5}$
MI_{t-1}^{B,V^*}	$4.18 \cdot 10^{-7}$	–810	1’081	0.002	–0.712***	$-1.63 \cdot 10^{-6}$	$-8.33 \cdot 10^{-5}$***
MI_{t-2}^{B,V^*}	$1.94 \cdot 10^{-5}$***	–214	494	0.006	–0.649***	$1.26 \cdot 10^{-6}$	$-7.38 \cdot 10^{-5}$***
MI_{t-3}^{B,V^*}	$9.54 \cdot 10^{-6}$	–3’885	447	0.002	–0.576***	$-5.24 \cdot 10^{-6}$	$-8.97 \cdot 10^{-5}$***
MI_{t-4}^{B,V^*}	$2.51 \cdot 10^{-5}$***	–2’695	–293	0.011**	–0.343***	$4.82 \cdot 10^{-6}$	$-6.47 \cdot 10^{-5}$***
MI_{t-5}^{B,V^*}	$1.31 \cdot 10^{-5}$*	–1’986	–470	0.011**	–0.136***	$-4.19 \cdot 10^{-6}$	$-5.84 \cdot 10^{-5}$***
MI_{t-6}^{B,V^*}	$1.72 \cdot 10^{-6}$	–1’921	–449	0.002	–0.130***	$-6.42 \cdot 10^{-6}$	$-3.79 \cdot 10^{-5}$***
MI_{t-7}^{B,V^*}	$1.95 \cdot 10^{-6}$	–4’228**	–1’341	0.005	–0.057***	$-7.28 \cdot 10^{-6}$*	$-3.96 \cdot 10^{-5}$***
$LR3_{t-1}$	0.035**	–1’277’114	2’033’507	–28.03***	–25.51	–0.809***	0.009
$LR3_{t-2}$	0.054***	–6’147’239	1’730’909	–23.95*	54.16	–0.666***	0.009
$LR3_{t-3}$	0.033	3’756’718	4’028’115	–11.62	85.66	–0.556***	–0.022
$LR3_{t-4}$	0.004	2’737’931	3’880’174	–11.98	75.40	–0.453***	–0.012
$LR3_{t-5}$	0.007	4’691’595	481’887	–16.82	126.69**	–0.345***	–0.063
$LR3_{t-6}$	0.001	2’464’110	–2’422’373	–11.00	53.10	–0.225***	–0.015
$LR3_{t-7}$	0.003	2’486’805	–4’167’393	–0.65	–16.66	–0.113***	–0.005
r_{t-1}	0.018***	–2’885’831	–23’508	–17.66***	–16.01	0.004	–0.190***
r_{t-2}	0.010*	–490’390	1’010’710	–4.46	–24.80*	0.001	–0.088***
r_{t-3}	–0.007	–5’661’085***	252’699	7.03*	34.64**	0.007	–0.033**
r_{t-4}	–0.013**	788’098	222’762	2.30	47.64***	$-4.80 \cdot 10^{-4}$	0.012
r_{t-5}	–0.008	–2’018’355	–604’750	–15.85***	57.24***	–0.001	–0.012
r_{t-6}	–0.006	–1’731’976	–1’602’500	–9.48**	–1.65	0.003	–0.027**
r_{t-7}	–0.012**	–4’000’488**	459’628	1.76	18.54	0.006	0.011
C	0.00	–387.83	–4.13	0.00	0.00	0.00	0.00
$Adj.R^2$	0.31	0.36	0.15	0.28	0.37	0.40	0.05

Table 5.9: Vector autoregressive model of Lonza with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

Up to lag six, the relative spread has a significantly positive impact on the liquidity ratio 3. The significant coefficients of the lagged market impact measures with respect to the liquidity ratio 3 are all negative. They are significant for lag two and seven on the ask-side and for lag seven on the bid-side. Returns are not able to predict the liquidity ratio 3 and vice versa; the lagged liquidity ratios 3 have no impact on return.

The return in time t is significantly positively influenced by the relative spread of lag seven. The other coefficients are zero. Turnover does not have a significant impact on returns. The market impact on the ask-side up to lag three is followed by a positive change in the stock price. The fourth lag has a slightly negative impact on returns. All the coefficients of the market impact on the bid-side show a highly significant impact on returns. The impact of lagged returns on return itself is negative and significant for lags one to three and six.

None of the constants is significantly different from zero. The adjusted R^2 is highest for the liquidity ratio 3 regression with 40% and lowest for the return regression with 5%.

5.12 Results of the VAR Model for Swiss Re

For the most liquid stock in this study, Swiss Re, the results of the vector autoregressive model are presented in table 5.10. All the liquidity measures depend highly significantly on its own lagged realizations.

The first four lags of turnover lead to a higher relative spread. Dollar depth and market impact on the bid-side have no significant influence on the relative spread. A rising market impact on the ask-side on lags two and three is followed by declining liquidity in the tightness dimension of the limit order book. Only lag seven of the liquidity ratio three leads to a significantly lower spread. In contrast to some other stocks, the return on lag two makes the relative spread decline. Returns of lag six have a slightly positive and of lag seven a negative impact on the relative spread.

The first two lags of the relative spread are followed by declining turnover. Rising liquidity in the tightness and depth dimension leads to higher turnover. The market impact on the ask-side makes turnover decline, as lags one, five and six show. The market impact on the bid-side has only a small influence with the coefficient for lag one. The lagged liquidity ratio 3 has no significant influence on turnover and, also, lagged turnover has no impact on the liquidity ratio 3. There is very little influence of returns on turnover as the second coefficient of the lagged turnovers shows.

The relative spread leads to declining depth on all lags. Turnover makes dollar depth decline on lags four and five significantly. The market impact on the ask-side does not change dollar depth at all, while the market impact on the bid-side has only a small influence on lag three. The lagged liquidity ratio 3 has no impact on dollar depth, and the opposite relation from lagged dollar depth to turnover does not show any significant coefficients. Lagged returns do not show any significant impact on dollar depth.

The relative spread does not influence the market impact on the ask-side. Rising turnover on lags four and seven let the market impact on the ask-side rise. A declining dollar depth on lags up to three leads to a higher market impact on the ask-side and on the-bid-side. The effect of dollar depth on market impact on the bid-side is for lags five and six significantly negative. Only the coefficient of lag three of the market impact on the bid-side lets the

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.83***	$-7.56 \cdot 10^7$**	$-5.95 \cdot 10^7$***	–1.15	4.60	0.06***	–0.42
$SrelM_{t-2}$	–0.70***	$-1.09 \cdot 10^8$**	$-5.56 \cdot 10^7$***	–1.16	–1.35	0.08***	–0.50
$SrelM_{t-3}$	–0.60***	$-7.23 \cdot 10^7$	$-6.76 \cdot 10^7$***	–2.01	–7.50*	0.06***	–0.50
$SrelM_{t-4}$	–0.49***	$-4.76 \cdot 10^7$	$-4.96 \cdot 10^7$***	–5.44	–15.92***	0.06***	–0.52
$SrelM_{t-5}$	–0.37***	$-5.35 \cdot 10^7$	$-3.82 \cdot 10^7$***	–5.71	–10.02**	0.05***	–0.41
$SrelM_{t-6}$	–0.24***	$1.96 \cdot 10^7$	$-3.21 \cdot 10^7$**	–1.25	–9.53**	0.04***	–0.23
$SrelM_{t-7}$	–0.13***	$-1.32 \cdot 10^7$	$-1.96 \cdot 10^7$*	–1.35	–4.94*	0.01***	–0.23
V_{t-1}	$1.16 \cdot 10^{-11}$**	–0.679***	–0.004	$5.52 \cdot 10^{-11}$	$1.47 \cdot 10^{-9}$	$4.14 \cdot 10^{-12}$	$-2.95 \cdot 10^{-11}$
V_{t-2}	$1.65 \cdot 10^{-11}$***	–0.528***	–0.004	$7.98 \cdot 10^{-10}$	$1.93 \cdot 10^{-11}$	$6.26 \cdot 10^{-12}$	$-5.81 \cdot 10^{-11}$**
V_{t-3}	$1.26 \cdot 10^{-11}$*	–0.413***	–0.004	$1.28 \cdot 10^{-9}$	$1.68 \cdot 10^{-9}$	$3.98 \cdot 10^{-12}$	$-4.04 \cdot 10^{-11}$
V_{t-4}	$1.58 \cdot 10^{-11}$**	–0.323***	–0.015***	$2.44 \cdot 10^{-9}$*	$3.34 \cdot 10^{-9}$**	$2.29 \cdot 10^{-12}$	$-1.08 \cdot 10^{-11}$
V_{t-5}	$6.40 \cdot 10^{-12}$	–0.242***	–0.009*	$2.02 \cdot 10^{-10}$	$2.71 \cdot 10^{-9}$*	$2.90 \cdot 10^{-12}$	$3.56 \cdot 10^{-12}$
V_{t-6}	$6.43 \cdot 10^{-12}$	–0.157***	–0.003	$1.86 \cdot 10^{-9}$	$9.06 \cdot 10^{-11}$	$5.51 \cdot 10^{-12}$	$1.99 \cdot 10^{-11}$
V_{t-7}	$8.02 \cdot 10^{-12}$	–0.073***	0.002	$2.00 \cdot 10^{-9}$**	$7.54 \cdot 10^{-10}$	$-5.57 \cdot 10^{-14}$	$-1.31 \cdot 10^{-12}$
$D\$_{t-1}$	$-1.98 \cdot 10^{-11}$	0.314***	–0.542***	$-9.51 \cdot 10^{-9}$***	$-1.38 \cdot 10^{-8}$***	$9.77 \cdot 10^{-12}$	$1.27 \cdot 10^{-10}$
$D\$_{t-2}$	$-2.05 \cdot 10^{-11}$	0.422***	–0.365***	$-8.25 \cdot 10^{-9}$***	$-1.08 \cdot 10^{-8}$**	$-4.93 \cdot 10^{-12}$	$6.96 \cdot 10^{-11}$
$D\$_{t-3}$	$-8.41 \cdot 10^{-12}$	0.313***	–0.244***	$-8.28 \cdot 10^{-9}$***	$-8.73 \cdot 10^{-9}$*	$9.70 \cdot 10^{-13}$	$9.65 \cdot 10^{-11}$
$D\$_{t-4}$	$-7.08 \cdot 10^{-12}$	0.253***	–0.236***	$-8.34 \cdot 10^{-10}$	$-6.76 \cdot 10^{-9}$	$-1.57 \cdot 10^{-11}$	$1.37 \cdot 10^{-10}$
$D\$_{t-5}$	$1.21 \cdot 10^{-11}$	0.300***	–0.165***	$-1.80 \cdot 10^{-9}$	$-9.47 \cdot 10^{-9}$**	$-1.23 \cdot 10^{-12}$	$1.43 \cdot 10^{-10}$
$D\$_{t-6}$	$-1.14 \cdot 10^{-11}$	0.134**	–0.116***	$-7.22 \cdot 10^{-10}$	$-7.52 \cdot 10^{-9}$*	$1.36 \cdot 10^{-11}$	$3.69 \cdot 10^{-11}$
$D\$_{t-7}$	$-5.85 \cdot 10^{-12}$	0.135***	–0.085***	$-5.66 \cdot 10^{-9}$	$-8.65 \cdot 10^{-10}$	$3.47 \cdot 10^{-12}$	$1.43 \cdot 10^{-10}$*
MI_{t-1}^{A,V^*}	$6.60 \cdot 10^{-5}$	–446'711***	77'798	–0.745***	0.019	$1.52 \cdot 10^{-4}$***	$1.49 \cdot 10^{-3}$***
MI_{t-2}^{A,V^*}	$2.75 \cdot 10^{-4}$***	–315'218	90'466	–0.591***	0.035*	$1.09 \cdot 10^{-4}$**	$1.79 \cdot 10^{-3}$***
MI_{t-3}^{A,V^*}	$2.34 \cdot 10^{-4}$**	–7'442	76'289	–0.491***	0.078***	$1.79 \cdot 10^{-4}$***	$2.46 \cdot 10^{-3}$***
MI_{t-4}^{A,V^*}	$1.38 \cdot 10^{-4}$	–69'867	–40'015	–0.383***	0.096***	$9.98 \cdot 10^{-5}$**	$2.41 \cdot 10^{-3}$***
MI_{t-5}^{A,V^*}	$1.24 \cdot 10^{-4}$	–379'284*	–13'558	–0.278***	0.044**	$7.00 \cdot 10^{-5}$	$1.63 \cdot 10^{-3}$***
MI_{t-6}^{A,V^*}	$-3.39 \cdot 10^{-5}$	–554'375***	–74'323	–0.211***	0.036**	$1.32 \cdot 10^{-4}$***	$1.19 \cdot 10^{-3}$***
MI_{t-7}^{A,V^*}	$-4.44 \cdot 10^{-5}$	–177'349	–61'255	–0.114***	0.021	$1.03 \cdot 10^{-4}$***	$7.94 \cdot 10^{-4}$***
MI_{t-1}^{B,V^*}	$1.18 \cdot 10^{-6}$	–257'827*	57'239	0.008	–0.722***	$1.71 \cdot 10^{-4}$***	$-7.76 \cdot 10^{-4}$***
MI_{t-2}^{B,V^*}	$-5.14 \cdot 10^{-5}$	–63'518	49'924	0.023	–0.552***	$9.68 \cdot 10^{-5}$**	$-1.58 \cdot 10^{-3}$***
MI_{t-3}^{B,V^*}	$-2.15 \cdot 10^{-5}$	36'516	106'321*	0.040***	–0.457***	$8.60 \cdot 10^{-5}$**	$-6.17 \cdot 10^{-4}$*
MI_{t-4}^{B,V^*}	$5.62 \cdot 10^{-5}$	31'359	83'217	0.020	–0.353***	$4.43 \cdot 10^{-5}$	$-1.84 \cdot 10^{-4}$
MI_{t-5}^{B,V^*}	$5.59 \cdot 10^{-5}$	148'498	57'480	–0.004	–0.320***	$2.68 \cdot 10^{-5}$	$-2.72 \cdot 10^{-5}$
MI_{t-6}^{B,V^*}	$1.07 \cdot 10^{-4}$	62'628	63'447	–0.001	–0.230***	$9.84 \cdot 10^{-5}$**	$-4.43 \cdot 10^{-4}$
MI_{t-7}^{B,V^*}	$7.57 \cdot 10^{-5}$	19'651	14'060	–0.011	–0.106***	$2.39 \cdot 10^{-6}$	$2.27 \cdot 10^{-4}$
$LR3_{t-1}$	–0.014	$-6.63 \cdot 10^7$	–8'809'534	3.45	–7.23	–0.823***	0.123
$LR3_{t-2}$	–0.043	$-5.31 \cdot 10^7$	$-2.24 \cdot 10^7$	–0.78	–5.72	–0.727***	0.031
$LR3_{t-3}$	–0.043	4'639'205	$-1.87 \cdot 10^7$	5.11	–3.05	–0.592***	0.136
$LR3_{t-4}$	–0.025	$-5.36 \cdot 10^7$	$-2.14 \cdot 10^7$	7.36	5.04	–0.481***	0.181
$LR3_{t-5}$	–0.026	$-8.09 \cdot 10^7$	$-1.10 \cdot 10^7$	4.64	0.48	–0.358***	0.190
$LR3_{t-6}$	–0.027	$-1.03 \cdot 10^8$	–5'913'100	1.54	–3.53	–0.243***	0.189
$LR3_{t-7}$	–0.046**	$-1.16 \cdot 10^7$	–9'464'514	–1.24	–1.17	–0.113***	0.089
r_{t-1}	$-2.60 \cdot 10^{-4}$	967'144	1'744'141	–0.35	1.27**	$-1.92 \cdot 10^{-4}$	–0.062***
r_{t-2}	–0.006**	$-1.20 \cdot 10^7$*	–708'952	–1.61***	–2.15***	–0.002	–0.013
r_{t-3}	–0.003	–2'931'532	–256'667	–0.47	–1.01	–0.002	0.024*
r_{t-4}	–0.002	6'848'321	1'684'888	–0.88	0.21	–0.003*	0.006
r_{t-5}	–0.002	1'904'365	–685'564	0.44	–0.93	–0.001	–0.018
r_{t-6}	0.005*	$-1.06 \cdot 10^7$	–530'812	0.78	0.59	0.001	–0.016
r_{t-7}	–0.005*	–4'741'393	463'048	–0.27	–0.54	–0.001	–0.002
C	0.00	259.25	75.17	0.00	0.00	0.00	0.00
$Adj.R^2$	0.41	0.33	0.25	0.36	0.34	0.42	0.03

Table 5.10: Vector autoregressive model of Swiss Re with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

market impact on the ask-side rise. The liquidity ratio 3 has no influence on the market impact measures at all. A rising stock price on lag two leads to a significantly lower market impact on the ask-side.

Lags three to seven of the relative spread have a negative effect on market impact on the bid-side of the limit order book. As for the ask-side, turnover leads to a higher market impact on the bid-side on lags four and five. Since the coefficients two to six are significantly positive, the lagged market impact on the ask-side is followed by a higher market impact on the bid-side. The effect of lagged returns on the market impact on the bid-side is ambiguous: on lag one there is a significantly positive influence, while on lag two the influence is significantly negative.

The rising spread leads on all lags to a rising liquidity ratio 3. A declining liquidity of the market impact measures makes liquidity, as measured by the liquidity ratio 3, decline. For the ask-side, there is significance for lags one to four, six and seven, while on the bid-side lags one to three and six are significantly positive. The lagged returns show only a slightly negative impact of lag four on the liquidity ratio 3.

The lagged relative spread does not change returns significantly, but a higher turnover on lag two leads to a declining stock price. Dollar depth on lag seven has only a slight impact on return. All lags of the market impact on the ask-side lead to significantly higher returns. For the market impact on the bid-side, only the first three lags lead to significantly lower returns. The liquidity ratio 3 does not change returns at all. Finally, return in time $t-1$ makes returns in time t decline significantly. The impact of return on lag three on return in t is slightly positive.

The constants of the vector autoregressive model are not significantly different from zero. The adjusted R^2-values are similar to the ones for the previous stocks.

5.13 Results of the VAR Model for Swisscom

The vector autoregressive model for Swisscom is presented in table 5.11. The negative dependence of the six liquidity measures on its own lagged changes is highly significant. For the return regression, only lagged returns one to three are significantly negative.

A higher turnover on lags one to five is followed by a significantly rising relative spread. Lagged dollar depth has almost no influence on the relative spread. A rising market impact on the ask-side leads to a significantly higher spread with significance on all lags. The market impact on the bid-side shows the same interrelation, but only lags one to four are significant. The lagged liquidity ratio 3 and the lagged returns show very little impact on the relative spread.

Declining liquidity, as measured by the relative spread, leads to significantly higher turnover. The lagged dollar depth has a positive effect on turnover. Also, declining market impact measures are followed by higher turnover. There is significance for lags up to six on the ask-side and lags one and three to seven on the bid-side. The lagged liquidity ratio 3 does not influence turnover and lagged returns have only a slight impact on lag six.

Rising liquidity in the tightness dimension leads to rising liquidity in depth as the significant coefficients for lags one to five show. Lagged turnover does not influence depth. The market impact on the ask-side leads to a lower depth with significance for lags one and two.

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.71***	$-6.45 \cdot 10^7$***	$-2.77 \cdot 10^7$***	15.19	18.56*	0.11***	–0.03
$SrelM_{t-2}$	–0.53***	$-3.83 \cdot 10^7$***	$-2.86 \cdot 10^7$***	10.81	40.01***	0.09***	–0.05
$SrelM_{t-3}$	–0.49***	$-4.50 \cdot 10^7$***	$-2.40 \cdot 10^7$***	–8.87	20.28	0.09***	0.00
$SrelM_{t-4}$	–0.38***	$-3.34 \cdot 10^7$**	$-2.61 \cdot 10^7$***	6.72	30.73**	0.07***	–0.07*
$SrelM_{t-5}$	–0.28***	$-3.16 \cdot 10^7$**	$-1.76 \cdot 10^7$***	–15.99	43.36***	0.05***	–0.02
$SrelM_{t-6}$	–0.21***	$-3.24 \cdot 10^7$**	–5'548'664	–5.27	21.40*	0.04***	–0.03
$SrelM_{t-7}$	–0.13***	$-2.53 \cdot 10^7$**	–3'272'538	–10.39	–5.98	0.01*	–0.01
V_{t-1}	$5.20 \cdot 10^{-11}$***	–0.702***	–0.008	$4.93 \cdot 10^{-9}$	$2.12 \cdot 10^{-8}$**	$1.05 \cdot 10^{-11}$	$2.80 \cdot 10^{-11}$
V_{t-2}	$6.29 \cdot 10^{-11}$***	–0.568***	0.004	$2.09 \cdot 10^{-9}$	$8.77 \cdot 10^{-9}$	$1.24 \cdot 10^{-11}$	$-9.93 \cdot 10^{-12}$
V_{t-3}	$6.25 \cdot 10^{-11}$***	–0.470***	0.002	$2.14 \cdot 10^{-8}$	$3.20 \cdot 10^{-8}$**	$2.35 \cdot 10^{-11}$**	$-7.19 \cdot 10^{-11}$
V_{t-4}	$4.89 \cdot 10^{-11}$**	–0.333***	0.008	$3.59 \cdot 10^{-8}$**	$3.22 \cdot 10^{-8}$**	$1.96 \cdot 10^{-11}$	$1.52 \cdot 10^{-11}$
V_{t-5}	$3.29 \cdot 10^{-11}$*	–0.236***	0.003	$2.24 \cdot 10^{-8}$	$2.32 \cdot 10^{-8}$*	$1.13 \cdot 10^{-11}$	$-3.40 \cdot 10^{-11}$
V_{t-6}	$2.77 \cdot 10^{-11}$	–0.150***	–0.008	$2.17 \cdot 10^{-8}$*	$2.16 \cdot 10^{-8}$*	$1.55 \cdot 10^{-11}$	$2.68 \cdot 10^{-12}$
V_{t-7}	$1.72 \cdot 10^{-11}$	–0.075***	0.001	$2.80 \cdot 10^{-8}$***	$3.73 \cdot 10^{-9}$	$8.19 \cdot 10^{-12}$	$-1.61 \cdot 10^{-12}$
$D\$_{t-1}$	$2.45 \cdot 10^{-11}$	0.322***	–0.501***	$-5.54 \cdot 10^{-8}$*	$-4.41 \cdot 10^{-8}$	$5.77 \cdot 10^{-12}$	$1.43 \cdot 10^{-10}$
$D\$_{t-2}$	$-3.16 \cdot 10^{-11}$	0.324***	–0.407***	$-9.18 \cdot 10^{-10}$	$1.26 \cdot 10^{-8}$	$4.96 \cdot 10^{-11}$*	$1.98 \cdot 10^{-10}$*
$D\$_{t-3}$	$1.57 \cdot 10^{-11}$	0.216***	–0.313***	$5.22 \cdot 10^{-8}$	$2.31 \cdot 10^{-8}$	$4.83 \cdot 10^{-11}$*	$3.38 \cdot 10^{-11}$
$D\$_{t-4}$	$2.55 \cdot 10^{-11}$	0.204***	–0.218***	$3.63 \cdot 10^{-8}$	$1.49 \cdot 10^{-8}$	$3.95 \cdot 10^{-11}$	$1.79 \cdot 10^{-10}$
$D\$_{t-5}$	$4.57 \cdot 10^{-11}$	0.091**	–0.161***	$4.46 \cdot 10^{-8}$	$-1.81 \cdot 10^{-8}$	$6.12 \cdot 10^{-11}$**	$1.09 \cdot 10^{-10}$
$D\$_{t-6}$	$7.56 \cdot 10^{-11}$*	0.069*	–0.119***	$5.58 \cdot 10^{-8}$*	$-2.10 \cdot 10^{-8}$	$4.32 \cdot 10^{-11}$	$7.50 \cdot 10^{-11}$
$D\$_{t-7}$	$5.01 \cdot 10^{-11}$	0.059*	–0.056***	$3.38 \cdot 10^{-8}$	$-4.30 \cdot 10^{-8}$	$1.61 \cdot 10^{-11}$	$4.18 \cdot 10^{-11}$
MI_{t-1}^{A,V^*}	$7.91 \cdot 10^{-5}$***	–38'659**	–13'575**	–0.552***	0.023*	$7.79 \cdot 10^{-5}$***	$1.61 \cdot 10^{-4}$***
MI_{t-2}^{A,V^*}	$8.21 \cdot 10^{-5}$***	–32'747*	–17'321**	–0.375***	0.041**	$8.93 \cdot 10^{-5}$***	$1.56 \cdot 10^{-4}$***
MI_{t-3}^{A,V^*}	$7.10 \cdot 10^{-5}$***	–42'629**	–7'222	–0.288***	0.013	$6.39 \cdot 10^{-5}$***	$1.21 \cdot 10^{-4}$**
MI_{t-4}^{A,V^*}	$7.83 \cdot 10^{-5}$***	–38'856**	–6'064	–0.235***	0.031*	$6.78 \cdot 10^{-5}$***	$6.90 \cdot 10^{-5}$
MI_{t-5}^{A,V^*}	$8.22 \cdot 10^{-5}$***	–41'500**	–6'618	–0.179***	0.031**	$5.82 \cdot 10^{-5}$***	$-7.23 \cdot 10^{-6}$
MI_{t-6}^{A,V^*}	$3.68 \cdot 10^{-5}$*	–42'855**	–5'031	–0.108***	0.010	$4.60 \cdot 10^{-5}$***	$6.46 \cdot 10^{-5}$
MI_{t-7}^{A,V^*}	$3.68 \cdot 10^{-5}$*	–22'584	–5'993	–0.031**	0.005	$1.40 \cdot 10^{-5}$	$4.75 \cdot 10^{-5}$
MI_{t-1}^{B,V^*}	$7.27 \cdot 10^{-5}$***	–35'755**	–4'213	0.024*	–0.505***	$5.21 \cdot 10^{-5}$***	$-1.29 \cdot 10^{-4}$***
MI_{t-2}^{B,V^*}	$7.49 \cdot 10^{-5}$***	–19'974	–11'388	0.073***	–0.392***	$7.17 \cdot 10^{-5}$***	$-1.68 \cdot 10^{-4}$***
MI_{t-3}^{B,V^*}	$8.31 \cdot 10^{-5}$***	–33'726*	–17'006**	0.081***	–0.308***	$5.14 \cdot 10^{-5}$***	$-1.16 \cdot 10^{-4}$**
MI_{t-4}^{B,V^*}	$5.25 \cdot 10^{-5}$**	–43'716**	–13'188	0.079***	–0.253***	$4.06 \cdot 10^{-5}$***	$-1.19 \cdot 10^{-4}$**
MI_{t-5}^{B,V^*}	$2.65 \cdot 10^{-5}$	–51'254**	–6'106	0.005	–0.218***	$2.62 \cdot 10^{-5}$*	$-6.64 \cdot 10^{-5}$
MI_{t-6}^{B,V^*}	$-8.29 \cdot 10^{-6}$	–36'206*	–9'162	0.030*	–0.144***	$8.53 \cdot 10^{-6}$	$-1.25 \cdot 10^{-4}$**
MI_{t-7}^{B,V^*}	$1.66 \cdot 10^{-5}$	–34'717**	–2'650	0.020	–0.100***	$8.98 \cdot 10^{-6}$	$-1.01 \cdot 10^{-4}$**
$LR3_{t-1}$	0.007	–9'866'972	2'216'739	21.77	7.68	–0.867***	0.089*
$LR3_{t-2}$	–0.032	$-1.27 \cdot 10^7$	–1'272'476	9.88	9.91	–0.748***	0.079
$LR3_{t-3}$	–0.019	$2.26 \cdot 10^7$	–1'466'921	–11.48	22.32	–0.611***	0.107
$LR3_{t-4}$	–0.027	$3.34 \cdot 10^7$	–643'607	–23.56	0.33	–0.488***	0.157**
$LR3_{t-5}$	–0.011	7'644'045	–531'629	–30.27	20.43	–0.382***	0.137*
$LR3_{t-6}$	–0.048*	–3'260'947	–9'013'642	–34.15*	5.38	–0.248***	0.118*
$LR3_{t-7}$	–0.014	–8'327'540	–2'675'928	–22.55	7.48	–0.102***	0.045
r_{t-1}	–0.004	4'191'724	–5'191'487***	–11.34***	12.98***	0.005	–0.155***
r_{t-2}	–0.010*	946'218	–1'051'078	–11.98***	5.77	0.004	–0.065***
r_{t-3}	–0.004	3'294'259	–838'168	–10.63***	–0.15	–0.002	–0.056***
r_{t-4}	–0.010*	295'365	–2'095'253	–3.76	1.86	0.004	–0.001
r_{t-5}	0.006	1'811'288	–2'182'450	–6.37	3.97	–0.007**	–0.007
r_{t-6}	–0.006	–8'463'228*	2'980'240	–5.29	–14.29***	–0.003	–0.006
r_{t-7}	0.002	–1'616'113	716'071	–0.03	–1.43	–0.006*	–0.020
C	0.00	680.02	–291.55	0.00	0.00	0.00	0.00
$Adj.R^2$	0.33	0.36	0.22	0.24	0.22	0.45	0.04

Table 5.11: Vector autoregressive model of Swisscom with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

For the market impact on the bid-side there is significance only for lag three. The lagged liquidity ratio 3 has no effect on depth. The return in $t-1$ is followed by a significant decline in dollar depth.

The lagged relative spread has no effect on market impact on the ask-side. Turnover leads to rising market impacts, on the ask-side with significance for lags four, six and seven, and on the bid-side for lags one and three to six. The impact of lagged dollar depth is very small. It is negative on lag one and positive on lag six. The market impact measures are positively related to each other. Lagged market impact on the bid-side has a significant influence on lags one to four and six, while lagged market impact on the ask-side makes market impact on the bid-side on lags one, two, four and five rise. There is only a small negative impact of the liquidity ratio 3 on market impact on the ask-side. Its effect on market impact on the bid-side cannot be distinguished from zero. Rising stock prices lead to lower market impacts on the ask-side, since the coefficients of lags one to three are significantly negative.

The lagged relative spread is followed by a rising market impact on the bid-side with significance on lags one, two and four to six. Lagged dollar depth does not change market impact on the bid-side. The effect of lagged returns on market impact on the bid-side is difficult to interpret: on lag one there is a significantly positive interrelation while on lag six it is significantly negative.

The liquidity ratio 3 rises significantly with all the lagged spreads. The effect of turnover is only significantly positive on lag three. Also, dollar depth has a positive impact with lags two, three and five. Declining liquidity, as measured by the two market impact measures, lets liquidity according to the liquidity ratio 3 decline: for the ask-side there is significance for lags one to six and on the bid-side for lags one to five. The lagged returns are followed by a declining liquidity ratio 3 since the coefficients of lag five and seven are significant.

The impact of the lagged relative spread on returns is small. Only the coefficient of lag four shows slight significance. Lagged turnover has no influence on returns. Also, the impact of lagged dollar depth on lagged returns is close to zero. As for the other stocks so far, the lagged market impact on the ask-side leads to higher returns and the lagged market impact on the bid-side to lower returns. There is significance on the ask-side for lags one to three and on the bid-side for lags one to four, six and seven. The lagged liquidity ratio 3 is positively related to returns with significance for lags one and four to six.

None of the constants is different from zero. With 4%, again, the return regression has the lowest R^2.

5.14 Results of the VAR Model for Serono

The results of the vector autoregressive model for Serono are presented in table 5.12. All the liquidity measures show a strongly negative dependence on the lagged changes of the respective measures.

Rising lagged turnover leads to rising spreads with the exception of lag two. Rising liquidity in the depth dimension is followed by a rise in liquidity in the tightness dimension with significance on the first two lags. The lagged market impact measures have a positive relation to the spread. For the ask-side there is significance for lags one to six while on the bid-side lags one to three and seven are significant. The lagged liquidity ratio 3 has no

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.70***	$-4.08 \cdot 10^{7}$***	–1'828'409**	–108.23***	–141.72	0.10***	–0.09**
$SrelM_{t-2}$	–0.59***	$-4.06 \cdot 10^{7}$***	–1'273'651	–182.19***	–108.05	0.09***	$4.09 \cdot 10^{-3}$
$SrelM_{t-3}$	–0.47***	$-3.14 \cdot 10^{7}$***	–1'411'740	–141.52***	186.75	0.06***	–0.06
$SrelM_{t-4}$	–0.37***	$-2.44 \cdot 10^{7}$***	–2'277'502*	–110.12**	32.77	0.06***	–0.08
$SrelM_{t-5}$	–0.31***	$-2.69 \cdot 10^{7}$***	–1'694'439	–133.47***	125.83	0.05***	–0.09
$SrelM_{t-6}$	–0.20***	$-1.30 \cdot 10^{7}$**	–7'016	–142.26***	42.29	0.02***	–0.13***
$SrelM_{t-7}$	–0.10***	–6'650'092	–188'542	–103.22***	22.80	0.01**	–0.16***
V_{t-1}	$4.55 \cdot 10^{-11}$***	–0.694***	$3.94 \cdot 10^{-5}$	$-1.38 \cdot 10^{-8}$	$3.89 \cdot 10^{-7}$	$2.21 \cdot 10^{-11}$	$-2.17 \cdot 10^{-10}$**
V_{t-2}	$5.07 \cdot 10^{-11}$	–0.512***	–0.002	$-3.51 \cdot 10^{-8}$	$3.02 \cdot 10^{-7}$	$7.19 \cdot 10^{-12}$	$-1.58 \cdot 10^{-10}$
V_{t-3}	$8.42 \cdot 10^{-11}$*	–0.382***	–0.002	$-1.28 \cdot 10^{-7}$	$1.60 \cdot 10^{-7}$	$1.40 \cdot 10^{-11}$	$8.97 \cdot 10^{-11}$
V_{t-4}	$9.68 \cdot 10^{-11}$**	–0.293***	–0.002	$6.72 \cdot 10^{-8}$	$1.67 \cdot 10^{-7}$	$2.71 \cdot 10^{-11}$	$-1.24 \cdot 10^{-10}$
V_{t-5}	$8.37 \cdot 10^{-11}$*	–0.196***	–0.005*	$7.65 \cdot 10^{-8}$	$1.99 \cdot 10^{-7}$	$3.12 \cdot 10^{-11}$	$3.74 \cdot 10^{-11}$
V_{t-6}	$9.87 \cdot 10^{-11}$**	–0.113***	–0.005*	$1.02 \cdot 10^{-7}$	$2.94 \cdot 10^{-8}$	$3.64 \cdot 10^{-11}$*	$-1.52 \cdot 10^{-10}$
V_{t-7}	$7.41 \cdot 10^{-11}$**	–0.072***	–0.004	$2.50 \cdot 10^{-8}$	$-2.73 \cdot 10^{-7}$	$2.80 \cdot 10^{-12}$	$-1.01 \cdot 10^{-10}$
$D\$_{t-1}$	$-4.88 \cdot 10^{-10}$**	0.833***	–0.673***	$4.94 \cdot 10^{-7}$	$-4.68 \cdot 10^{-6}$***	$-3.08 \cdot 10^{-10}$***	$5.32 \cdot 10^{-11}$
$D\$_{t-2}$	$-6.07 \cdot 10^{-10}$***	0.635***	–0.545***	$6.63 \cdot 10^{-7}$	$-5.41 \cdot 10^{-6}$***	$-2.56 \cdot 10^{-10}$**	$1.23 \cdot 10^{-9}$*
$D\$_{t-3}$	$-3.36 \cdot 10^{-10}$	0.425***	–0.428***	$6.90 \cdot 10^{-7}$	$-1.65 \cdot 10^{-6}$	$-2.14 \cdot 10^{-10}$*	$2.20 \cdot 10^{-9}$***
$D\$_{t-4}$	$-3.69 \cdot 10^{-10}$	0.297***	–0.325***	$7.07 \cdot 10^{-9}$	$-1.65 \cdot 10^{-6}$	$-1.50 \cdot 10^{-10}$	$2.27 \cdot 10^{-9}$***
$D\$_{t-5}$	$-3.15 \cdot 10^{-11}$	0.327***	–0.230***	$-1.41 \cdot 10^{-7}$	$-2.25 \cdot 10^{-6}$	$5.81 \cdot 10^{-11}$	$1.61 \cdot 10^{-9}$**
$D\$_{t-6}$	$-2.18 \cdot 10^{-10}$	0.167**	–0.135***	$-3.57 \cdot 10^{-7}$	$-2.62 \cdot 10^{-6}$	$3.51 \cdot 10^{-11}$	$1.05 \cdot 10^{-9}$
$D\$_{t-7}$	$8.79 \cdot 10^{-11}$	0.250***	–0.075***	$1.60 \cdot 10^{-7}$	$-1.54 \cdot 10^{-6}$	$9.08 \cdot 10^{-11}$	$1.14 \cdot 10^{-9}$*
MI_{t-1}^{A,V^*}	$1.99 \cdot 10^{-5}$***	–3'001	–490	–0.448***	0.146***	$9.49 \cdot 10^{-6}$***	$4.25 \cdot 10^{-5}$***
MI_{t-2}^{A,V^*}	$2.07 \cdot 10^{-5}$***	–3'764	–967***	–0.336***	0.141***	$1.17 \cdot 10^{-5}$***	$4.84 \cdot 10^{-5}$***
MI_{t-3}^{A,V^*}	$1.41 \cdot 10^{-5}$**	–1'896	–391	–0.225***	0.095**	$7.29 \cdot 10^{-6}$***	$2.53 \cdot 10^{-5}$
MI_{t-4}^{A,V^*}	$2.19 \cdot 10^{-5}$***	–3'170	–166	–0.177***	0.065	$7.21 \cdot 10^{-6}$***	$5.79 \cdot 10^{-5}$***
MI_{t-5}^{A,V^*}	$1.34 \cdot 10^{-5}$**	–1'545	97	–0.144***	0.016	$6.40 \cdot 10^{-6}$**	$2.96 \cdot 10^{-5}$*
MI_{t-6}^{A,V^*}	$2.20 \cdot 10^{-5}$***	–1'377	339	–0.091***	0.039	$9.03 \cdot 10^{-6}$***	$4.97 \cdot 10^{-5}$***
MI_{t-7}^{A,V^*}	$1.22 \cdot 10^{-6}$	580	216	–0.052***	0.011	$4.58 \cdot 10^{-6}$**	$4.67 \cdot 10^{-5}$***
MI_{t-1}^{B,V^*}	$7.07 \cdot 10^{-6}$***	3'495***	–527***	0.022***	–0.801***	$2.74 \cdot 10^{-6}$***	$-1.50 \cdot 10^{-5}$***
MI_{t-2}^{B,V^*}	$5.90 \cdot 10^{-6}$***	2'803***	–553***	0.009*	–0.670***	$2.55 \cdot 10^{-6}$***	$-1.21 \cdot 10^{-5}$**
MI_{t-3}^{B,V^*}	$3.96 \cdot 10^{-6}$*	1'382*	–549***	0.010*	–0.559***	$2.05 \cdot 10^{-6}$**	$-1.18 \cdot 10^{-5}$*
MI_{t-4}^{B,V^*}	$2.07 \cdot 10^{-6}$	1'000	–555***	0.008	–0.443***	$2.21 \cdot 10^{-6}$**	$-1.62 \cdot 10^{-5}$**
MI_{t-5}^{B,V^*}	$2.82 \cdot 10^{-6}$	355	–517***	0.004	–0.330***	$2.53 \cdot 10^{-7}$	$-1.10 \cdot 10^{-5}$*
MI_{t-6}^{B,V^*}	$6.71 \cdot 10^{-7}$	134	–379***	0.005	–0.222***	$1.40 \cdot 10^{-6}$	$-1.10 \cdot 10^{-5}$*
MI_{t-7}^{B,V^*}	$3.16 \cdot 10^{-6}$**	–762	–55	$1.02 \cdot 10^{-4}$	–0.115***	$1.81 \cdot 10^{-6}$**	$-1.66 \cdot 10^{-6}$
$LR3_{t-1}$	–0.001	8'771'788	583'031	8.89	88.30	–0.836***	0.026
$LR3_{t-2}$	0.009	–1'882'473	1'616'861	1.04	233.75	–0.696***	–0.195*
$LR3_{t-3}$	0.037	$-1.14 \cdot 10^{7}$	4'506'386*	–42.88	607.90*	–0.553***	–0.044
$LR3_{t-4}$	0.056	–9'635'283	3'216'576	39.25	290.75	–0.453***	–0.028
$LR3_{t-5}$	0.040	–8'032'515	656'227	122.61	147.18	–0.363***	0.108
$LR3_{t-6}$	0.010	–7'873'800	–809'519	44.90	–8.20	–0.240***	0.130
$LR3_{t-7}$	–0.011	–5'953'380	1'515'496	42.41	–123.94	–0.123***	0.108
r_{t-1}	0.003	–1'643'115	352'043	–35.13***	44.60	–0.005**	–0.089***
r_{t-2}	–0.007*	–2'623'905*	268'110	–54.62***	72.16**	–0.002	–0.028**
r_{t-3}	–0.002	–567'919	302'115	–19.42*	47.01	–0.001	–0.020
r_{t-4}	–0.003	258'735	–670'605**	–27.10**	70.23**	–0.005***	0.053***
r_{t-5}	0.003	1'323'578	67'616	–22.20**	53.91	0.001	0.018
r_{t-6}	0.008*	–1'425'909	448'645	–5.96	50.45	0.003	0.018
r_{t-7}	0.000	–3'430'840**	–417'005	–2.95	42.99	0.002	0.025**
C	0.00	–500.28	22.10	–0.01	0.03	0.00	0.00
$Adj.R^2$	0.33	0.37	0.33	0.20	0.40	0.42	0.02

Table 5.12: Vector autoregressive model of Serono with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

impact on the relative spread. Lagged returns show positive and negative influence on the spread, but the significance of the coefficients is low.

A rising spread in lags one to six is followed by lower turnover. Turnover is, also, positively influenced by all lags of depth. The market impact on the ask-side has no influence on turnover and, also lagged turnover does not lead to changes in market impact on the ask-side. A decrease in liquidity on the bid-side has a positive effect on turnover, as the first three coefficients show. The lagged liquidity ratio 3 has no impact on turnover while rising stock prices lead to a decrease in turnover. The values for lag two and seven are significant.

The relative spread at lags two and four leads to significantly lower dollar depth. The impact of lagged turnover on depth is slightly negative with some significance for lags five and six. Only lag two of the market impact on the ask-side leads to a significantly lower dollar depth. For the market impact on the bid-side, lags one to six are significant. The impact of the liquidity ratio 3 on dollar depth is slightly positive. Of the lagged returns only lag four causes a significantly negative change of dollar depth.

The relative spread has a negative effect on market impact on the ask-side on all lags while it has no influence at all on the market impact on the bid-side. Lagged dollar depth does not change market impact on the ask-side. On the bid-side it causes a significant decline on the first two lags. The first three lags of market impact on the bid-side lead to a higher market impact on the ask-side. For the relation from market impact on the ask-side to the bid-side the same lags are significantly positive. The lagged liquidity ratio 3 does not influence market impact on the ask-side. Its impact on the bid-side is, also, very small. Rising stock prices are related to declining market impacts on the ask-side as the first five coefficients show.

Lagged turnover has no significant influence on the market impact on the bid-side. Lagged returns lead to rising market impacts on the bid-side with significance for lags two and four.

All the lagged relative spread coefficients have a significantly positive impact on the liquidity ratio 3. The influence of lagged turnover is only slightly positive and hardly significant. Dollar depth is followed by a declining liquidity ratio 3 with significance for lags one to three. The lagged market impact measures are positively related to the liquidity ratio 3. On the ask-side all coefficients are significant, while on the bid-side lags one to four and seven are not zero. Rising stock prices have a negative effect on the liquidity ratio 3 with significance on lags one and four.

The impact of the lagged relative spread is negative with significance for lags one, six and seven. Only the first lag of turnover leads to a significantly lower return. Dollar depth of lags two to five and seven is followed by rising stock prices. Market impact on the ask-side leads to higher returns on almost all lags, while market impact on the bid-side is related to smaller returns. The impact of the liquidity ratio 3 on returns is negative and only slightly significant on lag two. The first two lags of returns are followed by declining returns, while for lags four and seven there is a positive relation.

All the constants of the vector autoregressive model are not significantly different from zero. The adjusted R^2 is, again, highest for the liquidity ratio 3 regression and lowest for the return regression with only 2%.

5.15 Results of the VAR Model for Surveillance

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.55***	–9'961'203***	1'376'086	38.68**	–87.65	0.06***	–0.05**
$SrelM_{t-2}$	–0.46***	–5'484'717***	2'460'961	38.14**	–122.46**	0.08***	–0.10***
$SrelM_{t-3}$	–0.39***	–7'709'147***	–1'096'366	25.97	–364.31***	0.08***	–0.06**
$SrelM_{t-4}$	–0.32***	–6'527'961***	–2'321'158	15.94	–368.19***	0.05***	–0.05*
$SrelM_{t-5}$	–0.24***	–6'512'604***	–2'033'057	59.43***	–291.69***	0.04***	–0.03
$SrelM_{t-6}$	–0.15***	–5'850'836***	–1'566'869	71.24***	–16.64	0.04***	–0.06**
$SrelM_{t-7}$	–0.08***	–2'326'076*	–1'540'745	49.28***	–54.12	0.02***	–0.02
V_{t-1}	$6.44 \cdot 10^{-10}$***	–0.72***	–0.003	$1.18 \cdot 10^{-7}$	$1.30 \cdot 10^{-6}$***	$2.28 \cdot 10^{-10}$***	$3.86 \cdot 10^{-10}$*
V_{t-2}	$8.13 \cdot 10^{-10}$***	–0.54***	–0.018	$3.43 \cdot 10^{-7}$*	$7.24 \cdot 10^{-7}$	$1.98 \cdot 10^{-10}$**	$-4.17 \cdot 10^{-10}$
V_{t-3}	$8.14 \cdot 10^{-10}$***	–0.44***	–0.033	$2.69 \cdot 10^{-7}$	$9.86 \cdot 10^{-7}$	$2.65 \cdot 10^{-10}$***	$-5.84 \cdot 10^{-10}$**
V_{t-4}	$6.03 \cdot 10^{-10}$***	–0.35***	–0.089	$4.81 \cdot 10^{-7}$**	$1.30 \cdot 10^{-6}$**	$3.31 \cdot 10^{-10}$***	$-4.66 \cdot 10^{-10}$
V_{t-5}	$5.59 \cdot 10^{-10}$***	–0.26***	0.063	$2.23 \cdot 10^{-7}$	$1.73 \cdot 10^{-6}$***	$3.43 \cdot 10^{-10}$***	$-3.82 \cdot 10^{-10}$
V_{t-6}	$4.26 \cdot 10^{-10}$***	–0.16***	0.035	$1.62 \cdot 10^{-7}$	$1.47 \cdot 10^{-6}$**	$1.84 \cdot 10^{-10}$**	$-1.23 \cdot 10^{-10}$
V_{t-7}	$1.91 \cdot 10^{-10}$*	–0.07***	0.005	$-7.20 \cdot 10^{-8}$	$7.69 \cdot 10^{-7}$	$1.43 \cdot 10^{-10}$**	$-2.67 \cdot 10^{-12}$
$D\$_{t-1}$	$1.33 \cdot 10^{-11}$	0.003	–0.854***	$6.88 \cdot 10^{-8}$*	$-1.34 \cdot 10^{-9}$	$4.81 \cdot 10^{-13}$	$1.11 \cdot 10^{-11}$
$D\$_{t-2}$	$7.38 \cdot 10^{-12}$	0.001	–0.724***	$4.43 \cdot 10^{-8}$	$1.00 \cdot 10^{-9}$	$1.11 \cdot 10^{-11}$	$-4.20 \cdot 10^{-12}$
$D\$_{t-3}$	$-5.39 \cdot 10^{-12}$	0.009*	–0.595***	$6.06 \cdot 10^{-8}$	$2.73 \cdot 10^{-8}$	$1.39 \cdot 10^{-11}$	$-1.35 \cdot 10^{-11}$
$D\$_{t-4}$	$-6.89 \cdot 10^{-12}$	0.018***	–0.469***	$5.73 \cdot 10^{-8}$	$-3.69 \cdot 10^{-9}$	$1.55 \cdot 10^{-11}$	$-3.54 \cdot 10^{-11}$
$D\$_{t-5}$	$2.84 \cdot 10^{-12}$	0.011**	–0.347***	$3.26 \cdot 10^{-8}$	$-1.04 \cdot 10^{-8}$	$9.14 \cdot 10^{-12}$	$-2.37 \cdot 10^{-11}$
$D\$_{t-6}$	$1.01 \cdot 10^{-11}$	0.005	–0.226***	$1.65 \cdot 10^{-8}$	$-1.76 \cdot 10^{-8}$	$1.27 \cdot 10^{-11}$	$-1.47 \cdot 10^{-11}$
$D\$_{t-7}$	$2.95 \cdot 10^{-12}$	0.001	–0.111***	$1.13 \cdot 10^{-8}$	$9.59 \cdot 10^{-9}$	$3.97 \cdot 10^{-12}$	$4.07 \cdot 10^{-13}$
MI_{t-1}^{A,V^*}	$8.65 \cdot 10^{-6}$	–3'656***	–1'683	–0.304***	0.008	$9.21 \cdot 10^{-6}$	$9.54 \cdot 10^{-5}$***
MI_{t-2}^{A,V^*}	$4.57 \cdot 10^{-6}$	–4'022***	–1'372	–0.215***	–0.034	$2.18 \cdot 10^{-5}$***	$1.07 \cdot 10^{-4}$***
MI_{t-3}^{A,V^*}	$9.49 \cdot 10^{-6}$	–3'491***	22	–0.152***	0.074*	$2.07 \cdot 10^{-5}$***	$1.11 \cdot 10^{-4}$***
MI_{t-4}^{A,V^*}	$2.85 \cdot 10^{-5}$***	–4'316***	–107	–0.118***	0.067	$1.07 \cdot 10^{-5}$	$1.30 \cdot 10^{-4}$***
MI_{t-5}^{A,V^*}	$2.26 \cdot 10^{-5}$**	–1'462	5'784	–0.114***	0.018	$-4.06 \cdot 10^{-6}$	$5.54 \cdot 10^{-5}$***
MI_{t-6}^{A,V^*}	$9.69 \cdot 10^{-6}$	–2'442**	–775	–0.087***	–0.061	$8.68 \cdot 10^{-6}$	$3.85 \cdot 10^{-5}$**
MI_{t-7}^{A,V^*}	$1.55 \cdot 10^{-5}$	–1'642	–798	–0.037***	0.042	$-5.41 \cdot 10^{-6}$	$2.81 \cdot 10^{-5}$
MI_{t-1}^{B,V^*}	$1.52 \cdot 10^{-5}$***	523	–450	–0.002	–0.572***	$5.90 \cdot 10^{-6}$***	$-8.50 \cdot 10^{-7}$
MI_{t-2}^{B,V^*}	$6.02 \cdot 10^{-6}$*	931**	–511	0.005	–0.178***	$3.19 \cdot 10^{-6}$	$-1.40 \cdot 10^{-5}$**
MI_{t-3}^{B,V^*}	$2.43 \cdot 10^{-5}$***	991***	134	0.005	–0.137***	$4.07 \cdot 10^{-6}$*	$-2.70 \cdot 10^{-5}$***
MI_{t-4}^{B,V^*}	$2.14 \cdot 10^{-5}$***	991***	398	0.012***	–0.008	$1.53 \cdot 10^{-6}$	$-4.95 \cdot 10^{-5}$***
MI_{t-5}^{B,V^*}	$1.91 \cdot 10^{-5}$***	1'013***	208	–0.002	0.042***	$-2.01 \cdot 10^{-6}$	$-4.30 \cdot 10^{-5}$***
MI_{t-6}^{B,V^*}	$6.22 \cdot 10^{-6}$*	157	298	–0.007	–0.191***	$7.22 \cdot 10^{-7}$	$-1.88 \cdot 10^{-5}$***
MI_{t-7}^{B,V^*}	$3.68 \cdot 10^{-6}$	–372	219	–0.002	–0.210***	$1.39 \cdot 10^{-6}$	$-5.69 \cdot 10^{-6}$
$LR3_{t-1}$	0.018	–1'698'619	–2'829'382	–60.93**	–147.47*	–0.841***	0.076**
$LR3_{t-2}$	0.023	36'652	–2'369'765	–46.32	–201.77*	–0.694***	0.081*
$LR3_{t-3}$	–0.012	–3'489'346	–2'154'874	–55.56	–295.78**	–0.549***	0.091*
$LR3_{t-4}$	0.006	–7'355'803**	–5'531'381	–50.43	–221.77*	–0.433***	0.035
$LR3_{t-5}$	–0.016	–7'102'558**	–5'925'316	–21.62	–262.08**	–0.333***	–0.028
$LR3_{t-6}$	–0.060**	–7'904'589***	–4'461'456	18.23	–194.32*	–0.230***	–0.054
$LR3_{t-7}$	–0.018	–6'307'993***	–4'184'608	20.11	–178.57**	–0.120***	0.014
r_{t-1}	–0.020***	1'155'684	–488'186	–3.35	51.89*	0.001	–0.215***
r_{t-2}	0.002	1'181'806	469'039	–28.22***	125.66***	–0.002	–0.109***
r_{t-3}	0.007	–800'279	937'074	–13.27	145.11***	0.008*	–0.082***
r_{t-4}	0.009	–1'957'724**	799'585	1.50	35.68	–0.005	–0.034***
r_{t-5}	–0.007	–1'865'891**	2'788'393	7.85	8.20	–0.005	–0.024*
r_{t-6}	–0.006	–1'816'902**	–95'374	–9.84	18.20	0.012	0.005
r_{t-7}	–0.004	–1'696'025**	350'726	–18.77**	3.01	–0.007	0.031**
C	0.00	42.13	65.52	0.00	0.00	0.00	0.00
$Adj.R^2$	0.25	0.36	0.42	0.10	0.31	0.42	0.07

Table 5.13: Vector autoregressive model of Surveillance with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

Table 5.13 presents the results of the vector autoregressive model for Surveillance. Almost all the lagged changes in liquidity measures are significantly negatively related to the changes of the respective liquidity measures in time t. Only the coefficient of market impact on the bid-side on lag four is not significantly different from zero.

Lagged turnover leads to a rising spread with significance on all lags. Lagged dollar depth has no impact on the relative spread. The market impact on the ask-side has, with its lags four and five, a positive effect on the relative spread. Also the market impact on the bid-side has a significant influence on the relative spread. It is significant for lags one to six. The liquidity ratio 3 on lag six is followed by a declining relative spread. The return in time $t-1$ has a positive relation to liquidity in the tightness dimension.

All the lagged relative spreads decrease turnover. Dollar depth is, with its lags three to five, positively related to turnover. This is the only influence of dollar depth on the other variables of the vector autoregressive model, with the exception of a slightly positive impact on the market impact on the ask-side. The market impact on the ask-side leads to significantly lower turnover on lags one to four and six. On the other hand, market impact on the bid-side leads to significantly higher turnover with lags two to five. The lags four to seven of the liquidity ratio 3 decrease turnover. Rising stock prices of lags four to seven are followed by declining turnover.

What is new for Surveillance with respect to the previous stocks is that dollar depth depends only on lagged dollar depth itself. The other five liquidity measures and returns do not have any significant impact.

A rising lagged spread has a positive influence on market impact on the ask-side on lags one, two and five to seven. Also, turnover on lags two and four leads to a higher market impact on the ask-side. Only lag four of the market impact on the bid-side has a significant influence on market impact on the ask-side. The liquidity ratio 3 has a significantly negative impact with lag one on market impact on the ask-side. Also, rising stock prices lead to smaller market impacts on the ask-side, with significance for lags two and seven.

The rising relative spread reduces the market impact on the bid-side, significantly on lags two to five. Rising turnover leads to a rising market impact on the bid-side, with significance for lags one and four to six. There is only a small impact of lagged market impact on the ask-side with respect to market impact on the bid-side. All lags of the liquidity ratio 3 are followed by a declining market impact on the bid-side. A rising stock price leads to higher market impacts on the bid-side, with significance for lags one to three.

All the lagged relative spreads are related to a rising liquidity ratio 3. All the lagged turnovers have the same impact. The market impact measures lead to a higher liquidity ratio 3. For the ask-side there is significance for lags two and three and for the bid-side for lags one and three. The lagged returns only have a slightly positive impact on lag three.

Return reacts negatively on changes in the lagged relative spread with significance for lags one to four and six. Turnover on lag one is related to rising returns, while turnover on lag three is followed by declining returns. The market impact on the ask-side leads, with lags one to six, to larger returns. The lags two to six of market impact on the bid-side are related to smaller returns. The liquidity ratio 3 is positively related to returns with significance for lags one to three. Return depends negatively on the lagged returns for the first five lags. The interrelation of lag seven and return in time t is significantly positive.

All the constants of the model are close to zero. The adjusted R^2-values are in the range of the previous stocks.

5.16 Results of the VAR Model for Sulzer

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.46***	–943'292	–980'266*	14.76	–41.38	0.05***	–0.01
$SrelM_{t-2}$	–0.39***	–1'328'466**	–1'451'151**	–35.46**	–248.77***	0.08***	0.05**
$SrelM_{t-3}$	–0.25***	–1'469'399**	–973'489	–18.34	–636.24***	0.08***	–0.09***
$SrelM_{t-4}$	–0.18***	–790'238	–533'419	–9.08	–393.94***	0.07***	0.09***
$SrelM_{t-5}$	–0.20***	–777'250	5'869	–5.31	–177.82*	0.05***	–0.02
$SrelM_{t-6}$	–0.12***	–1'185'936*	774'388	–24.45	–169.61*	0.05***	0.03
$SrelM_{t-7}$	–0.08***	–1'006'123*	237'703	3.24	–165.60**	$4.90 \cdot 10^{-3}$	0.03
V_{t-1}	$1.10 \cdot 10^{-9}$***	–0.775***	–0.017	$5.38 \cdot 10^{-7}$*	$1.92 \cdot 10^{-6}$	$3.20 \cdot 10^{-10}$	$4.25 \cdot 10^{-10}$
V_{t-2}	$6.41 \cdot 10^{-10}$**	–0.665***	–0.047***	$6.75 \cdot 10^{-7}$*	$6.68 \cdot 10^{-7}$	$3.93 \cdot 10^{-10}$	$4.26 \cdot 10^{-10}$
V_{t-3}	$1.10 \cdot 10^{-9}$***	–0.513***	–0.035**	$6.95 \cdot 10^{-7}$*	$1.93 \cdot 10^{-6}$	$1.42 \cdot 10^{-10}$	$6.84 \cdot 10^{-12}$
V_{t-4}	$2.88 \cdot 10^{-10}$	–0.369***	–0.027	$5.76 \cdot 10^{-7}$	$1.85 \cdot 10^{-7}$	$2.88 \cdot 10^{-10}$	$4.90 \cdot 10^{-11}$
V_{t-5}	$4.33 \cdot 10^{-10}$	–0.295***	–0.033**	$5.98 \cdot 10^{-7}$	$1.92 \cdot 10^{-7}$	$2.12 \cdot 10^{-10}$	$7.05 \cdot 10^{-10}$
V_{t-6}	$1.34 \cdot 10^{-10}$	–0.211***	–0.004	$9.39 \cdot 10^{-8}$	$6.23 \cdot 10^{-7}$	$2.20 \cdot 10^{-10}$	$7.83 \cdot 10^{-11}$
V_{t-7}	$1.44 \cdot 10^{-10}$	–0.127***	–0.008	$2.17 \cdot 10^{-8}$	$1.17 \cdot 10^{-6}$	$-4.49 \cdot 10^{-11}$	$-6.31 \cdot 10^{-11}$
$D\$_{t-1}$	$1.23 \cdot 10^{-10}$	0.025*	–0.417***	$6.34 \cdot 10^{-7}$**	$3.21 \cdot 10^{-6}$*	$-2.60 \cdot 10^{-11}$	$-9.29 \cdot 10^{-11}$
$D\$_{t-2}$	$-2.07 \cdot 10^{-10}$	–0.009	–0.264***	$1.44 \cdot 10^{-7}$	$2.18 \cdot 10^{-6}$	$-4.36 \cdot 10^{-10}$*	$-3.94 \cdot 10^{-10}$
$D\$_{t-3}$	$-2.43 \cdot 10^{-10}$	0.026*	–0.191***	$2.04 \cdot 10^{-7}$	$2.54 \cdot 10^{-6}$	$-5.58 \cdot 10^{-10}$**	$9.66 \cdot 10^{-10}$*
$D\$_{t-4}$	$-4.70 \cdot 10^{-10}$	0.053***	–0.143***	$4.17 \cdot 10^{-7}$	$1.61 \cdot 10^{-6}$	$-3.14 \cdot 10^{-10}$	$5.19 \cdot 10^{-10}$
$D\$_{t-5}$	$4.55 \cdot 10^{-11}$	0.010	–0.175***	$8.58 \cdot 10^{-8}$	$7.69 \cdot 10^{-7}$	$-1.68 \cdot 10^{-11}$	$-2.66 \cdot 10^{-10}$
$D\$_{t-6}$	$-4.17 \cdot 10^{-10}$	–0.013	–0.013	$1.23 \cdot 10^{-7}$	$-3.35 \cdot 10^{-7}$	$-4.11 \cdot 10^{-10}$*	$-1.31 \cdot 10^{-9}$**
$D\$_{t-7}$	$2.03 \cdot 10^{-10}$	0.008	–0.064***	$2.75 \cdot 10^{-7}$	$1.33 \cdot 10^{-6}$	$-3.28 \cdot 10^{-10}$	$-8.29 \cdot 10^{-10}$
MI_{t-1}^{A,V^*}	$-4.46 \cdot 10^{-5}$***	–998*	98	–0.279***	0.104	$1.68 \cdot 10^{-5}$*	$7.19 \cdot 10^{-5}$***
MI_{t-2}^{A,V^*}	$-2.22 \cdot 10^{-5}$*	–997*	666	–0.179***	0.190**	$-2.32 \cdot 10^{-5}$**	$4.93 \cdot 10^{-5}$**
MI_{t-3}^{A,V^*}	$-3.08 \cdot 10^{-5}$**	–1'271**	343	–0.078***	–0.138*	$-4.92 \cdot 10^{-6}$	$8.62 \cdot 10^{-5}$***
MI_{t-4}^{A,V^*}	$-1.62 \cdot 10^{-5}$	–1'216**	152	–0.081***	–0.054	$-1.15 \cdot 10^{-5}$	$5.44 \cdot 10^{-5}$**
MI_{t-5}^{A,V^*}	$-3.64 \cdot 10^{-5}$***	–1'045*	–928*	–0.066***	0.057	$-3.32 \cdot 10^{-5}$***	$9.32 \cdot 10^{-5}$***
MI_{t-6}^{A,V^*}	$-5.06 \cdot 10^{-5}$***	–593	680	–0.018	–0.109	$-3.20 \cdot 10^{-5}$***	$6.09 \cdot 10^{-5}$**
MI_{t-7}^{A,V^*}	$-1.98 \cdot 10^{-5}$*	–666	160	–0.007	–0.025	$-1.21 \cdot 10^{-5}$	$4.55 \cdot 10^{-5}$**
MI_{t-1}^{B,V^*}	$-7.47 \cdot 10^{-7}$	72	–13	0.002	–0.299***	$5.70 \cdot 10^{-6}$***	$-1.02 \cdot 10^{-5}$***
MI_{t-2}^{B,V^*}	$1.74 \cdot 10^{-6}$	–30	–68	0.018***	–0.309***	$5.52 \cdot 10^{-6}$***	$-1.86 \cdot 10^{-5}$***
MI_{t-3}^{B,V^*}	$7.30 \cdot 10^{-6}$***	–67	–53	0.014***	–0.172***	$2.34 \cdot 10^{-6}$	$-1.13 \cdot 10^{-5}$***
MI_{t-4}^{B,V^*}	$1.12 \cdot 10^{-5}$***	–4	–88	0.023***	–0.109***	$5.63 \cdot 10^{-6}$***	$-3.40 \cdot 10^{-5}$***
MI_{t-5}^{B,V^*}	$1.34 \cdot 10^{-5}$***	–92	–50	0.007***	–0.012	$6.07 \cdot 10^{-6}$***	$-2.48 \cdot 10^{-5}$***
MI_{t-6}^{B,V^*}	$1.69 \cdot 10^{-5}$***	–45	–82	0.002	–0.130***	$6.79 \cdot 10^{-7}$	$-2.23 \cdot 10^{-5}$***
MI_{t-7}^{B,V^*}	$6.19 \cdot 10^{-6}$***	–7	–55	0.001	–0.018	$3.18 \cdot 10^{-6}$**	$-1.53 \cdot 10^{-5}$***
$LR3_{t-1}$	0.126***	–577'690	–680'354	64.71***	164.31	–0.815***	–0.219***
$LR3_{t-2}$	0.094***	–366'875	1'511'791	37.97	–79.95	–0.681***	–0.123***
$LR3_{t-3}$	0.058**	279'838	1'388'455	23.53	–520.72***	–0.570***	–0.119***
$LR3_{t-4}$	0.063***	994'069	1'041'148	2.64	–457.98***	–0.482***	–0.214***
$LR3_{t-5}$	0.017	518'932	1'021'396	–4.43	–532.76***	–0.357***	–0.076*
$LR3_{t-6}$	0.018	576'696	278'003	–10.04	–128.18	–0.255***	–0.096**
$LR3_{t-7}$	0.044***	301'834	–294'441	4.04	19.93	–0.112***	0.017
r_{t-1}	–0.045***	–23'677	–13'396	–18.39**	18.55	$4.60 \cdot 10^{-4}$	–0.124***
r_{t-2}	–0.012*	263'289	309'437	–2.94	108.34**	0.011**	0.008
r_{t-3}	–0.013*	7'752	–419'535	–28.15***	210.99***	0.011**	–0.025**
r_{t-4}	–0.017**	–345'584	–259'139	5.42	–20.49	0.011**	–0.026**
r_{t-5}	–0.008	76'512	87'844	–1.18	232.98***	–0.008	–0.046***
r_{t-6}	–0.003	–132'174	291'038	–16.61**	15.60	–0.016***	–0.081***
r_{t-7}	–0.009	47'486	–212'267	5.61	186.58***	–0.005	–0.050***
C	0.00	27.82	147.77	0.00	0.01	0.00	0.00
$Adj.R^2$	0.22	0.39	0.17	0.09	0.16	0.40	0.06

Table 5.14: Vector autoregressive model of Sulzer with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

The results of the vector autoregressive model of Sulzer are shown in table 5.14. The dependence of the liquidity measures on its own lags is not as clear-cut for Sulzer as for the previous stocks. There is significance on all lags for the relative spread, turnover and the liquidity ratio 3. Dollar depth shows no impact of lag six on dollar depth in time t. The lags six and seven of market impact on the ask-side do not influence market impact on the ask-side in time t. Market impact on the bid-side on lags five and seven do not lead to any significant changes of the market impact on the bid-side.

The lags one to three of turnover lead to a significantly higher relative spread, while dollar depth has no significant impact on the spread. Market impact on the ask-side is related to a declining spread, with significance on almost all lags; this in contrast to some of the other stocks. Market impact on the bid-side leads to a significantly higher spread for lags three to seven. The liquidity ratio 3 has a significantly positive impact on the relative spread on lags one to four and seven. Rising stock prices tend to decrease the spread, as the coefficients of the first four lags show.

The lagged relative spread reduces turnover significantly on lags two, three, six and seven. Increasing dollar depth leads to higher turnover on lags one, three and four. The market impact on the ask-side reduces turnover with its lags one to five, while the market impact on the bid-side does not change turnover significantly. In the other direction, lagged turnover has no impact on market impact on the bid-side. The lagged liquidity ratio 3 and the lagged returns have no significant impact on turnover and lagged turnover does not change either the liquidity ratio 3 or returns.

A rising spread in lags one and two leads to a significantly declining dollar depth. Turnover has a significantly negative impact on dollar depth on lags two, three and five. The influence of the market impact on dollar depth is almost not distinguishable from zero. The lagged liquidity ratio 3 and lagged returns do not have any significant impact on dollar depth.

Only the second lag of the relative spread makes the market impact on the ask-side decrease significantly. Turnover leads to a higher market impact on the ask-side, as slightly significant lags one to three show. A rise in dollar depth is followed by a rise in market impact on the ask-side. Rising market impact on the bid-side is positively related to market impact on the ask-side on lags two to five. The first lag of the liquidity ratio 3 has a positive effect on market impact on the ask-side. The lagged returns have a negative influence on the market impact on the ask-side on lags one, three and six.

The lagged relative spread leads to a decrease in market impact on the bid-side with significance at almost all lags. Only the first lag of dollar depth is slightly positively related to market impact on the bid-side. Market impact on the ask-side leads with lag two to a significantly higher market impact on the bid-side. In contrast to this, lag three is significantly negative on the 10% level. The liquidity ratio 3 leads to a lower market impact on the bid-side since lags three to five are significantly different from zero. Rising stock prices are followed by a larger market impact on the bid-side with significance for lags two, three, five and seven.

The liquidity ratio 3 is positively affected by the relative spread on lags one to six. Dollar depth has a significantly negative effect on the liquidity ratio 3 on lags two, three and six. The market impact on the ask-side leads to a significantly lower liquidity ratio 3 on lags two, five and six, while on lag one there is a slightly negative significance. The market impact on the bid-side affects the liquidity ratio 3 positively on lags one, two, four, five and seven. The returns on lag two to four make the liquidity ratio 3 rise while the lag six decreases it.

The impact of the relative spread on returns is ambiguous: on lag three it is significantly negative while on lags two and four it is positive. Dollar depth also shows positive and negative influence on returns. Positive significance is found for lag three and a negative one for lag six. All the lagged market impacts on the ask-side lead to higher returns, while all the market impacts on the bid-side are related to lower returns. The liquidity ratio 3 leads on lags one to six to lower returns. The return depends on its own lags negatively. There is significance for lags one and three to seven.

None of the constants of the model is significantly different from zero. The adjusted R^2 is, with 6% for the returns regression, so far relatively high. The other R^2-values are in line with the ones of the other stocks.

5.17 Results of the VAR Model for Syngenta

The results of the vector autoregressive model for Syngenta are presented in table 5.15. Again, we have the clear negative dependence of the liquidity measures on its own lagged realizations. The coefficients are all highly significant.

The relative spread is strongly positively influenced by turnover up to lag six. Lagged dollar depth does not influence the relative spread significantly. The lagged spread shows only a very small impact on dollar depth. Market impact on the ask-side leads on lags one to three and six to a significantly higher spread. The seventh lag is negatively related to the relative spread. Lags one to four of market impact on the bid-side increase the spread. The impact of the lagged liquidity ratio 3 on the relative spread is only slightly significant on lag seven. The coefficient is negative. Lagged returns do not influence the spread of the Syngenta stock at all.

All the lags of the relative spread have a highly significant negative impact on turnover. Dollar depth is positively related to turnover on the first three lags. The market impact measures lead to decreasing turnover. On the ask-side the first lag is significant while on the bid-side the first two coefficients are significantly different from zero. The impact of the liquidity ratio 3 on turnover is negative but there is only significance at the 10% level. The lagged returns have no impact on turnover at all.

Dollar depth is neither changed by lagged turnover nor by the market impact on the ask-side. The market impact on the bid-side has a significantly negative influence on lags one, two and five. The lagged liquidity ratio 3 and the lagged returns do not change dollar depth significantly.

The relative spread on lags five and six decreases market impact on the ask-side. The impact of lagged turnover on the market impact on the ask-side is only slightly significant on lag four. Also, lagged dollar depth has only a very small positive influence on market impact on the ask-side. The first four lags of market impact on the bid-side lead to a significant rise in market impact on the ask-side. The liquidity ratio 3 has no influence on the market impact measures. Increasing stock prices lead to a decrease in market impact on the ask-side with significance on almost all lags.

Decreasing liquidity in the tightness dimension increases the market impact on the bid-side with significance for lags one to five. For lag seven there is a slightly negative effect. The influence of lagged turnover on market impact on the bid-side is negative but only slightly significant. Dollar depth does not change market impact on the bid-side at all. The lagged

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.60***	$-1.95 \cdot 10^{7}$***	3'093'644	0.39	6.86**	0.14***	–0.11***
$SrelM_{t-2}$	–0.48***	$-1.49 \cdot 10^{7}$***	–568'962	–4.75	8.76**	0.13***	–0.06*
$SrelM_{t-3}$	–0.39***	$-1.49 \cdot 10^{7}$***	–1'487'319	–0.82	6.89*	0.11***	$4.63 \cdot 10^{-4}$
$SrelM_{t-4}$	–0.32***	$-1.55 \cdot 10^{7}$***	1'636'907	–4.31	8.58**	0.10***	–0.01
$SrelM_{t-5}$	–0.21***	$-1.65 \cdot 10^{7}$***	7'457'391*	–15.88**	7.21*	0.09***	0.03
$SrelM_{t-6}$	–0.15***	$-1.32 \cdot 10^{7}$***	5'506'027	–21.33***	–2.41	0.06***	0.02
$SrelM_{t-7}$	–0.10***	$-1.41 \cdot 10^{7}$***	2'503'222	–4.93	–6.01*	0.04***	–0.01
V_{t-1}	$1.65 \cdot 10^{-10}$***	–0.754***	0.008	$2.31 \cdot 10^{-8}$	$1.02 \cdot 10^{-8}$	$2.85 \cdot 10^{-11}$	$-3.25 \cdot 10^{-10}$***
V_{t-2}	$1.92 \cdot 10^{-10}$***	–0.606***	0.001	$2.96 \cdot 10^{-8}$	$1.78 \cdot 10^{-8}$	$-1.39 \cdot 10^{-11}$	$-3.81 \cdot 10^{-10}$***
V_{t-3}	$1.56 \cdot 10^{-10}$**	–0.491***	–0.002	$2.15 \cdot 10^{-8}$	$1.28 \cdot 10^{-8}$	$3.19 \cdot 10^{-11}$	$-2.74 \cdot 10^{-10}$**
V_{t-4}	$2.24 \cdot 10^{-10}$***	–0.385***	–0.005	$4.22 \cdot 10^{-8}$*	$2.57 \cdot 10^{-8}$*	$4.15 \cdot 10^{-11}$	$-3.04 \cdot 10^{-10}$**
V_{t-5}	$1.54 \cdot 10^{-10}$**	–0.298***	–0.010	$2.11 \cdot 10^{-8}$	$1.51 \cdot 10^{-8}$	$-8.23 \cdot 10^{-12}$	$-2.10 \cdot 10^{-10}$*
V_{t-6}	$1.78 \cdot 10^{-10}$***	–0.202***	–0.013	$1.95 \cdot 10^{-8}$	$6.39 \cdot 10^{-10}$	$4.03 \cdot 10^{-11}$	$-2.75 \cdot 10^{-11}$
V_{t-7}	$5.93 \cdot 10^{-11}$	–0.091***	–0.008	$2.79 \cdot 10^{-8}$	$1.21 \cdot 10^{-8}$	$1.60 \cdot 10^{-11}$	$-1.09 \cdot 10^{-10}$
$D\$_{t-1}$	$-4.28 \cdot 10^{-11}$	0.060***	–0.816***	$2.85 \cdot 10^{-8}$	$-1.28 \cdot 10^{-8}$	$1.60 \cdot 10^{-11}$	$-5.42 \cdot 10^{-11}$
$D\$_{t-2}$	$-1.17 \cdot 10^{-11}$	0.066***	–0.672***	$5.11 \cdot 10^{-8}$*	$-1.59 \cdot 10^{-8}$	$2.60 \cdot 10^{-11}$	$-4.21 \cdot 10^{-13}$
$D\$_{t-3}$	$-4.63 \cdot 10^{-11}$	0.050**	–0.537***	$2.19 \cdot 10^{-8}$	$-1.90 \cdot 10^{-8}$	$-2.63 \cdot 10^{-11}$	$5.72 \cdot 10^{-11}$
$D\$_{t-4}$	$1.59 \cdot 10^{-11}$	0.030	–0.415***	$2.78 \cdot 10^{-8}$	$-2.14 \cdot 10^{-8}$	$-6.45 \cdot 10^{-11}$	$1.52 \cdot 10^{-10}$
$D\$_{t-5}$	$3.82 \cdot 10^{-11}$	0.016	–0.310***	$2.25 \cdot 10^{-8}$	$-7.06 \cdot 10^{-9}$	$-1.88 \cdot 10^{-11}$	$2.64 \cdot 10^{-10}$*
$D\$_{t-6}$	$3.83 \cdot 10^{-11}$	0.024	–0.215***	$1.60 \cdot 10^{-8}$	$1.89 \cdot 10^{-9}$	$-1.16 \cdot 10^{-11}$	$1.63 \cdot 10^{-10}$
$D\$_{t-7}$	$2.42 \cdot 10^{-11}$	–0.001	–0.119***	$1.03 \cdot 10^{-9}$	$4.79 \cdot 10^{-10}$	$1.32 \cdot 10^{-11}$	$1.65 \cdot 10^{-10}$
MI_{t-1}^{A,V^*}	$1.28 \cdot 10^{-4}$***	–25'998***	–10'186	–0.512***	0.033***	$8.89 \cdot 10^{-5}$***	$3.32 \cdot 10^{-4}$***
MI_{t-2}^{A,V^*}	$1.34 \cdot 10^{-4}$***	–5'207	–11'456	–0.336***	0.033***	$9.52 \cdot 10^{-5}$***	$4.04 \cdot 10^{-4}$***
MI_{t-3}^{A,V^*}	$1.23 \cdot 10^{-4}$***	3'605	–7'838	–0.286***	0.051***	$9.22 \cdot 10^{-5}$***	$3.78 \cdot 10^{-4}$***
MI_{t-4}^{A,V^*}	$3.00 \cdot 10^{-5}$	–11'068	–12'179	–0.243***	0.008	$6.80 \cdot 10^{-5}$***	$2.18 \cdot 10^{-4}$***
MI_{t-5}^{A,V^*}	$4.67 \cdot 10^{-5}$	–1'033	–11'147	–0.158***	0.027***	$1.43 \cdot 10^{-5}$	$1.98 \cdot 10^{-4}$***
MI_{t-6}^{A,V^*}	$8.30 \cdot 10^{-5}$**	1'079	–4'611	–0.117***	0.025***	$6.84 \cdot 10^{-7}$	$1.48 \cdot 10^{-4}$**
MI_{t-7}^{A,V^*}	$-7.14 \cdot 10^{-5}$**	–6'491	–5'173	–0.072***	0.003	$2.83 \cdot 10^{-5}$*	$1.59 \cdot 10^{-4}$**
MI_{t-1}^{B,V^*}	$1.89 \cdot 10^{-4}$***	–32'497**	–19'494*	0.076***	–0.570***	$4.41 \cdot 10^{-5}$*	$-5.23 \cdot 10^{-4}$***
MI_{t-2}^{B,V^*}	$2.24 \cdot 10^{-4}$***	–27'003*	–27'375**	0.069***	–0.392***	$6.49 \cdot 10^{-5}$**	$-1.02 \cdot 10^{-3}$***
MI_{t-3}^{B,V^*}	$2.24 \cdot 10^{-4}$***	–18'711	–10'928	0.058**	–0.209***	$1.11 \cdot 10^{-5}$	$-5.99 \cdot 10^{-4}$***
MI_{t-4}^{B,V^*}	$1.33 \cdot 10^{-4}$**	–10'090	–15'005	0.052**	–0.192***	$1.02 \cdot 10^{-5}$	$-4.37 \cdot 10^{-4}$***
MI_{t-5}^{B,V^*}	$8.04 \cdot 10^{-5}$	11'471	–24'780*	0.013	–0.222***	$6.67 \cdot 10^{-5}$**	$-1.88 \cdot 10^{-4}$
MI_{t-6}^{B,V^*}	$-1.32 \cdot 10^{-5}$	–5'742	–19'787	0.028	–0.156***	$4.43 \cdot 10^{-5}$	$-2.23 \cdot 10^{-4}$*
MI_{t-7}^{B,V^*}	$-2.51 \cdot 10^{-6}$	–7'119	–10'663	0.015	–0.085***	$3.21 \cdot 10^{-5}$	$1.64 \cdot 10^{-4}$*
$LR3_{t-1}$	–0.014	1'201'218	–1'435'899	0.36	6.70	–0.846***	–0.005
$LR3_{t-2}$	0.000	$-1.54 \cdot 10^{7}$*	–3'127'755	14.15	–0.90	–0.724***	–0.014
$LR3_{t-3}$	–0.036	$-1.38 \cdot 10^{7}$	–6'007'513	10.07	–4.62	–0.606***	–0.027
$LR3_{t-4}$	–0.043	$-1.47 \cdot 10^{7}$	8'115'622	19.18	5.09	–0.497***	–0.167**
$LR3_{t-5}$	–0.032	$-1.94 \cdot 10^{7}$**	8'648'633	12.66	8.54	–0.397***	–0.204***
$LR3_{t-6}$	–0.047	$-1.48 \cdot 10^{7}$*	6'409'356	–10.05	–5.02	–0.269***	–0.109*
$LR3_{t-7}$	–0.043*	$-1.43 \cdot 10^{7}$**	2'339'575	–11.26	0.46	–0.103***	–0.082*
r_{t-1}	0.007	2'098'630	–642'348	–8.66***	–0.46	0.005	–0.129***
r_{t-2}	–0.005	769'969	–77'989	–3.33	6.18***	0.001	–0.004
r_{t-3}	–0.009	854'083	–524'435	–10.70***	0.54	–0.001	$-1.31 \cdot 10^{-4}$
r_{t-4}	0.008	–1'300'942	–2'075'678	–6.53***	6.04***	0.005	–0.009
r_{t-5}	–0.002	2'149'304	–503'513	–11.05***	0.50	$3.37 \cdot 10^{-4}$	0.026**
r_{t-6}	0.003	223'357	90'764	–8.70***	9.71***	0.005	–0.007
r_{t-7}	0.006	488'485	570'685	–7.97***	7.65***	$1.29 \cdot 10^{-4}$	–0.001
C	0.00	894.51	–280.21	0.00	0.00	0.00	0.00
$Adj.R^2$	0.27	0.38	0.40	0.22	0.26	0.44	0.04

Table 5.15: Vector autoregressive model of Syngenta with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

market impact on the ask-side leads to a significant increase of market impact on the bid-side on the lags one to three, five and six. Lagged returns increase the market impact on the bid-side with significance on the lags two, four, six and seven.

The lagged spread leads to an increase in the liquidity ratio 3 on all lags. Also the market impact measures are positively related to the liquidity ratio 3 with significance for lags one to four and seven on the ask-side and lags one, two and five on the bid-side. Lagged returns have no impact on the liquidity ratio 3.

An increasing spread on the lags one and two leads to a decrease in returns. Also, turnover on lags one to four have a negative impact on returns. The influence of dollar depth on returns is only slightly significant on lag five. The market impact on the ask-side makes stock prices rise with significance on all lags. Similarly, market impact on the bid-side leads to smaller returns on the lags one to four and six. Only lag seven is slightly positive. The liquidity ratio 3 is negatively related to lower returns on lags four to seven. Finally, the lagged returns lead to lower stock prices with significance on lag one and increase return in time t significantly on lag five.

All the constants of the model are close to zero. The adjusted R^2-values are similar to the previous stocks.

5.18 Results of the VAR Model for Swatch Bearer Share

The vector autoregressive model for Swatch bearer share is presented in table 5.16. All the liquidity measures depend significantly on its own lags. As for the other stocks so far, the impact is negative.

Lagged turnover leads to higher spreads with significance on almost all lags. Lagged dollar depth decreases the spread with slight significance only on lag three. The market impact measures are related to higher spreads with significance for lags two and four on the ask-side and two, three and five on the bid-side. The liquidity ratio 3 has only on lag seven a significantly negative impact on the spread. Higher stock prices lead to significantly lower spreads on lags two, six and seven.

Turnover depends negatively on lagged spreads with significance up to lag six. Rising liquidity in the depth dimension is related to rising turnover on lags one to five. Market impact on the ask-side has only a slightly positive influence on turnover on lag two. The market impact on the bid-side has a negative effect on turnover with significance for lags one to three, five and six. The lagged liquidity ratio 3 does not change turnover at all. There is only a positive relation from returns on turnover on lag five. Rising lagged spreads make the depth dimension of the order book smaller on lags three to six. Turnover has only a slightly negative impact on dollar depth. The market impact measures are not related to dollar depth at all and, vice versa, dollar depth is not related to the market impacts significantly. Depth is neither changed by the liquidity ratio 3 nor by the lagged returns.

Rising spreads lead to a higher market impact on the ask-side on lags two to five, while the market impact on the bid-side is not affected by the spread. The influence of turnover on market impact on the ask-side is significantly negative on lags one and five. Lagged market

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.65***	$-1.22 \cdot 10^{7}$***	–1'234'742	3.44	–0.43	0.13***	–0.04*
$SrelM_{t-2}$	–0.50***	$-1.08 \cdot 10^{7}$***	–1'527'133	15.66**	5.53	0.15***	–0.03
$SrelM_{t-3}$	–0.40***	–5'816'168***	–1'882'606*	16.48**	2.36	0.13***	–0.09***
$SrelM_{t-4}$	–0.33***	–7'064'369***	–2'870'308***	22.01***	4.47	0.10***	–0.02
$SrelM_{t-5}$	–0.27***	–5'557'226***	–2'434'233**	14.19*	–2.92	0.07***	–0.09***
$SrelM_{t-6}$	–0.17***	–3'312'377*	–1'961'828**	6.80	4.68	0.06***	–0.05*
$SrelM_{t-7}$	–0.11***	–986'704	–889'287	7.30	1.31	0.03***	–0.03
V_{t-1}	$5.01 \cdot 10^{-10}$***	–0.792***	$-5.84 \cdot 10^{-5}$	$-1.21 \cdot 10^{-7}$***	$4.63 \cdot 10^{-8}$	$-2.01 \cdot 10^{-11}$	$3.48 \cdot 10^{-11}$
V_{t-2}	$5.57 \cdot 10^{-10}$***	–0.626***	–0.013*	$-4.90 \cdot 10^{-8}$	$9.26 \cdot 10^{-8}$**	$-7.40 \cdot 10^{-11}$	$-1.11 \cdot 10^{-10}$
V_{t-3}	$4.35 \cdot 10^{-10}$***	–0.495***	–0.013	$-6.66 \cdot 10^{-8}$	$3.91 \cdot 10^{-8}$	$-8.45 \cdot 10^{-11}$	$-3.16 \cdot 10^{-10}$
V_{t-4}	$2.11 \cdot 10^{-10}$	–0.380***	–0.008	$-9.81 \cdot 10^{-8}$	$7.52 \cdot 10^{-9}$	$-1.04 \cdot 10^{-10}$	$-5.58 \cdot 10^{-10}$*
V_{t-5}	$2.75 \cdot 10^{-10}$*	–0.287***	–0.003	$-1.11 \cdot 10^{-7}$*	$1.15 \cdot 10^{-8}$	$-1.14 \cdot 10^{-10}$	$-3.15 \cdot 10^{-10}$
V_{t-6}	$2.93 \cdot 10^{-10}$**	–0.180***	–0.007	$2.47 \cdot 10^{-9}$	$2.42 \cdot 10^{-8}$	$-4.29 \cdot 10^{-11}$	$-4.02 \cdot 10^{-11}$
V_{t-7}	$3.35 \cdot 10^{-10}$***	–0.086***	–0.001	$5.63 \cdot 10^{-8}$	$-6.84 \cdot 10^{-9}$	$5.17 \cdot 10^{-11}$	$-1.83 \cdot 10^{-11}$
$D\$_{t-1}$	$-1.51 \cdot 10^{-11}$	0.234***	–0.464***	$1.09 \cdot 10^{-7}$	$3.10 \cdot 10^{-8}$	$-9.54 \cdot 10^{-11}$	$3.52 \cdot 10^{-10}$
$D\$_{t-2}$	$-2.41 \cdot 10^{-10}$	0.352***	–0.396***	$4.09 \cdot 10^{-9}$	$5.00 \cdot 10^{-8}$	$-2.77 \cdot 10^{-12}$	$-2.78 \cdot 10^{-10}$
$D\$_{t-3}$	$-4.10 \cdot 10^{-10}$*	0.242***	–0.267***	$1.71 \cdot 10^{-7}$	$3.96 \cdot 10^{-8}$	$-1.55 \cdot 10^{-10}$	$-5.02 \cdot 10^{-11}$
$D\$_{t-4}$	$-6.48 \cdot 10^{-11}$	0.184***	–0.157***	$-2.74 \cdot 10^{-8}$	$2.77 \cdot 10^{-8}$	$-9.36 \cdot 10^{-11}$	$1.30 \cdot 10^{-10}$
$D\$_{t-5}$	$-2.53 \cdot 10^{-11}$	0.143***	–0.161***	$3.31 \cdot 10^{-8}$	$2.51 \cdot 10^{-8}$	$5.36 \cdot 10^{-11}$	$4.97 \cdot 10^{-11}$
$D\$_{t-6}$	$-2.47 \cdot 10^{-10}$	0.047	–0.137***	$7.67 \cdot 10^{-8}$	$7.59 \cdot 10^{-8}$	$1.74 \cdot 10^{-11}$	$5.00 \cdot 10^{-10}$
$D\$_{t-7}$	$-1.45 \cdot 10^{-11}$	0.028	–0.133***	$1.31 \cdot 10^{-7}$	$-3.29 \cdot 10^{-8}$	$2.27 \cdot 10^{-10}$*	$-9.54 \cdot 10^{-11}$
MI_{t-1}^{A,V^*}	$4.83 \cdot 10^{-5}$	758	–563	–0.394***	0.011	$2.27 \cdot 10^{-5}$	$2.59 \cdot 10^{-4}$***
MI_{t-2}^{A,V^*}	$1.24 \cdot 10^{-4}$***	7'559*	–2'196	–0.239***	0.015	$1.27 \cdot 10^{-5}$	$2.77 \cdot 10^{-4}$***
MI_{t-3}^{A,V^*}	$1.78 \cdot 10^{-5}$	–2'238	–1'292	–0.220***	0.013	$5.25 \cdot 10^{-6}$	$2.14 \cdot 10^{-4}$***
MI_{t-4}^{A,V^*}	$5.97 \cdot 10^{-5}$*	–3'598	256	–0.125***	–0.005	$-1.00 \cdot 10^{-5}$	$-4.91 \cdot 10^{-5}$
MI_{t-5}^{A,V^*}	$4.24 \cdot 10^{-5}$	–2'980	–2'389	–0.079***	0.009	$2.85 \cdot 10^{-5}$	$1.54 \cdot 10^{-4}$**
MI_{t-6}^{A,V^*}	$2.45 \cdot 10^{-5}$	–2'753	–1'006	–0.062***	–0.006	$-2.04 \cdot 10^{-5}$	$2.39 \cdot 10^{-4}$***
MI_{t-7}^{A,V^*}	$-2.62 \cdot 10^{-5}$	–683	–2'153	–0.054***	–0.015	$-5.92 \cdot 10^{-5}$***	$3.71 \cdot 10^{-5}$
MI_{t-1}^{B,V^*}	$6.50 \cdot 10^{-5}$	–25'307***	–508	–0.026	–0.486***	$8.27 \cdot 10^{-5}$***	$-7.43 \cdot 10^{-5}$
MI_{t-2}^{B,V^*}	$2.13 \cdot 10^{-4}$***	–18'677***	–2'310	–0.023	–0.297***	$7.09 \cdot 10^{-5}$**	$-2.55 \cdot 10^{-4}$***
MI_{t-3}^{B,V^*}	$1.69 \cdot 10^{-4}$***	–16'239***	–3'863	0.026	–0.152***	$3.43 \cdot 10^{-5}$	$-4.25 \cdot 10^{-4}$***
MI_{t-4}^{B,V^*}	$6.38 \cdot 10^{-5}$	–4'874	–3'951	0.011	–0.098***	$1.89 \cdot 10^{-5}$	$-3.22 \cdot 10^{-4}$***
MI_{t-5}^{B,V^*}	$1.84 \cdot 10^{-4}$***	–14'482**	–2'596	–0.001	–0.096***	$6.01 \cdot 10^{-5}$**	$-3.45 \cdot 10^{-4}$***
MI_{t-6}^{B,V^*}	$4.96 \cdot 10^{-5}$	–12'883**	–1'666	0.003	–0.055***	$2.26 \cdot 10^{-5}$	$-2.86 \cdot 10^{-4}$***
MI_{t-7}^{B,V^*}	$1.35 \cdot 10^{-5}$	–4'852	–1'466	0.003	–0.030***	$1.81 \cdot 10^{-5}$	$-1.87 \cdot 10^{-4}$**
$LR3_{t-1}$	0.020	–2'990'525	–660'970	23.62***	–11.65*	–0.865***	0.050
$LR3_{t-2}$	0.041	–1'500'410	–390'676	38.41***	–11.37	–0.710***	0.055
$LR3_{t-3}$	0.041	–2'056'364	–779'375	38.45***	–22.90**	–0.596***	0.027
$LR3_{t-4}$	0.019	–3'215'621	–920'951	20.89	–21.54**	–0.478***	0.040
$LR3_{t-5}$	0.015	–1'541'643	–52'599	16.98	–22.24**	–0.353***	0.127**
$LR3_{t-6}$	–0.036	1'407'783	–615'747	9.84	–19.42**	–0.235***	0.023
$LR3_{t-7}$	–0.051**	–845'172	–927'658	20.63**	–3.19	–0.113***	–0.002
r_{t-1}	0.005	1'118'252	519'887	–11.51***	11.76***	–0.002	–0.170***
r_{t-2}	–0.012**	–442'237	212'176	–9.10***	10.45***	–0.005	–0.084***
r_{t-3}	0.004	1'219'430	147'799	–7.27**	2.44	–0.011***	–0.030**
r_{t-4}	–0.010	1'186'958	505'083	–5.69**	–4.03*	–0.001	–0.013
r_{t-5}	–0.003	1'941'156**	107'650	1.51	1.68	$1.04 \cdot 10^{-4}$	0.015
r_{t-6}	–0.016**	658'704	132'111	–14.97***	–1.40	–0.013***	0.026**
r_{t-7}	–0.020***	37'599	174'732	–12.05***	0.03	–0.011***	0.022*
C	0.00	281.60	58.78	0.00	0.00	0.00	0.00
$Adj.R^2$	0.30	0.41	0.21	0.16	0.19	0.43	0.04

Table 5.16: Vector autoregressive model of Swatch bearer share with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

impact on the bid-side does not affect market impact on the ask-side. Also, from the ask-side to the bid-side there is no significant interrelation. The liquidity ratio 3 leads to a higher market impact on the ask-side with significance for lags one to three and seven. Rising stock prices are followed by a smaller market impact on the ask-side with significance on almost all lags.

Turnover on lag two leads to a significantly higher market impact on the bid-side. The liquidity ratio 3 is related to a declining market impact on the bid-side with significance for lags one and three to six. The first two lags of return increase the market impact on the bid-side while lag four leads to a slight decrease.

The relative spread has a significantly positive impact on the liquidity ratio 3 on all lags. Turnover does not affect the liquidity ratio 3 and lagged dollar depth has only a slightly positive impact on lag seven. Market impact on the ask-side leads to a lower liquidity ratio 3 on lag seven while the coefficients one, two and five of the market impact on the bid-side influence the liquidity ratio 3 positively. The lagged returns show a negative relation to the liquidity ratio three with significance for lags three, six and seven.

Lagged spreads are related to lower returns with significance for lags one, three, five and six. Turnover has almost no impact on returns and dollar depth shows no influence at all. Market impact on the ask-side increases returns significantly on lags one to three, five and six. Market impact on the bid-side is followed by smaller returns with significance on almost all lags. The liquidity ratio 3 shows only a significantly positive effect on returns on lag five. Finally, lags one to three of returns lead to decreasing returns in time t. On the other hand, the coefficients of lags six and seven are significantly negative.

None of the constants is significantly different from zero. The adjusted R^2-values show the same picture as for the previous stocks.

5.19 Results of the VAR Model for Swatch Registered Share

The results of the vector autoregressive model for Swatch registered share are presented in table 5.17. All the liquidity measures depend negatively on its own lagged values with high significance. Also, for the return regression there is negative significance but only for lags one to four and six.

The relative spread depends positively on lagged turnover with significance on almost all lags. Only lag four of dollar depth leads to a significantly higher spread. Market impact on the ask-side has a positive influence on spread with significant lags two, five and seven. The influence of market impact on the bid-side is slightly positive on lag four and negative on lag seven. The liquidity ratio 3 leads to higher spreads with significance for lags one, two, four and five. Only lag two of returns is followed by a significantly smaller spread.

All the lagged relative spreads leads to significantly smaller turnover. Lagged dollar depth increases turnover significantly. The market impact on the ask-side has only a slightly negative influence on turnover, while market impact on the bid-side does not change turnover at all. The interrelation of the liquidity ratio 3 and turnover shows no significance in both directions. Nor do the returns have impact on turnover.

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.61***	–5'242'645***	–908'417***	–0.01	37.41***	0.09***	–0.13***
$SrelM_{t-2}$	–0.51***	–4'605'217***	–1'177'303***	2.05	34.77**	0.11***	–0.11***
$SrelM_{t-3}$	–0.36***	–4'027'390***	–1'096'006**	4.45***	43.94***	0.10***	–0.04
$SrelM_{t-4}$	–0.33***	–2'832'844***	–968'529**	3.84**	4.27	0.07***	–0.04
$SrelM_{t-5}$	–0.25***	–2'943'521***	–939'458**	2.07	19.37	0.05***	0.00
$SrelM_{t-6}$	–0.18***	–2'218'883***	–753'550*	2.67	1.87	0.04***	–0.02
$SrelM_{t-7}$	–0.12***	–1'259'966**	–590'679*	2.56**	–0.86	0.04***	–0.03
V_{t-1}	$1.30 \cdot 10^{-9}$***	-0.729***	–0.008	$4.73 \cdot 10^{-8}$*	$1.15 \cdot 10^{-7}$	$2.31 \cdot 10^{-10}$	$4.43 \cdot 10^{-10}$
V_{t-2}	$1.53 \cdot 10^{-9}$***	–0.570***	–0.011	$8.69 \cdot 10^{-8}$***	$8.66 \cdot 10^{-7}$***	$1.43 \cdot 10^{-10}$	$-1.29 \cdot 10^{-9}$**
V_{t-3}	$1.50 \cdot 10^{-9}$***	–0.461***	0.003	$4.78 \cdot 10^{-8}$	$7.39 \cdot 10^{-7}$**	$1.85 \cdot 10^{-10}$	$-4.86 \cdot 10^{-10}$
V_{t-4}	$1.12 \cdot 10^{-9}$***	–0.369***	–0.003	$6.66 \cdot 10^{-8}$**	$9.18 \cdot 10^{-7}$***	$2.04 \cdot 10^{-10}$	$-9.72 \cdot 10^{-10}$*
V_{t-5}	$1.14 \cdot 10^{-9}$***	–0.280***	–0.007	$7.65 \cdot 10^{-8}$**	$6.74 \cdot 10^{-7}$**	$9.92 \cdot 10^{-11}$	$-6.13 \cdot 10^{-10}$
V_{t-6}	$4.49 \cdot 10^{-10}$	–0.186***	0.001	$6.53 \cdot 10^{-8}$**	$3.29 \cdot 10^{-7}$	$2.03 \cdot 10^{-10}$	$5.80 \cdot 10^{-11}$
V_{t-7}	$6.22 \cdot 10^{-10}$**	–0.101***	0.006	$1.24 \cdot 10^{-8}$	$-9.52 \cdot 10^{-8}$	$1.12 \cdot 10^{-10}$	$5.89 \cdot 10^{-10}$
$D\$_{t-1}$	$-3.77 \cdot 10^{-10}$	0.121***	–0.576***	$1.14 \cdot 10^{-8}$	$-7.07 \cdot 10^{-7}$	$-3.81 \cdot 10^{-10}$	$1.22 \cdot 10^{-9}$
$D\$_{t-2}$	$-8.08 \cdot 10^{-11}$	0.098***	–0.406***	$-1.06 \cdot 10^{-7}$**	$-5.02 \cdot 10^{-8}$	$-6.69 \cdot 10^{-10}$**	$2.03 \cdot 10^{-9}$**
$D\$_{t-3}$	$7.10 \cdot 10^{-11}$	0.120***	–0.308***	$-7.33 \cdot 10^{-8}$	$4.60 \cdot 10^{-7}$	$-6.38 \cdot 10^{-10}$*	$2.40 \cdot 10^{-10}$
$D\$_{t-4}$	$1.47 \cdot 10^{-9}$**	0.093***	–0.237***	$-4.41 \cdot 10^{-8}$	$9.67 \cdot 10^{-7}$	$2.00 \cdot 10^{-10}$	$8.39 \cdot 10^{-10}$
$D\$_{t-5}$	$7.86 \cdot 10^{-10}$	0.081***	–0.175***	$-3.29 \cdot 10^{-8}$	$3.49 \cdot 10^{-7}$	$-1.93 \cdot 10^{-11}$	$5.07 \cdot 10^{-10}$
$D\$_{t-6}$	$-7.54 \cdot 10^{-10}$	0.057***	–0.130***	$-1.01 \cdot 10^{-7}$*	$2.96 \cdot 10^{-7}$	$-6.40 \cdot 10^{-10}$*	$6.46 \cdot 10^{-10}$
$D\$_{t-7}$	$4.93 \cdot 10^{-10}$	0.058***	–0.057***	$-8.19 \cdot 10^{-8}$*	$-2.75 \cdot 10^{-7}$	$-3.36 \cdot 10^{-10}$	$1.18 \cdot 10^{-9}$
MI_{t-1}^{A,V^*}	$-1.16 \cdot 10^{-5}$	–6'452	–354	–0.368***	0.057	$-1.40 \cdot 10^{-4}$*	$4.81 \cdot 10^{-4}$**
MI_{t-2}^{A,V^*}	$2.43 \cdot 10^{-4}$*	–11'458*	4'341	–0.303***	–0.005	$1.14 \cdot 10^{-4}$	$6.09 \cdot 10^{-4}$**
MI_{t-3}^{A,V^*}	$1.31 \cdot 10^{-4}$	–10'275	9'689**	–0.261***	0.358**	$2.33 \cdot 10^{-5}$	$6.85 \cdot 10^{-4}$***
MI_{t-4}^{A,V^*}	$2.19 \cdot 10^{-4}$	–5'214	3'300	–0.188***	0.019	$3.19 \cdot 10^{-5}$	$4.20 \cdot 10^{-4}$*
MI_{t-5}^{A,V^*}	$2.88 \cdot 10^{-4}$*	–5'032	13'404***	–0.133***	–0.019	$-1.86 \cdot 10^{-5}$	$5.71 \cdot 10^{-4}$**
MI_{t-6}^{A,V^*}	$1.33 \cdot 10^{-4}$	–4'369	10'178***	–0.119***	–0.024	$1.64 \cdot 10^{-4}$**	$3.16 \cdot 10^{-4}$
MI_{t-7}^{A,V^*}	$2.81 \cdot 10^{-4}$**	–1'418	13'181***	–0.071***	–0.091	$1.01 \cdot 10^{-4}$	$3.05 \cdot 10^{-4}$
MI_{t-1}^{B,V^*}	$1.98 \cdot 10^{-5}$	748	–306	0.003**	–0.450***	$1.01 \cdot 10^{-6}$	$-7.13 \cdot 10^{-5}$***
MI_{t-2}^{B,V^*}	$9.98 \cdot 10^{-6}$	652	–433	$4.78 \cdot 10^{-4}$	–0.344***	$3.77 \cdot 10^{-6}$	$-4.67 \cdot 10^{-5}$**
MI_{t-3}^{B,V^*}	$-9.83 \cdot 10^{-6}$	671	–189	$-4.86 \cdot 10^{-4}$	–0.263***	$9.12 \cdot 10^{-6}$	$-5.66 \cdot 10^{-6}$
MI_{t-4}^{B,V^*}	$2.75 \cdot 10^{-5}$*	–117	–352	$-8.93 \cdot 10^{-5}$	–0.266***	$9.22 \cdot 10^{-6}$	$-2.80 \cdot 10^{-5}$
MI_{t-5}^{B,V^*}	$2.35 \cdot 10^{-5}$	–824	–348	–0.002	–0.135***	$1.46 \cdot 10^{-5}$*	$-2.67 \cdot 10^{-5}$
MI_{t-6}^{B,V^*}	$8.29 \cdot 10^{-6}$	–539	–76	–0.003**	–0.114***	$6.63 \cdot 10^{-6}$	$-6.19 \cdot 10^{-5}$***
MI_{t-7}^{B,V^*}	$-2.59 \cdot 10^{-5}$**	658	509	–0.003***	–0.056***	$1.91 \cdot 10^{-5}$***	$-7.18 \cdot 10^{-5}$***
$LR3_{t-1}$	0.045**	289'171	164'757	–1.45	–33.80	–0.849***	0.033
$LR3_{t-2}$	0.072**	–760'574	1'121'860	–3.13	–43.17	–0.704***	0.050
$LR3_{t-3}$	0.045	–815'099	365'735	–2.22	–20.07	–0.611***	0.021
$LR3_{t-4}$	0.083**	–1'203'448	–168'619	–1.09	4.55	–0.485***	–0.033
$LR3_{t-5}$	0.065**	–1'079'486	169'002	–1.29	–45.39	–0.374***	–0.043
$LR3_{t-6}$	0.008	–1'167'328	–363'327	–0.65	–22.52	–0.251***	–0.029
$LR3_{t-7}$	–0.010	375'117	–101'239	–1.01	0.80	–0.108***	0.036
r_{t-1}	–0.005	410'838	231'868	–2.09***	–12.62*	–0.007	–0.197***
r_{t-2}	–0.017**	179'288	177'390	–1.41*	–9.61	0.007	–0.103***
r_{t-3}	–0.002	–390'473	–70'272	–2.70***	1.26	–0.003	–0.058***
r_{t-4}	–0.002	232'055	–196'656	–0.73	–8.78	0.003	–0.032**
r_{t-5}	–0.004	65'894	–45'214	0.74	–5.36	–0.003	–0.008
r_{t-6}	–0.005	–62'915	193'900	–0.73	11.21	0.005	–0.023*
r_{t-7}	0.006	252'472	332'937*	–0.53	15.51**	–0.010**	0.018
C	0.00	43.90	107.59	0.00	0.00	0.00	0.00
$Adj.R^2$	0.29	0.36	0.26	0.15	0.19	0.43	0.06

Table 5.17: Vector autoregressive model of Swatch registered share with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

Dollar depth is negatively affected by the spread on all lags, while lagged turnover does not change depth. The market impact on the ask-side leads to higher dollar depth with significance for lags three and five to seven. Market impact on the bid-side does not change depth and, vice versa, lagged dollar depth has no influence on the market impact on the bid-side. Dollar depth is not significantly changed by the liquidity ratio 3 and, also, return shows only a slightly positive impact on lag seven.

The relative spread increases the market impact measures. For the ask-side there is significance for lags three, four and seven, and on the bid-side the first three lags are significantly different from zero. Rising turnover leads to increasing market impact measures; on the ask-side with lags one, two and four to six, and on the bid-side with lags two to five. Lags two, six and seven have a significantly negative influence on the market impact on the ask-side. Market impact on the bid-side on lag one is followed by an increasing market impact on the ask-side. On the other hand, lags six and seven are negatively significant. The lagged liquidity ratio 3 has no significant influence on the market impact measures. Rising stock prices have a positive effect on market impact on the ask-side with significance on the first three lags.

The market impact on the bid-side is positively affected by market impact on the ask-side on lag three. Returns lead to a significantly lower market impact on the bid-side on lag one. On lag seven there is a significantly positive interrelation.

The spread induces a higher liquidity ratio 3 with significance on all lags. Rising dollar depth decreases the liquidity ratio 3 significantly on lags two and three. Market impact on the ask-side has a slightly negative influence on the liquidity ratio 3 on lag one while lag six is positive. The market impact on the bid-side affects the liquidity ratio 3 positively with significance for lags five and seven. Only the return on lag seven has a significantly negative influence on the liquidity ratio 3.

Rising spreads lead to decreasing stock prices as the first two lags of the return regression show. Also, rising turnover leads to smaller returns on lags two and four. Dollar depth increases returns with significance on lag two. Market impact on the ask-side is related to higher stock prices with its lags up to five. Market impact on the bid-side decreases returns with significance for lags one, two, six and seven. The liquidity ratio 3 has no impact on returns.

The constants of the vector autoregressive model are essentially zero. The R^2-values are similar to the ones of the other stocks, so far.

5.20 Results of the VAR Model for Unaxis

For the last stock in the sample, Unaxis, the results of the vector autoregressive model are presented in table 5.18. Also for this stock there is a highly significant impact of the lagged liquidity measures on liquidity measures in time t. Only the coefficient of the market impact on the ask-side on lag seven is not significant. For the return regression the first four coefficients are significantly negative.

Rising turnover leads to higher spreads. Rising dollar depth is followed by declining spreads with significance for lags three, six and seven. Both market impact measures increase the spread with significance for lags two, three, five and seven on the ask-side and one to

	$SrelM_t$	V_t	$D\$_t$	MI_t^{A,V^*}	MI_t^{B,V^*}	$LR3_t$	r_t
$SrelM_{t-1}$	–0.64***	–7'834'366***	–523'871	–37.71**	92.61	0.07***	–0.02
$SrelM_{t-2}$	–0.50***	–5'234'656***	–1'338'317**	–23.56	–145.86	0.06***	–0.03
$SrelM_{t-3}$	–0.37***	–4'556'078***	–1'459'049***	4.98	–129.03	0.07***	–0.04
$SrelM_{t-4}$	–0.32***	–3'706'820***	–1'524'205***	39.19*	365.84***	0.06***	–0.03
$SrelM_{t-5}$	–0.24***	–3'651'670***	–469'981	29.89	77.65	0.06***	–0.07**
$SrelM_{t-6}$	–0.17***	–2'600'022**	–105'217	39.65*	128.38	0.04***	–0.01
$SrelM_{t-7}$	–0.08***	–1'193'057	–28'006	30.39*	347.91***	0.03***	0.01
V_{t-1}	$5.41 \cdot 10^{-10}$***	–0.716***	0.009*	$-2.00 \cdot 10^{-8}$	$9.53 \cdot 10^{-7}$	$2.18 \cdot 10^{-10}$**	$-3.43 \cdot 10^{-10}$
V_{t-2}	$8.34 \cdot 10^{-10}$***	–0.587***	0.007	$-1.29 \cdot 10^{-7}$	$1.55 \cdot 10^{-6}$	$2.78 \cdot 10^{-10}$**	$-3.28 \cdot 10^{-10}$
V_{t-3}	$7.91 \cdot 10^{-10}$***	–0.447***	–0.003	$5.58 \cdot 10^{-8}$	$8.52 \cdot 10^{-7}$	$3.88 \cdot 10^{-10}$***	$6.93 \cdot 10^{-11}$
V_{t-4}	$6.58 \cdot 10^{-10}$***	–0.347***	–0.004	$3.74 \cdot 10^{-7}$	$9.71 \cdot 10^{-8}$	$4.24 \cdot 10^{-10}$***	$1.14 \cdot 10^{-10}$
V_{t-5}	$6.33 \cdot 10^{-10}$***	–0.282***	0.006	$5.54 \cdot 10^{-7}$*	$1.98 \cdot 10^{-7}$	$2.14 \cdot 10^{-10}$*	$-2.16 \cdot 10^{-10}$
V_{t-6}	$5.99 \cdot 10^{-10}$***	–0.219***	–0.001	$2.74 \cdot 10^{-7}$	$-7.19 \cdot 10^{-7}$	$2.17 \cdot 10^{-10}$*	$-4.29 \cdot 10^{-10}$
V_{t-7}	$4.81 \cdot 10^{-10}$***	–0.112***	–0.002	$1.84 \cdot 10^{-7}$	$-3.70 \cdot 10^{-7}$	$1.64 \cdot 10^{-10}$*	$-1.35 \cdot 10^{-10}$
$D\$_{t-1}$	$-3.07 \cdot 10^{-10}$	0.239***	–0.583***	$1.37 \cdot 10^{-6}$**	$-7.76 \cdot 10^{-7}$	$-3.51 \cdot 10^{-10}$	$1.07 \cdot 10^{-9}$
$D\$_{t-2}$	$-6.30 \cdot 10^{-10}$	0.184***	–0.410***	$1.55 \cdot 10^{-6}$**	$-7.05 \cdot 10^{-7}$	$-4.48 \cdot 10^{-10}$	$8.26 \cdot 10^{-10}$
$D\$_{t-3}$	$-1.19 \cdot 10^{-9}$**	0.169***	–0.350***	$1.01 \cdot 10^{-6}$	$-6.09 \cdot 10^{-7}$	$-5.29 \cdot 10^{-10}$*	$5.78 \cdot 10^{-10}$
$D\$_{t-4}$	$-6.38 \cdot 10^{-10}$	0.143***	–0.298***	$7.44 \cdot 10^{-7}$	$-3.72 \cdot 10^{-6}$	$-5.08 \cdot 10^{-10}$*	$-3.35 \cdot 10^{-10}$
$D\$_{t-5}$	$-7.59 \cdot 10^{-10}$	0.191***	–0.220***	$1.21 \cdot 10^{-7}$	$-5.59 \cdot 10^{-6}$	$-3.98 \cdot 10^{-10}$	$4.62 \cdot 10^{-10}$
$D\$_{t-6}$	$-9.84 \cdot 10^{-10}$**	0.123***	–0.177***	$4.68 \cdot 10^{-8}$	$-6.76 \cdot 10^{-6}$*	$-5.94 \cdot 10^{-10}$**	$6.72 \cdot 10^{-10}$
$D\$_{t-7}$	$-1.53 \cdot 10^{-9}$***	0.047	–0.118***	$-3.70 \cdot 10^{-7}$	$-1.05 \cdot 10^{-5}$***	$-7.05 \cdot 10^{-10}$***	$9.40 \cdot 10^{-10}$
MI_{t-1}^{A,V^*}	$1.34 \cdot 10^{-6}$	–878	–173	–0.353***	–0.008	$2.39 \cdot 10^{-5}$***	$9.25 \cdot 10^{-6}$
MI_{t-2}^{A,V^*}	$2.29 \cdot 10^{-5}$**	–590	–50	–0.180***	–0.047	$1.67 \cdot 10^{-5}$***	$2.60 \cdot 10^{-5}$
MI_{t-3}^{A,V^*}	$2.12 \cdot 10^{-5}$**	–35	–107	–0.133***	0.065	$2.83 \cdot 10^{-6}$	$1.57 \cdot 10^{-5}$
MI_{t-4}^{A,V^*}	$1.60 \cdot 10^{-5}$	–1'223	–7	–0.079***	0.130	$4.98 \cdot 10^{-6}$	$2.77 \cdot 10^{-5}$
MI_{t-5}^{A,V^*}	$2.90 \cdot 10^{-5}$***	–694	–230	–0.053***	–0.088	$1.03 \cdot 10^{-5}$*	$3.40 \cdot 10^{-5}$**
MI_{t-6}^{A,V^*}	$5.50 \cdot 10^{-6}$	–59	–528*	–0.034**	0.003	$2.66 \cdot 10^{-6}$	$1.25 \cdot 10^{-5}$
MI_{t-7}^{A,V^*}	$2.46 \cdot 10^{-5}$***	–1'015	–217	–0.009	0.030	$4.06 \cdot 10^{-6}$	$3.50 \cdot 10^{-5}$**
MI_{t-1}^{B,V^*}	$5.27 \cdot 10^{-6}$***	–56	–2	0.001	–0.362***	$9.66 \cdot 10^{-7}$	$-6.27 \cdot 10^{-6}$**
MI_{t-2}^{B,V^*}	$4.76 \cdot 10^{-6}$***	47	–9	–0.002	–0.176***	$1.61 \cdot 10^{-6}$	$-6.20 \cdot 10^{-6}$**
MI_{t-3}^{B,V^*}	$3.88 \cdot 10^{-6}$**	–67	6	0.001	–0.138***	$5.36 \cdot 10^{-7}$	$-1.96 \cdot 10^{-6}$
MI_{t-4}^{B,V^*}	$2.52 \cdot 10^{-6}$	–51	9	–0.002	–0.069***	$4.05 \cdot 10^{-7}$	$-4.99 \cdot 10^{-6}$*
MI_{t-5}^{B,V^*}	$7.01 \cdot 10^{-7}$	–21	–45	–0.001	–0.039***	$1.37 \cdot 10^{-6}$	$-4.78 \cdot 10^{-7}$
MI_{t-6}^{B,V^*}	$3.39 \cdot 10^{-6}$**	–33	58	–0.007***	–0.076***	$1.55 \cdot 10^{-7}$	$-2.85 \cdot 10^{-7}$
MI_{t-7}^{B,V^*}	$1.89 \cdot 10^{-6}$	65	1	$-2.61 \cdot 10^{-4}$	–0.059***	$-1.12 \cdot 10^{-6}$	$-2.39 \cdot 10^{-6}$
$LR3_{t-1}$	–0.004	–913'725	–1'141'430*	–63.76**	33.16	–0.816***	0.007
$LR3_{t-2}$	0.009	–704'756	–488'864	–59.95	242.48	–0.660***	0.013
$LR3_{t-3}$	0.004	–2'412'198	–61'228	–31.84	–55.22	–0.547***	–0.016
$LR3_{t-4}$	–0.006	1'210'456	–1'355'956	–46.68	165.59	–0.448***	–0.062
$LR3_{t-5}$	–0.036	129'350	–1'977'427**	–60.77	–30.51	–0.318***	–0.023
$LR3_{t-6}$	–0.008	–154'874	–1'605'420*	–76.54**	–95.19	–0.236***	–0.044
$LR3_{t-7}$	0.012	–408'235	–767'422	–44.59	35.71	–0.122***	–0.009
r_{t-1}	–0.003	1'269'623**	166'531	–11.23	–83.70	0.002	–0.165***
r_{t-2}	–0.008	715'702	106'104	–28.44***	–11.71	0.004	–0.044***
r_{t-3}	–0.008	–38'810	328'718	–7.80	83.23	0.008*	–0.038***
r_{t-4}	–0.001	195'042	–70'173	–16.24	125.79**	–0.005	–0.040***
r_{t-5}	–0.008	108'410	–172'222	29.38***	288.73***	–0.002	–0.016
r_{t-6}	–0.014*	–367'570	–175'209	1.92	65.26	–0.003	0.001
r_{t-7}	0.011	–538'348	68'664	4.38	–14.06	–0.007*	0.006
C	0.00	142.06	–7.40	0.00	0.01	0.00	0.00
$Adj.R^2$	0.29	0.36	0.27	0.12	0.13	0.40	0.03

Table 5.18: Vector autoregressive model of Unaxis with the first differences of six liquidity measures and returns including seven lags. */**/*** denotes significance on a level of 10%/5%/1%.

three and six on the bid-side. The liquidity ratio 3 has no significant impact on the relative spread, while all lags of the relative spread are highly significant with respect to the liquidity ratio 3. Only returns on lag six have a slightly negative impact on the relative spread.

Turnover depends heavily on relative spreads up to lag six. The same holds for the effect of lagged dollar depth on turnover. The market impact measures do not influence turnover significantly. In the other direction from lagged turnover to the market impacts, there is only a slightly positive significance on the ask-side. The lagged liquidity ratio 3 has no impact on turnover. Return on lag one leads to a significantly higher turnover in time t.

The relative spread is related to lower dollar depth on lags two to four. Turnover has only a slightly positive influence on depth with lag one. Depth, almost, does not depend on the market impact measures. There is only a small significance for lag six of the market impact on the ask-side. The liquidity ratio 3 is followed by a declining dollar depth, with significance for lags one, five and six. Between dollar depth and returns there is no interrelation in either direction.

The first lag of the relative spread decreases market impact on the ask-side, while lags four, six and seven show a slightly positive significance. Market impact depends positively on the first two lags of dollar depth. Lag six of the market impact on the bid-side is related to a declining market impact on the ask-side. The liquidity ratio 3 decreases market impact on the ask-side, with significance for lags one and six. Return has a negative influence on lag two with respect to market impact on the ask-side, while lag five is significantly positive.

Lags four and seven of the relative spread are related to a rising market impact on the bid-side. Rising dollar depth leads to a decrease in market impact on the bid-side, as lags six and seven show. Market impact on the ask-side has no significant influence on market impact on the bid-side. There is no interrelation of market impact on the bid-side and the liquidity ratio 3 in both directions. Rising stock prices lead to a rise in market impact on the bid-side as lags four and five show.

Rising turnover is followed by a rising liquidity ratio 3 with significance on all lags. An increase in dollar depth is related to a smaller liquidity ratio 3, with significance for lags three, four, six and seven. Market impact on the ask-side has a positive effect on the liquidity ratio 3, as lags one, two and five show. There is only slight significance for the impact of returns on the liquidity ratio 3.

The relative spread is related to negative returns with significance on lag five. Lagged turnover does not influence returns. Market impact on the ask-side leads to rising stock prices on lags five and seven. Similarly, market impact on the bid-side leads to declining returns with significance for lags one, two and four. The liquidity ratio 3 does not affect returns significantly.

All the constants of the vector autoregressive model are virtually zero and the adjusted R^2-values are in line with the other stocks.

5.21 General Results of the Vector Autoregressive Model

The following interrelations among the seven variables of the vector autoregressive model hold more or less across all the eighteen stocks:

- All the changes in liquidity measures depend negatively on their own lags.

Since there is high autocorrelation among the variables, they do not follow a random walk but tend to return to their long range mean.

- The relative spread is positively influenced by turnover.

  Increasing trading activity due to market orders (or marketable limit orders) cancels the best bid and ask quotes and leads, therefore, to a higher spread.

- The market impact measures increase the spread.

  Due to a thin order book on one or the other side of the order book, trades delete the best bid or ask quote more rapidly and the spread rises.

- Turnover depends negatively on the relative spread.

  A higher spread makes trading more costly and causes, therefore, less turnover.

- Dollar depth increases turnover.

  The same argument as above holds: a high depth makes trading cheaper and causes, therefore, higher turnover.

- The market impact on the ask-side decreases turnover.

  If the market impact is high, larger trades become more expensive because they have to walk the book to be executed. Therefore, market impact induces less turnover. For market impact on the bid-side the effect is not that clear.

- A rising spread decreases dollar depth.

  This effect is more difficult to justify from an economic point of view. One explanation may be that, since a large spread is a sign of uncertainty in the market, market participants may be more prudent and reduce there positions at the best bid and ask quotes.

- Rising turnover increases the market impact on the bid- and the ask-side.

  Higher turnover, due to market orders, takes depth away and leads, therefore, to higher market impacts.

- Rising Market impact on the ask-side increases market impact on the bid-side.

  In the other direction, the effect is not very pronounced. The asymmetry of this empirical finding is difficult to explain. Increased trading activity in the market may lead to a thinner order book on both sides of the market, but there is no reason for the one side of the market to react first.

- A rising relative spread leads to a larger liquidity ratio 3.

  Since the rising spread decreases turnover the liquidity ratio 3 must rise.

- Market impact on the bid-side leads to a larger liquidity ratio 3.

  Fewer stocks show this effect for the market impact on the ask-side. Since the liquidity ratio 3 is calculated with the absolute return in the numerator it is difficult to justify why the effect is different for the bid- and the ask-side of the order book.

- Market impact on the ask-side leads to higher stock prices; market impact on the bid-side makes stock prices decline.

  If liquidity on the ask-side of the order book is already scarce, subsequent market orders lead to higher stock prices. For the bid-side the opposite holds.

- All of the constants of the vector autoregressive model are zero.

  Since the model is built with the differences of the liquidity measures and there is no trend in liquidity the constants must be zero.

Chapter 6

Prediction Models for the Liquidity Measures

From the vector autoregressive model we have hints which variables are leading indicators for the liquidity measures. In this chapter linear models are built to predict the liquidity measures. First, the parameters are estimated using a sliding window of 300 data points which corresponds to an estimation period of three days. Then the prediction of the changes in the liquidity measure is calculated with the estimated coefficients. The methodology is similar to Wang (2002). To determine the fit of the models I calculate the mean squared errors of the prediction, as described in Hamilton (1994), instead of the adjusted R^2-values.

The models are compared to two benchmarks: I calculate the mean squared error of an adaptive expectation which takes the change of the liquidity measures in time t as prediction for time $t+1$. Since the first differences of the liquidity measures show negative autocorrelation, I additionally calculate the mean squared error between the negative change of the liquidity measure in time t and the change in $t+1$.

6.1 Predicting the Relative Spread

The results from the vector autoregressive model across the 18 stocks show that the relative spread depends negatively on the lagged spread itself. The dependence on turnover and the market impact measures is mainly positive, while the return has a negative impact. Therefore, these five variables are included in the model. I propose three different models which use a different number of lags to estimate the regression parameters.

Model 1, which is shown in equation 6.1, includes the spread, turnover, market impact on the ask- and on the bid-side and returns of the first lag:

$$\begin{aligned} dSrelM_t = c \quad &+ \quad \beta_1 \cdot dSrelM_{t-1} + \beta_2 \cdot dV_{t-1} + \beta_3 \cdot dMI_{t-1}^{A,V^*} \\ &+ \quad \beta_4 \cdot dMI_{t-1}^{B,V^*} + \beta_5 \cdot r_{t-1} + \varepsilon \end{aligned} \tag{6.1}$$

In addition to model 1, the second model in equation 6.2 includes the second lag of the relative spread and of turnover.

$$\begin{aligned} dSrelM_t = c \quad &+ \quad \beta_1 \cdot dSrelM_{t-1} + \beta_2 \cdot dSrelM_{t-2} + \beta_3 \cdot dV_{t-1} + \beta_4 \cdot dV_{t-2} \\ &+ \quad \beta_5 \cdot dMI_{t-1}^{A,V^*} + \beta_6 \cdot dMI_{t-1}^{B,V^*} + \beta_7 \cdot r_{t-1} + \varepsilon \end{aligned} \tag{6.2}$$

Model 3 takes, in addition, the third lag of the relative spread and of turnover into account, as equation 6.3 shows. Therefore, nine coefficients and the constant have to be estimated.

$$\begin{aligned} dSrelM_t = c \quad &+ \quad \beta_1 \cdot dSrelM_{t-1} + \beta_2 \cdot dSrelM_{t-2} + \beta_3 \cdot dSrelM_{t-3} \\ &+ \quad \beta_4 \cdot dV_{t-1} + \beta_5 \cdot dV_{t-2} + \beta_6 \cdot dV_{-3} \\ &+ \quad \beta_7 \cdot dMI_{t-1}^{A,V^*} + \beta_8 \cdot dMI_{t-1}^{B,V^*} + \beta_9 \cdot r_{t-1} + \varepsilon \end{aligned} \tag{6.3}$$

	Model 1	Model 2	Model 3	$dSrelM_{t-1}$	$-dSrelM_{t-1}$
ADEN	$2.16 \cdot 10^{-6}$	$2.01 \cdot 10^{-6}$	$1.95 \cdot 10^{-6}$	$7.32 \cdot 10^{-6}$	$2.96 \cdot 10^{-6}$
BAER	$3.69 \cdot 10^{-6}$	$3.47 \cdot 10^{-6}$	$3.35 \cdot 10^{-6}$	$1.15 \cdot 10^{-5}$	$4.28 \cdot 10^{-6}$
CFR	$4.47 \cdot 10^{-6}$	$4.22 \cdot 10^{-6}$	$4.09 \cdot 10^{-6}$	$1.32 \cdot 10^{-5}$	$6.07 \cdot 10^{-6}$
CIBN	$1.06 \cdot 10^{-6}$	$9.86 \cdot 10^{-7}$	$9.65 \cdot 10^{-7}$	$3.44 \cdot 10^{-6}$	$1.45 \cdot 10^{-6}$
CLN	$4.10 \cdot 10^{-6}$	$3.81 \cdot 10^{-6}$	$3.70 \cdot 10^{-6}$	$1.33 \cdot 10^{-5}$	$5.43 \cdot 10^{-6}$
GIVN	$1.39 \cdot 10^{-6}$	$1.31 \cdot 10^{-6}$	$1.28 \cdot 10^{-6}$	$4.41 \cdot 10^{-6}$	$1.92 \cdot 10^{-6}$
HOL	$1.37 \cdot 10^{-6}$	$1.29 \cdot 10^{-6}$	$1.24 \cdot 10^{-6}$	$4.65 \cdot 10^{-6}$	$1.84 \cdot 10^{-6}$
KUD	$6.74 \cdot 10^{-6}$	$6.19 \cdot 10^{-6}$	$6.01 \cdot 10^{-6}$	$2.30 \cdot 10^{-5}$	$9.22 \cdot 10^{-6}$
LONN	$1.93 \cdot 10^{-6}$	$1.79 \cdot 10^{-6}$	$1.72 \cdot 10^{-6}$	$5.16 \cdot 10^{-6}$	$2.28 \cdot 10^{-6}$
RUKN	$8.45 \cdot 10^{-7}$	$7.72 \cdot 10^{-7}$	$7.34 \cdot 10^{-7}$	$3.16 \cdot 10^{-6}$	$1.11 \cdot 10^{-6}$
SCMN	$6.60 \cdot 10^{-7}$	$6.34 \cdot 10^{-7}$	$6.12 \cdot 10^{-7}$	$2.30 \cdot 10^{-6}$	$8.94 \cdot 10^{-7}$
SEO	$3.24 \cdot 10^{-6}$	$2.93 \cdot 10^{-6}$	$2.85 \cdot 10^{-6}$	$1.01 \cdot 10^{-5}$	$4.22 \cdot 10^{-6}$
SGSN	$5.13 \cdot 10^{-6}$	$4.80 \cdot 10^{-6}$	$4.65 \cdot 10^{-6}$	$1.39 \cdot 10^{-5}$	$7.20 \cdot 10^{-6}$
SUN	$6.40 \cdot 10^{-6}$	$6.05 \cdot 10^{-6}$	$5.98 \cdot 10^{-6}$	$1.72 \cdot 10^{-5}$	$9.28 \cdot 10^{-6}$
SYNN	$2.36 \cdot 10^{-6}$	$2.24 \cdot 10^{-6}$	$2.21 \cdot 10^{-6}$	$7.17 \cdot 10^{-6}$	$3.25 \cdot 10^{-6}$
UHR	$5.27 \cdot 10^{-6}$	$4.98 \cdot 10^{-6}$	$4.90 \cdot 10^{-6}$	$1.73 \cdot 10^{-5}$	$7.27 \cdot 10^{-6}$
UHRN	$8.58 \cdot 10^{-6}$	$7.98 \cdot 10^{-6}$	$7.93 \cdot 10^{-6}$	$2.57 \cdot 10^{-5}$	$1.16 \cdot 10^{-5}$
UNAX	$5.12 \cdot 10^{-6}$	$4.72 \cdot 10^{-6}$	$4.60 \cdot 10^{-6}$	$1.55 \cdot 10^{-5}$	$6.69 \cdot 10^{-6}$
Average	$3.58 \cdot 10^{-6}$	$3.34 \cdot 10^{-6}$	$3.26 \cdot 10^{-6}$	$1.10 \cdot 10^{-5}$	$4.86 \cdot 10^{-6}$

Table 6.1: Mean squared errors of the three prediction models for the relative spread and mean squared deviations of the changes in the relative spread in time t from the change in relative spread in time $t-1$ and from the negative change in relative spread in time $t-1$.

Table 6.1 presents the mean squared errors of the three models and the two benchmarks. The results for the prediction models for the relative spread are very clear: model 3, which includes three lags, performs best for every single stock and on average. It is followed by model two and model one, respectively. As suggested by the autocorrelations in the series of the liquidity measures, the prediction based on the negative change in the previous time space performs better than the prediction based on the positive change. But the prediction based on three models is clearly better than on the two sorts of "adaptive" information.

6.2 Predicting Turnover

As well as for the relative spread, three models are built for turnover and compared against each other and against turnover in the preceding time space. From the vector autoregressive model we know that turnover depends primarily on lagged turnover and relative spread negatively, and on dollar depth positively. The influence of the market impact measures is predominantly negative but not so clear-cut.

These five liquidity measures are used to predict turnover and model 1 includes the first lags:

$$\begin{aligned} dV_t = c &+ \beta_1 \cdot dV_{t-1} + \beta_2 \cdot dSrelM_{t-1} + \beta_3 \cdot dD\$_{t-1} \\ &+ \beta_4 \cdot dMI_{t-1}^{A,V^*} + \beta_5 \cdot dMI_{t-1}^{B,V^*} + \varepsilon \end{aligned} \tag{6.4}$$

In model 2 the second lags of turnover, relative spread and dollar depth are included. Since the influence of the market impact measures is not always clear, their second lags are left out. Therefore, model 2 includes eight variables:

$$\begin{aligned} dV_t = c &+ \beta_1 \cdot dV_{t-1} + \beta_2 \cdot dV_{t-2} + \beta_3 \cdot dSrelM_{t-1} + \beta_4 \cdot dSrelM_{t-2} \\ &+ \beta_5 \cdot dD\$_{t-1} + \beta_6 \cdot dD\$_{t-2} \\ &+ \beta_7 dMI_{t-1}^{A,V^*} + \beta_8 \cdot dMI_{t-1}^{B,V^*} + \varepsilon \end{aligned} \tag{6.5}$$

In addition to model 2, model 3 includes the third lags of turnover, relative spread and dollar depth:

$$\begin{aligned} dV_t = c &+ \beta_1 \cdot dV_{t-1} + \beta_2 \cdot dV_{t-2} + \beta_3 \cdot dV_{t-3} \\ &+ \beta_4 \cdot dSrelM_{t-1} + \beta_5 \cdot dSrelM_{t-2} + \beta_6 \cdot dSrelM_{t-3} \\ &+ \beta_7 \cdot dD\$_{t-1} + \beta_8 \cdot dD\$_{t-2} + \beta_9 \cdot dD\$_{t-3} \\ &+ \beta_{10} \cdot dMI_{t-1}^{A,V^*} + \beta_{11} \cdot dMI_{t-1}^{B,V^*} + \varepsilon \end{aligned} \tag{6.6}$$

Table 6.2 presents the mean squared errors of the prediction models for turnover with the respective benchmarks.

For sixteen of the eighteen stocks, model 3 performs best and has the smallest mean squared errors, on average. For Adecco, model 2, with only two lags included, shows the best results. For Surveillance it is the negative turnover in time t that is the best predictor for turnover in $t+1$.

6.3 Predicting Dollar Depth

The results of the vector autoregressive model for dollar depth show a clearly negative dependence on dollar depth itself as well as on the relative spread. The influence of the other liquidity measures and returns is ambiguous across the 18 stocks. Therefore, only two

	Model 1	Model 2	Model 3	dV	$-dV$
ADEN	$8.02 \cdot 10^{11}$	$7.47 \cdot 10^{11}$	$7.60 \cdot 10^{11}$	$2.55 \cdot 10^{12}$	$1.10 \cdot 10^{12}$
BAER	$1.28 \cdot 10^{11}$	$1.20 \cdot 10^{11}$	$1.14 \cdot 10^{11}$	$4.02 \cdot 10^{11}$	$1.52 \cdot 10^{11}$
CFR	$3.72 \cdot 10^{11}$	$3.51 \cdot 10^{11}$	$3.32 \cdot 10^{11}$	$1.08 \cdot 10^{12}$	$4.11 \cdot 10^{11}$
CIBN	$2.62 \cdot 10^{11}$	$2.43 \cdot 10^{11}$	$2.38 \cdot 10^{11}$	$9.22 \cdot 10^{11}$	$3.36 \cdot 10^{11}$
CLN	$6.72 \cdot 10^{10}$	$6.49 \cdot 10^{10}$	$6.25 \cdot 10^{10}$	$1.91 \cdot 10^{11}$	$7.73 \cdot 10^{10}$
GIVN	$4.40 \cdot 10^{11}$	$4.19 \cdot 10^{11}$	$4.12 \cdot 10^{11}$	$1.42 \cdot 10^{12}$	$5.64 \cdot 10^{11}$
HOL	$3.84 \cdot 10^{11}$	$3.61 \cdot 10^{11}$	$3.42 \cdot 10^{11}$	$1.13 \cdot 10^{12}$	$4.83 \cdot 10^{11}$
KUD	$5.27 \cdot 10^{10}$	$4.82 \cdot 10^{10}$	$4.68 \cdot 10^{10}$	$1.80 \cdot 10^{11}$	$7.09 \cdot 10^{10}$
LONN	$1.64 \cdot 10^{11}$	$1.55 \cdot 10^{11}$	$1.47 \cdot 10^{11}$	$5.37 \cdot 10^{11}$	$2.17 \cdot 10^{11}$
RUKN	$5.13 \cdot 10^{12}$	$4.74 \cdot 10^{12}$	$4.58 \cdot 10^{12}$	$1.63 \cdot 10^{13}$	$6.47 \cdot 10^{12}$
SCMN	$4.93 \cdot 10^{11}$	$4.77 \cdot 10^{11}$	$4.58 \cdot 10^{11}$	$1.61 \cdot 10^{12}$	$6.47 \cdot 10^{11}$
SEO	$3.88 \cdot 10^{11}$	$3.58 \cdot 10^{11}$	$3.50 \cdot 10^{11}$	$1.35 \cdot 10^{12}$	$5.08 \cdot 10^{11}$
SGSN	$7.89 \cdot 10^{10}$	$1.14 \cdot 10^{11}$	$1.15 \cdot 10^{11}$	$1.62 \cdot 10^{11}$	$5.98 \cdot 10^{10}$
SUN	$1.67 \cdot 10^{10}$	$1.37 \cdot 10^{10}$	$1.30 \cdot 10^{10}$	$4.21 \cdot 10^{10}$	$1.55 \cdot 10^{10}$
SYNN	$2.19 \cdot 10^{11}$	$2.18 \cdot 10^{11}$	$2.15 \cdot 10^{11}$	$6.65 \cdot 10^{11}$	$2.45 \cdot 10^{11}$
UHR	$9.09 \cdot 10^{10}$	$8.10 \cdot 10^{10}$	$7.92 \cdot 10^{10}$	$3.16 \cdot 10^{11}$	$1.09 \cdot 10^{11}$
UHRN	$1.99 \cdot 10^{10}$	$1.86 \cdot 10^{10}$	$1.80 \cdot 10^{10}$	$6.64 \cdot 10^{10}$	$2.52 \cdot 10^{10}$
UNAX	$3.20 \cdot 10^{10}$	$2.96 \cdot 10^{10}$	$2.89 \cdot 10^{10}$	$1.11 \cdot 10^{11}$	$4.32 \cdot 10^{10}$
Average	$5.08 \cdot 10^{11}$	$4.75 \cdot 10^{11}$	$4.62 \cdot 10^{11}$	$1.61 \cdot 10^{12}$	$6.41 \cdot 10^{11}$

Table 6.2: Mean squared errors of the three prediction models for turnover and mean squared deviations of the changes in turnover in time t from the change in turnover in time $t-1$ and from the negative change in turnover in time $t-1$.

liquidity measures are included to predict dollar depth. Model 1 makes use of the first lags of dollar depth and the relative spread:

$$dD\$_t = c + \beta_1 \cdot dD\$_{t-1} + \beta_2 \cdot dSrelM_{t-1} + \varepsilon \tag{6.7}$$

In model 2 the second lags of dollar depth and the relative spread are also included:

$$\begin{aligned} dD\$_t = c &+ \beta_1 \cdot dD\$_{t-1} + \beta_2 \cdot dD\$_{t-2} \\ &+ \beta_3 \cdot dSrelM_{t-1} + \beta_4 \cdot dSrelM_{t-2} + \varepsilon \end{aligned} \tag{6.8}$$

The third lags are added in model 3:

$$\begin{aligned} dD\$_t = c &+ \beta_1 \cdot dD\$_{t-1} + \beta_2 \cdot dD\$_{t-2} + \beta_3 \cdot dD\$_{t-3} \\ &+ \beta_4 \cdot dSrelM_{t-1} + \beta_5 \cdot dSrelM_{t-2} \\ &+ \beta_6 \cdot dSrelM_{t-3} + \varepsilon \end{aligned} \tag{6.9}$$

The results of the prediction models for dollar depth are presented in table 6.3. For two thirds of the 18 stocks, model 3 performs best, but the average mean squared error is smallest for model 1. For Surveillance and Swatch bearer share, model 1, which includes only one lag, has the smallest mean squared error. Model 2 shows the best results for Kudelski and

	Model 1	Model 2	Model 3	$dD\$$	$-dD\$$
ADEN	$2.23 \cdot 10^{12}$	$2.34 \cdot 10^{12}$	$2.39 \cdot 10^{12}$	$4.17 \cdot 10^{12}$	$1.42 \cdot 10^{12}$
BAER	$9.03 \cdot 10^{11}$	$8.29 \cdot 10^{11}$	$8.15 \cdot 10^{11}$	$3.03 \cdot 10^{12}$	$1.22 \cdot 10^{12}$
CFR	$2.67 \cdot 10^{10}$	$2.59 \cdot 10^{10}$	$2.57 \cdot 10^{10}$	$8.25 \cdot 10^{10}$	$3.87 \cdot 10^{10}$
CIBN	$5.09 \cdot 10^{10}$	$4.97 \cdot 10^{10}$	$4.96 \cdot 10^{10}$	$1.50 \cdot 10^{11}$	$7.62 \cdot 10^{10}$
CLN	$7.34 \cdot 10^{9}$	$7.00 \cdot 10^{9}$	$6.88 \cdot 10^{9}$	$2.22 \cdot 10^{10}$	$1.06 \cdot 10^{10}$
GIVN	$8.93 \cdot 10^{11}$	$8.92 \cdot 10^{11}$	$8.88 \cdot 10^{11}$	$2.53 \cdot 10^{12}$	$1.24 \cdot 10^{12}$
HOL	$5.04 \cdot 10^{10}$	$4.88 \cdot 10^{10}$	$4.83 \cdot 10^{10}$	$1.48 \cdot 10^{11}$	$7.50 \cdot 10^{10}$
KUD	$1.20 \cdot 10^{10}$	$1.19 \cdot 10^{10}$	$1.22 \cdot 10^{10}$	$3.45 \cdot 10^{10}$	$1.71 \cdot 10^{10}$
LONN	$4.11 \cdot 10^{10}$	$4.02 \cdot 10^{10}$	$3.99 \cdot 10^{10}$	$1.16 \cdot 10^{11}$	$9.19 \cdot 10^{10}$
RUKN	$3.74 \cdot 10^{11}$	$3.58 \cdot 10^{11}$	$3.55 \cdot 10^{11}$	$1.22 \cdot 10^{12}$	$5.26 \cdot 10^{11}$
SCMN	$7.10 \cdot 10^{10}$	$6.73 \cdot 10^{10}$	$6.60 \cdot 10^{10}$	$2.09 \cdot 10^{11}$	$1.05 \cdot 10^{11}$
SEO	$1.37 \cdot 10^{10}$	$1.27 \cdot 10^{10}$	$1.25 \cdot 10^{10}$	$4.51 \cdot 10^{10}$	$1.80 \cdot 10^{10}$
SGSN	$1.21 \cdot 10^{12}$	$1.36 \cdot 10^{12}$	$2.35 \cdot 10^{12}$	$3.59 \cdot 10^{12}$	$1.22 \cdot 10^{12}$
SUN	$8.70 \cdot 10^{9}$	$8.57 \cdot 10^{9}$	$8.98 \cdot 10^{9}$	$2.48 \cdot 10^{10}$	$1.21 \cdot 10^{10}$
SYNN	$2.18 \cdot 10^{11}$	$2.13 \cdot 10^{11}$	$2.63 \cdot 10^{11}$	$4.94 \cdot 10^{11}$	$1.71 \cdot 10^{11}$
UHR	$1.89 \cdot 10^{10}$	$1.96 \cdot 10^{10}$	$2.10 \cdot 10^{10}$	$5.10 \cdot 10^{10}$	$2.73 \cdot 10^{10}$
UHRN	$5.33 \cdot 10^{9}$	$5.13 \cdot 10^{9}$	$5.03 \cdot 10^{9}$	$1.67 \cdot 10^{10}$	$7.27 \cdot 10^{9}$
UNAX	$4.45 \cdot 10^{9}$	$4.30 \cdot 10^{9}$	$4.22 \cdot 10^{9}$	$1.40 \cdot 10^{10}$	$6.16 \cdot 10^{9}$
Average	$3.41 \cdot 10^{11}$	$3.49 \cdot 10^{11}$	$4.09 \cdot 10^{11}$	$8.86 \cdot 10^{11}$	$3.49 \cdot 10^{11}$

Table 6.3: Mean squared errors of the three prediction models for dollar depth and mean squared deviations of the changes in dollar depth in time t from the change in dollar depth in time $t-1$ and from the negative change in dollar depth in time $t-1$.

Sulzer. For Adecco and Syngenta, negative dollar depth of the preceding time space is the best predictor of dollar depth in time t.

6.4 Predicting Market Impact on the Ask-Side

Market impact on the ask-side depends negatively on lagged market impact on the ask-side itself and on returns. The influence of turnover and market impact on the bid-side is mainly positive while the other three liquidity measures show no consistent impact across the 18 stocks in the vector autoregressive model. The prediction model 1 for market impact on the ask-side in equation 6.10 includes, therefore, lagged market impact on the ask-side, turnover, market impact on the bid-side and returns.

$$\begin{aligned} dMI_t^{A,V^*} = c \quad &+ \quad \beta_1 \cdot dMI_{t-1}^{A,V^*} + \beta_2 \cdot dV_{t-1} \\ &+ \quad \beta_3 \cdot dMI_{t-1}^{B,V^*} + \beta_4 \cdot r_{t-1} + \varepsilon \end{aligned} \tag{6.10}$$

Model 2 adds the second lags of market impact on the ask-side, market impact on the bid-side and returns to model 1:

$$\begin{aligned} dMI_t^{A,V^*} = c &+ \beta_1 \cdot dMI_{t-1}^{A,V^*} + \beta_2 \cdot dMI_{t-2}^{A,V^*} + \beta_3 \cdot dV_{t-1} \\ &+ \beta_4 \cdot dMI_{t-1}^{B,V^*} + \beta_5 \cdot dMI_{t-2}^{B,V^*} \\ &+ \beta_6 \cdot r_{t-1} + \beta_7 \cdot r_{t-2} + \varepsilon \end{aligned} \tag{6.11}$$

Model 3 is built out of ten variables; the third lags of the market impact measures and returns are added to model 2:

$$\begin{aligned} dMI_t^{A,V^*} = c &+ \beta_1 \cdot dMI_{t-1}^{A,V^*} + \beta_2 \cdot dMI_{t-2}^{A,V^*} + \beta_3 \cdot dMI_{t-3}^{A,V^*} \\ &+ \beta_4 \cdot dV_{t-1} \\ &+ \beta_5 \cdot dMI_{t-1}^{B,V^*} + \beta_6 \cdot dMI_{t-2}^{B,V^*} + \beta_7 \cdot dMI_{t-3}^{B,V^*} \\ &+ \beta_8 \cdot r_{t-1} + \beta_9 \cdot r_{t-2} + \beta_{10} \cdot r_{t-3} + \varepsilon \end{aligned} \tag{6.12}$$

	Model 1	Model 2	Model 3	dMI^{A,V^*}	$-dMI^{A,V^*}$
ADEN	0.047	0.045	0.046	0.141	0.068
BAER	4.643	4.354	4.535	11.989	6.823
CFR	0.081	0.082	0.083	0.212	0.119
CIBN	0.050	0.050	0.050	0.142	0.074
CLN	0.231	0.236	0.241	0.626	0.344
GIVN	1.249	1.218	1.221	3.292	1.860
HOL	0.779	0.765	0.760	2.165	1.162
KUD	0.228	0.228	0.234	0.568	0.360
LONN	0.633	0.631	0.662	2.023	0.840
RUKN	0.029	0.027	0.026	0.106	0.039
SCMN	0.323	0.314	0.312	1.007	0.458
SEO	40.363	31.089	32.468	54.173	28.202
SGSN	7.270	7.433	7.535	17.736	11.185
SUN	7.598	7.958	8.551	17.940	11.520
SYNN	0.326	0.327	0.326	0.972	0.459
UHR	0.889	0.883	0.878	2.460	1.312
UHRN	0.061	0.062	0.063	0.156	0.095
UNAX	8.257	8.337	8.434	21.849	12.106
Average	4.059	3.558	3.690	7.642	4.279

Table 6.4: Mean squared errors of the three prediction models for market impact on the ask-side and mean squared deviations of the changes in market impact on the ask-side in time t from the change in market impact on the ask-side in time $t-1$ and from the negative change in market impact on the ask-side in time $t-1$.

For market impact on the ask-side no best prediction model can be selected from the results in table 6.4. As the bottom line shows, model 2 performs best, on average. But only for the four stocks Adecco, Baer, Givaudan and Lonza is model 2 really the best model. For seven out of the 18 stocks it is model 1 which shows the best results and for another six stocks it is model 3 which has the smallest mean squared errors. For Serono it is the negative market impact on the ask-side which yields the best prediction. This may be due to the extraordinarily high mean squared errors that the models show for Serono. The reason for the bad performance of the prediction models is the temporarily very thin order book which leads to huge changes in market impact on the ask-side.

6.5 Predicting Market Impact on the Bid-Side

For the prediction models of market impact on the bid-side, the same variables are included as for the market impact on the ask-side models. Model 1 in equation 6.13 is, therefore, built out of the first lags of market impact on the bid-side, turnover, market impact on the ask-side and returns.

$$\begin{aligned} dMI_t^{B,V^*} = c &+ \beta_1 \cdot dMI_{t-1}^{B,V^*} + \beta_2 \cdot dV_{t-1} \\ &+ \beta_3 \cdot dMI_{t-1}^{A,V^*} + \beta_4 \cdot r_{t-1} + \varepsilon \end{aligned} \tag{6.13}$$

Model 2 includes, in addition to model 1, the second lags of market impact on the bid-side, market impact on the ask-side and returns:

$$\begin{aligned} dMI_t^{B,V^*} = c &+ \beta_1 \cdot dMI_{t-1}^{B,V^*} + \beta_2 \cdot dMI_{t-2}^{B,V^*} + \beta_3 \cdot dV_{t-1} \\ &+ \beta_4 \cdot dMI_{t-1}^{A,V^*} + \beta_5 \cdot dMI_{t-2}^{A,V^*} \\ &+ \beta_6 \cdot r_{t-1} + \beta_7 \cdot r_{t-2} + \varepsilon \end{aligned} \tag{6.14}$$

Model 3 with ten variables takes also the third lags of market impact on the bid-side, market impact on the ask-side and returns into account:

$$\begin{aligned} dMI_t^{B,V^*} = c &+ \beta_1 \cdot dMI_{t-1}^{B,V^*} + \beta_2 \cdot dMI_{t-2}^{B,V^*} + \beta_3 \cdot dMI_{t-3}^{B,V^*} \\ &+ \beta_4 \cdot dV_{t-1} \\ &+ \beta_5 \cdot dMI_{t-1}^{A,V^*} + \beta_6 \cdot dMI_{t-2}^{A,V^*} + \beta_7 \cdot dMI_{t-3}^{A,V^*} \\ &+ \beta_8 \cdot r_{t-1} + \beta_9 \cdot r_{t-2} + \beta_{10} \cdot r_{t-3} + \varepsilon \end{aligned} \tag{6.15}$$

The mean squared errors for the prediction models of market impact on the bid-side in table 6.5 are much larger than on the ask-side. This is due to temporarily very low liquidity on the bid-side which led to huge changes in the bid-side-specific liquidity measure. The general picture is the same as for the ask-side: there is no model that is superior with respect to the others. On average, the negative change in market impact on the bid-side in time t is the best predictor of market impact on the bid-side in $t+1$. This result stems from the very poor performance of the other models for the Serono stock. If Serono had been excluded from the sample, model 2 would perform best. Aside from Serono, the negative change in market impact on the bid-side is the best predictor only for Lonza. Models 1 and 3 each show the best results for five of the 18 stocks. Model 2 is superior for six of the 18 stocks.

	Model 1	Model 2	Model 3	dMI^{B,V^*}	$-dMI^{B,V^*}$
ADEN	0.046	0.046	0.045	0.136	0.067
BAER	199.229	138.752	148.982	510.595	237.465
CFR	2.072	2.019	2.229	5.659	2.644
CIBN	0.048	0.047	0.047	0.142	0.068
CLN	2.378	2.684	2.839	7.204	2.380
GIVN	0.882	0.877	0.872	2.538	1.309
HOL	0.522	0.503	0.503	1.478	0.779
KUD	0.134	0.133	0.135	0.359	0.205
LONN	38.065	42.057	56.009	32.521	14.353
RUKN	0.037	0.035	0.034	0.130	0.051
SCMN	0.311	0.301	0.298	0.900	0.462
SEO	3990.374	4905.137	4843.680	835.655	296.248
SGSN	98.637	121.296	134.248	309.026	110.228
SUN	380.569	416.900	419.116	609.669	410.056
SYNN	0.147	0.138	0.142	0.440	0.192
UHR	0.463	0.446	0.449	1.408	0.663
UHRN	7.595	7.696	7.722	20.911	11.114
UNAX	287.150	289.330	292.538	772.398	423.433
Average	278.259	329.355	328.327	172.843	83.984

Table 6.5: Mean squared errors of the three prediction models for market impact on the bid-side and mean squared deviations of the changes in market impact on the bid-side in time t from the change in market impact on the bid-side in time $t-1$ and from the negative change in market impact on the bid-side in time $t-1$.

6.6 Predicting the Liquidity Ratio 3

The liquidity ratio 3 depends on its own lags negatively as the vector autoregressive model shows. The influence of the relative spread and of the market impact measures is predominantly positive. Therefore, model 1 in equation 6.16 for the prediction of the liquidity ratio 3 includes the first lags of these four liquidity measures. Turnover, dollar depth and returns are left out.

$$\begin{aligned} dLR3_t = c \quad &+ \quad \beta_1 \cdot dLR3_{t-1} + \beta_2 \cdot dSrelM_{t-1} \\ &+ \quad \beta_3 \cdot dMI^{A,V^*}_{t-1} + \beta_4 \cdot dMI^{B,V^*}_{t-1} + \varepsilon \end{aligned} \tag{6.16}$$

Model 2 includes, in addition to model 1, the second lag of the liquidity ratio 3 and the spread. Since the influence of the market impact measures on the liquidity ratio 3 is not that clear-cut across the 18 stocks, their second lags are left out in equation 6.17.

$$\begin{aligned} dLR3_t = c \quad &+ \quad \beta_1 \cdot dLR3_{t-1} + \beta_2 \cdot dLR3_{t-2} \\ &+ \quad \beta_3 \cdot dSrelM_{t-1} + \beta_4 \cdot dSrelM_{t-2} \\ &+ \quad \beta_5 \cdot dMI^{A,V^*}_{t-1} + \beta_6 \cdot dMI^{B,V^*}_{t-1} + \varepsilon \end{aligned} \tag{6.17}$$

In model 3 the third lags of the liquidity ratio 3 and the relative spread are added to model 2:

$$\begin{aligned} dLR3_t = c &+ \beta_1 \cdot dLR3_{t-1} + \beta_2 \cdot dLR3_{t-2} + \beta_3 \cdot dLR3_{t-3} \\ &+ \beta_4 \cdot dSrelM_{t-1} + \beta_5 \cdot dSrelM_{t-2} + \beta_6 \cdot dSrelM_{t-3} \\ &+ \beta_7 \cdot dMI_{t-1}^{A,V^*} + \beta_8 \cdot dMI_{t-1}^{B,V^*} + \varepsilon \end{aligned} \tag{6.18}$$

	Model 1	Model 2	Model 3	$dLR3$	$-dLR3$
ADEN	$4.12 \cdot 10^{-7}$	$3.75 \cdot 10^{-7}$	$3.54 \cdot 10^{-7}$	$1.55 \cdot 10^{-6}$	$5.73 \cdot 10^{-7}$
BAER	$1.72 \cdot 10^{-6}$	$1.58 \cdot 10^{-6}$	$1.52 \cdot 10^{-6}$	$6.08 \cdot 10^{-6}$	$2.22 \cdot 10^{-6}$
CFR	$1.15 \cdot 10^{-6}$	$1.05 \cdot 10^{-6}$	$1.01 \cdot 10^{-6}$	$4.06 \cdot 10^{-6}$	$1.44 \cdot 10^{-6}$
CIBN	$7.32 \cdot 10^{-7}$	$6.69 \cdot 10^{-7}$	$6.37 \cdot 10^{-7}$	$2.85 \cdot 10^{-6}$	$9.66 \cdot 10^{-7}$
CLN	$1.20 \cdot 10^{-6}$	$1.07 \cdot 10^{-6}$	$1.01 \cdot 10^{-6}$	$4.61 \cdot 10^{-6}$	$1.58 \cdot 10^{-6}$
GIVN	$7.40 \cdot 10^{-7}$	$6.66 \cdot 10^{-7}$	$6.30 \cdot 10^{-7}$	$2.69 \cdot 10^{-6}$	$9.99 \cdot 10^{-7}$
HOL	$4.56 \cdot 10^{-7}$	$4.17 \cdot 10^{-7}$	$3.99 \cdot 10^{-7}$	$1.75 \cdot 10^{-6}$	$6.03 \cdot 10^{-7}$
KUD	$1.67 \cdot 10^{-6}$	$1.55 \cdot 10^{-6}$	$1.48 \cdot 10^{-6}$	$6.20 \cdot 10^{-6}$	$2.29 \cdot 10^{-6}$
LONN	$1.12 \cdot 10^{-6}$	$9.85 \cdot 10^{-7}$	$9.37 \cdot 10^{-7}$	$3.79 \cdot 10^{-6}$	$1.35 \cdot 10^{-6}$
RUKN	$2.43 \cdot 10^{-7}$	$2.16 \cdot 10^{-7}$	$2.05 \cdot 10^{-7}$	$8.87 \cdot 10^{-7}$	$3.34 \cdot 10^{-7}$
SCMN	$2.58 \cdot 10^{-7}$	$2.31 \cdot 10^{-7}$	$2.19 \cdot 10^{-7}$	$1.01 \cdot 10^{-6}$	$3.55 \cdot 10^{-7}$
SEO	$7.37 \cdot 10^{-7}$	$6.61 \cdot 10^{-7}$	$6.38 \cdot 10^{-7}$	$2.66 \cdot 10^{-6}$	$9.65 \cdot 10^{-7}$
SGSN	$2.02 \cdot 10^{-6}$	$1.82 \cdot 10^{-6}$	$1.73 \cdot 10^{-6}$	$7.65 \cdot 10^{-6}$	$2.62 \cdot 10^{-6}$
SUN	$4.11 \cdot 10^{-6}$	$3.92 \cdot 10^{-6}$	$3.77 \cdot 10^{-6}$	$1.49 \cdot 10^{-5}$	$5.28 \cdot 10^{-6}$
SYNN	$7.07 \cdot 10^{-7}$	$6.38 \cdot 10^{-7}$	$6.11 \cdot 10^{-7}$	$2.66 \cdot 10^{-6}$	$9.82 \cdot 10^{-7}$
UHR	$2.12 \cdot 10^{-6}$	$1.95 \cdot 10^{-6}$	$1.84 \cdot 10^{-6}$	$8.23 \cdot 10^{-6}$	$2.81 \cdot 10^{-6}$
UHRN	$2.89 \cdot 10^{-6}$	$2.66 \cdot 10^{-6}$	$2.51 \cdot 10^{-6}$	$1.11 \cdot 10^{-5}$	$3.77 \cdot 10^{-6}$
UNAX	$1.97 \cdot 10^{-6}$	$1.83 \cdot 10^{-6}$	$1.78 \cdot 10^{-6}$	$7.03 \cdot 10^{-6}$	$2.44 \cdot 10^{-6}$
Average	$1.35 \cdot 10^{-6}$	$1.24 \cdot 10^{-6}$	$1.18 \cdot 10^{-6}$	$4.98 \cdot 10^{-6}$	$1.75 \cdot 10^{-6}$

Table 6.6: Mean squared errors of the three prediction models for the liquidity ratio 3 and mean squared deviations of the changes in the liquidity ratio 3 in time t from the change in the liquidity ratio 3 in time $t-1$ and from the negative change in the liquidity ratio 3 in time $t-1$.

The results of the prediction models for the liquidity ratio 3 are presented in table 6.6. Model 3 performs best in predicting the liquidity ratio 3 for each single stock and on average. The second-best model is model 2. This result is similar to the prediction model for the relative spread.

Chapter 7

Summary and Outlook

Liquidity is not a one-dimensional variable. Traditionally, the different dimensions of liquidity in a limit order book are trading time, depth, tightness and resiliency. These dimensions can be measured by a variety of liquidity measures as current research in this area shows. 31 of them, which are empirically used in the present dissertation, are described in the first chapter.

Intraday data was collected for a sample of 18 stocks of the Swiss Market Index which includes 65 trading days. With the order history reports of the Swiss Exchange the reconstruction of order books is possible. For this sample, the liquidity measures are calculated on a five-minute interval and compared to each other. Among the 18 stocks, there are huge differences in liquidity – over time and with respect to the other stocks. The stocks are ranked according to the different liquidity measures and a clear difference shows up between the most liquid stock in this study, Swiss Re, and the least liquid, Sulzer. The rankings of the stocks according to different liquidity measures are tested for their significance using the Spearman rank correlation test. Two groups of liquidity measures can be distinguished from this test: One group contains all the liquidity measures that depend on the absolute stock price, the other group contains the liquidity measures which are independent of the stock price. Only the order ratio cannot be attributed to one of those groups. For the eighteen stocks, the correlations of the liquidity measures are calculated – for each stock and on average. It is apparent that some measures describe the same changes in liquidity. Therefore, eight liquidity measures are sorted out.

With the remaining 23 liquidity measures, a principal component analysis is carried out for each stock to investigate how the different dimensions of liquidity can be incorporated in liquidity measures. Due to the right-skewed and fat-tailed distributional properties, this principal component analysis is based on the first differences of the liquidity measures. As it turns out, liquidity cannot be fully described by the above-mentioned four dimensions of liquidity. As a fifth and a sixth dimension a bid-side and an ask-side related liquidity had to be introduced. The six dimensions of liquidity are described by the relative spread, turnover, dollar depth, market impact on the ask-side and market impact on the bid-side.

To investigate the lead-lag patterns of liquidity, a vector autoregressive model is built with the changes of these six measures and returns. The changes in liquidity show negative autocorrelations; periods of high liquidity tend to be followed by periods of low liquidity and vice versa. Rising turnover and rising market impact measures lead to a higher relative spread. A rising relative spread and a rising market impact on the ask-side have a negative effect on turnover. For the market impact on the bid-side no such effect can be found. An increase in dollar depth also increases turnover. Also, declining liquidity as measured by the relative spread leads to a declining depth. A higher turnover is related to rising market impact on the ask-side and on the bid-side of the limit order book. Lower liquidity on the ask-side of the order book is followed by lower liquidity on the bid-side. No consistent influence from the bid-side to the ask-side of the order book can be found across the 18 stocks. A rising relative spread and a rising market impact on the bid-side lead to a higher liquidity ratio 3. Low liquidity on the ask-side leads to higher stock prices, low liquidity on the bid-side to lower ones. In general, the impact of returns on liquidity and vice versa is weak.

Linear prediction models are built for the six liquidity measures mentioned above, based on lagged liquidity and returns. The models for the relative spread, turnover and the liquidity ratio 3 show promising results, while the models for the market impact measures and – to a lesser extent – for dollar depth perform very poorly.

The prediction models of chapter 6 leave room for further research. Advanced models, using for example a GARCH approach, may lead to more accurate predictions of liquidity.

Another line of research would be the modelling of extreme events. With the data of stock market crashes it would be interesting to investigate whether the correlations and factor structures are stable in extreme market situations and whether the prediction of liquidity is still possible.

Finally, the impact of large orders entered in the order book is only poorly investigated so far. For decisions on how and when large orders should be placed in the order book, the development of liquidity in the aftermath of such large order placements may be crucial.

Appendix A

Liquidity Measures Not Used in the present Dissertation

This appendix describes liquidity measures that are not used in the empirical work.

A.1 Size of the Firm

Usually the liquidity measures related to firm size give a rather crude measure of liquidity, but they do pretty well in studies that use only monthly instead of higher frequency data. The following measures may be used:

- Market capitalization
- Free float

In line with the adjustment of the index calculation recently, free float is considered as the relevant measure. Only the free float part of the market capitalization can be traded at the exchange and is, therefore, relevant as a measure of market liquidity.

- Number of shareholders
- Number of market makers

In the present dissertation these four proxies for the size of firm are not investigated further[1] because in a context of daily or intradaily measurement they do not show enough variation. But they may be very useful in cross-sectional studies, as e.g. in Loderer & Roth (2001) for the Swiss market, that have a focus on the impact of liquidity on stock prices in the long run.

[1]Open interest as liquidity proxy for the futures market, which is used in Clyman et al. (1997), is obviously neglected in this dissertation.

A.2 Net Directional Volume

A refinement of the liquidity ratios 1, 2, and 3 is the net directional volume:

$$VNET_t = \ln \left| \sum_{i=1}^{N} (I_i \cdot q_i) \right|$$

$VNET_t$ captures the net directional volume over a so called "price-dura-tion". The price-duration is the time elapsed between significant price moves. This means that N is the number of trades while the market is moving for a predefined threshold-return in one direction. These price-durations are of different length which leads to a varying number of observations of $VNET_t$ per day. The number of price-durations depends on the price threshold, which has to be selected to the desired resolution. Engle & Lange (2001) consider ten price durations per day as reasonable to distinguish noise from informational events, which leads to price thresholds from USD 0.0625 to USD 0.25 for American stocks of different liquidity. The imbalance between the number of shares bought and sold shows the realized depth of the market. I_i is the direction of trade indicator which is +1 for a buyer-initiated and −1 for a seller-initiated trade.[2]

A.3 Variance Ratio

$$VR = \frac{k \cdot \sigma_{SP}^2}{\sigma_{LP}^2}$$

The variance ratio (or market efficiency coefficient) compares the return variance of a short period (e.g. ten minutes) σ_{SP}^2 to the return variance of a longer period (e.g. one day) σ_{LP}^2, where k is the number of short periods in the longer period. If the return series follows a random walk, the variance ratio equals one. Large execution cost rise the volatility of realized prices compared to the volatility of the equilibrium price. Therefore, liquidity ratios larger than one indicate illiquidity.[3] Ito, Lyons & Melvin (1998) use a similar measure $1 - \frac{1}{VR} = 1 - \frac{\sigma_{LP}^2}{k \cdot \sigma_{SP}^2}$, to investigate the activity on the Tokio FX market. In another study, Stoll & Whaley (1990) use the variance ratio to compare the volatility at the opening of the stock market with the volatility at the close.

[2] See Engle & Lange (2001).

[3] See Andersen & Bollerslev (1997), Baker (1996), Corwin (1999) or the similar measure in Ranaldo (2000).

Appendix B

Overview of Intraday Studies

The following table shows an overview of the studies using intraday data incorporated in this dissertation. The column labelled “Sort of intraday study” indicates the style of the study.

- “intraday” studies investigate phenomenons actually on a higher frequency than daily.
- “daily” studies consolidate the intraday data to get daily, or even less frequent measures.
- “quote/trade” studies try to find properties of the trades, orders or quotes.

The column “Subject” indicates the sort of data used. Most studies use stock market or foreign exchange data. The column “other” incorporates options, futures and bond data.

Study	Sort of intraday study			Subject		
	intraday	daily	quote/trade	Stocks	FX	other
Andersen & Bollerslev (1997)	x	x		x		x
Andersen & Bollerslev (1998)	x	x			x	
Bacidore (1997)		x	x	x		
Bacidore et al. (2002)		x	x	x		
Ball & Chordia (2001)			x	x		
Barclay et al. (1999)	x	x	x	x		
Battalio et al. (1998)			x	x		
Breedon & Holland (1997)	x					x
Brockman & Chung (2000)	x			x		
Butler et al. (2002)		x		x		
Chan & Pinder (2000)			x	x		x
Chan et al. (2002)	x	x		x		x
Chordia et al. (2000)		x		x		
Chordia, Roll & Subrahmanyam (2001)		x		x		
Christie & Schultz (1998)	x			x		
Chung et al. (1999)	x		x	x		
Chung & Van Ness (2001)	x			x		

Study	Sort of intraday study			Subject		
	intraday	daily	quote/trade	Stocks	FX	other
Clyman et al. (1997)			x			x
Clyman & Jaycobs (1998)			x			x
Coppejans & Domowitz (2002)	x		x			x
Coppejans et al. (2003)	x					x
Corwin (1999)	x			x		
Corwin & Lipson (2000)	x			x		
Daníelsson & Payne (2002)	x				x	
Engle & Lange (2001)	x			x		
Fleming & Remolona (1999)	x					x
George & Hwang (1998)	x			x		
Gervais et al. (2001)		x		x		
Goldstein & Kavajecz (2000)	x			x		
Gomber & Schweickert (2002)	x			x		
Gouriéroux et al. (1999)	x			x		
Grammig et al. (2001)	x			x		
Greene & Smart (1999)	x			x		
Hamao & Hasbrouck (1995)	x	x		x		
Harris et al. (2002)	x			x		
Hasbrouck (1999)	x			x		
Hasbrouck (2003)	x	x		x		x
Hasbrouck & Saar (2002)	x	x		x		
Hasbrouck & Seppi (2001)	x			x		
Irvine et al. (2000)				x		
Ito et al. (1998)	x				x	
Jones & Lipson (1999)		x		x		
Kamara & Koski (2001)		x		x		
Karagozoglu (2000)		x				x
Kavajecz (1999)			x	x		
Kavajecz & Odders-White (2001)	x			x		
Lee et al. (1993)	x			x		
Lee et al. (2001)	x			x		
Levin & Wright (1999)	x			x		
Lin et al. (1995)	x		x	x		
Menyah & Paudyal (2000)			x	x		
Peng (2001)	x		x	x		
Ranaldo (2000)	x			x		
Ranaldo (2001)	x			x		
Ranaldo (2002)	x		x	x		
Ranaldo (2003)	x	x		x		
Ranaldo (2004)	x		x	x		
Sarin et al. (1996)		x		x		
Schultz (2000)		x		x		

Study	Sort of intraday study			Subject		
	intraday	daily	quote/trade	Stocks	FX	other
Stoll & Whaley (1990)			x	x		
Theissen (2002)	x			x		
Trapletti et al. (2002)	x				x	
Van Ness et al. (2000)			x	x		
Walsh (1998)		x	x	x		
Wang (2002)	x			x		
Yang et al. (2001)	x			x		

Table B.1: Overview of intraday studies

Appendix C

Correlation Matrices of the 31 Liquidity Measures for the 18 Stocks

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$	$LogSabs$	$SrelM$	$Srelp$
Q	1										
V	0.98	1									
D	0.05	0.05	1								
$Dlog$	-0.02	0.02	0.28	1							
$D\$$	0.03	0.05	1.00	0.32	1						
N	0.83	0.81	0.01	-0.11	0.00	1					
NO	0.67	0.64	0.01	-0.17	-0.02	0.80	1				
$Sabs$	0.03	0.04	0.09	0.35	0.11	-0.01	-0.01	1			
$LogSabs$	0.00	0.01	0.09	0.37	0.12	-0.04	-0.04	0.92	1		
$SrelM$	0.08	0.05	0.05	0.21	0.05	0.05	0.08	0.94	0.85	1	
$Srelp$	0.08	0.05	0.05	0.21	0.05	0.05	0.08	0.94	0.85	1.00	1
$Srellog$	0.08	0.05	0.05	0.21	0.05	0.05	0.08	0.94	0.85	1.00	1.00
$LogSrellog$	0.03	0.02	0.07	0.28	0.08	0.00	0.03	0.90	0.97	0.89	0.89
$Seff$	-0.02	-0.02	0.08	0.24	0.10	-0.04	-0.03	0.61	0.61	0.58	0.58
$Seffrelp$	0.03	0.00	0.05	0.12	0.05	0.01	0.05	0.58	0.56	0.64	0.64
$SeffrelM$	0.03	0.00	0.05	0.12	0.05	0.01	0.05	0.58	0.56	0.64	0.64
QS	0.05	0.04	0.02	0.09	0.03	0.03	0.05	0.95	0.88	0.95	0.95
$LogQS$	0.09	0.05	-0.01	-0.04	-0.02	0.08	0.13	0.86	0.77	0.96	0.96
$LogQSadj$	0.11	0.07	0.00	-0.23	-0.01	0.11	0.13	0.54	0.47	0.65	0.65
CL	0.06	0.02	-0.09	-0.44	-0.10	0.09	0.13	0.17	0.15	0.29	0.29
$LR1$	0.51	0.52	0.00	-0.04	0.00	0.40	0.29	-0.14	-0.15	-0.12	-0.12
$LR3$	0.02	-0.01	0.01	0.02	0.01	-0.02	0.10	0.28	0.27	0.35	0.35
FR	0.79	0.81	0.03	0.00	0.03	0.69	0.50	0.00	-0.02	0.02	0.02
OR	-0.07	-0.07	0.04	0.08	0.05	-0.09	-0.08	0.03	0.04	0.01	0.01
MI^{V^*}	0.03	-0.02	-0.12	-0.35	-0.14	0.08	0.15	0.25	0.21	0.38	0.38
MI^{A,V^*}	0.02	-0.03	-0.09	-0.29	-0.11	0.06	0.13	0.19	0.16	0.30	0.30
MI^{B,V^*}	0.03	-0.01	-0.10	-0.29	-0.12	0.07	0.12	0.22	0.18	0.33	0.33
$DI^A(k)$	0.01	0.07	0.12	0.34	0.16	-0.03	-0.11	0.04	0.06	-0.10	-0.10
$DI^B(k)$	0.02	0.05	0.63	0.21	0.64	-0.01	-0.07	-0.06	-0.05	-0.13	-0.13
$PI^A(q)$	0.03	-0.02	-0.10	-0.32	-0.12	0.08	0.15	0.23	0.19	0.37	0.37
$PI^B(q)$	0.05	-0.01	-0.11	-0.31	-0.13	0.09	0.14	0.26	0.21	0.39	0.39

	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$
$Srellog$	1										
$LogSrellog$	0.89	1									
$Seff$	0.58	0.59	1								
$Seffrelp$	0.64	0.59	0.95	1							
$SeffrelM$	0.64	0.59	0.95	1.00	1						
QS	0.95	0.89	0.59	0.60	0.60	1					
$LogQS$	0.96	0.84	0.54	0.63	0.63	0.95	1				
$LogQSadj$	0.65	0.54	0.37	0.46	0.46	0.68	0.76	1			
CL	0.29	0.22	0.12	0.22	0.22	0.37	0.48	0.32	1		
$LR1$	-0.12	-0.15	-0.15	-0.13	-0.13	-0.13	-0.11	-0.06	-0.03	1	
$LR3$	0.35	0.32	0.28	0.33	0.33	0.30	0.35	0.24	0.15	-0.10	1
FR	0.02	-0.01	-0.02	0.00	0.00	0.01	0.02	0.04	0.02	0.32	0.01
OR	0.01	0.03	0.05	0.03	0.03	0.01	-0.01	0.00	-0.03	-0.05	0.12
MI^{V^*}	0.38	0.31	0.18	0.30	0.30	0.38	0.48	0.38	0.37	-0.12	0.26
MI^{A,V^*}	0.30	0.25	0.13	0.23	0.23	0.29	0.39	0.30	0.30	-0.10	0.21
MI^{B,V^*}	0.33	0.27	0.17	0.27	0.27	0.32	0.41	0.33	0.30	-0.10	0.22
$DI^A(k)$	-0.10	-0.05	0.03	-0.09	-0.09	-0.06	-0.19	-0.16	-0.21	0.08	-0.12
$DI^B(k)$	-0.13	-0.11	-0.03	-0.09	-0.09	-0.12	-0.18	-0.12	-0.14	0.07	-0.11
$PI^A(q)$	0.37	0.29	0.16	0.28	0.28	0.35	0.47	0.38	0.36	-0.10	0.25
$PI^B(q)$	0.39	0.31	0.20	0.32	0.32	0.37	0.48	0.39	0.36	-0.10	0.25

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.03	1							
MI^{V^*}	-0.01	-0.04	1						
MI^{A,V^*}	-0.02	-0.02	0.83	1					
MI^{B,V^*}	0.00	-0.04	0.81	0.35	1				
$DI^A(k)$	0.03	0.04	-0.46	-0.46	-0.28	1			
$DI^B(k)$	0.02	0.02	-0.33	-0.22	-0.33	0.20	1		
$PI^A(q)$	-0.01	-0.03	0.82	0.95	0.38	-0.50	-0.23	1	
$PI^B(q)$	0.01	-0.04	0.81	0.39	0.95	-0.31	-0.35	0.44	1

Table C.1: Correlation matrix of the 31 liquidity measures for Adecco

	Q	V	D	Dlog	D$	N	NO	Sabs	LogSabs	SrelM	Srelp
Q	1										
V	0.99	1									
D	-0.06	-0.01	1								
Dlog	-0.02	0.02	0.74	1							
D$	-0.06	-0.01	0.99	0.68	1						
N	0.70	0.69	-0.16	-0.10	-0.17	1					
NO	0.42	0.41	-0.18	-0.14	-0.18	0.62	1				
Sabs	0.05	0.03	-0.18	-0.19	-0.17	0.08	0.22	1			
LogSabs	0.04	0.02	-0.16	-0.18	-0.15	0.06	0.18	0.93	1		
SrelM	0.07	0.04	-0.30	-0.27	-0.29	0.11	0.24	0.98	0.90	1	
Srelp	0.07	0.04	-0.30	-0.27	-0.29	0.11	0.24	0.98	0.90	1.00	1
Srellog	0.07	0.04	-0.30	-0.27	-0.29	0.11	0.24	0.98	0.90	1.00	1.00
LogSrellog	0.05	0.03	-0.31	-0.27	-0.30	0.10	0.22	0.92	0.98	0.92	0.92
Seff	0.06	0.04	-0.21	-0.24	-0.19	0.07	0.19	0.85	0.80	0.83	0.83
Seffrelp	0.07	0.04	-0.30	-0.29	-0.29	0.10	0.20	0.79	0.73	0.81	0.81
SeffrelM	0.07	0.04	-0.30	-0.29	-0.29	0.10	0.21	0.80	0.74	0.81	0.82
QS	0.06	0.03	-0.37	-0.46	-0.33	0.10	0.23	0.92	0.85	0.94	0.94
LogQS	0.07	0.03	-0.45	-0.51	-0.42	0.12	0.25	0.88	0.80	0.93	0.93
LogQSadj	0.03	0.01	-0.19	-0.30	-0.20	0.09	0.21	0.84	0.79	0.84	0.84
CL	0.05	0.02	-0.40	-0.56	-0.34	0.07	0.12	0.28	0.24	0.35	0.35
LR1	0.71	0.72	0.03	0.05	0.03	0.46	0.22	-0.04	-0.05	-0.04	-0.04
LR3	0.07	0.05	-0.20	-0.17	-0.21	0.10	0.24	0.24	0.21	0.27	0.27
FR	0.84	0.84	-0.02	0.00	-0.02	0.65	0.39	0.04	0.04	0.05	0.05
OR	-0.10	-0.10	0.08	0.05	0.08	-0.12	-0.08	0.00	0.01	-0.01	-0.01
MI^{V^*}	0.03	0.00	-0.42	-0.47	-0.38	0.11	0.16	0.22	0.21	0.28	0.28
MI^{A,V^*}	0.05	0.01	-0.43	-0.50	-0.38	0.13	0.17	0.26	0.24	0.33	0.33
MI^{B,V^*}	0.02	0.00	-0.34	-0.37	-0.31	0.08	0.13	0.17	0.16	0.21	0.21
$DI^A(k)$	-0.06	0.00	0.91	0.60	0.92	-0.18	-0.20	-0.20	-0.19	-0.33	-0.33
$DI^B(k)$	0.04	0.04	0.32	0.26	0.29	0.00	-0.01	-0.04	-0.06	-0.02	-0.02
$PI^A(q)$	0.04	0.00	-0.50	-0.57	-0.43	0.08	0.12	0.18	0.17	0.24	0.24
$PI^B(q)$	0.02	-0.01	-0.67	-0.68	-0.59	0.09	0.11	0.21	0.20	0.29	0.29

	Srellog	LogSrellog	Seff	Seffrelp	SeffrelM	QS	LogQS	LogQSadj	CL	LR1	LR3
Srellog	1										
LogSrellog	0.92	1									
Seff	0.83	0.80	1								
Seffrelp	0.81	0.75	0.98	1							
SeffrelM	0.81	0.76	0.98	1.00	1						
QS	0.94	0.87	0.80	0.77	0.78	1					
LogQS	0.93	0.84	0.76	0.76	0.77	0.99	1				
LogQSadj	0.84	0.80	0.71	0.68	0.68	0.79	0.76	1			
CL	0.35	0.28	0.27	0.32	0.32	0.58	0.62	0.19	1		
LR1	-0.04	-0.06	-0.04	-0.04	-0.04	-0.04	-0.04	-0.06	0.00	1	
LR3	0.27	0.25	0.22	0.23	0.24	0.27	0.28	0.22	0.15	0.00	1
FR	0.05	0.04	0.04	0.05	0.05	0.04	0.04	0.03	0.01	0.57	0.03
OR	-0.01	0.00	0.00	-0.01	-0.01	-0.02	-0.03	0.01	-0.04	-0.08	0.09
MI^{V^*}	0.28	0.27	0.17	0.21	0.22	0.36	0.40	0.20	0.36	-0.05	0.16
MI^{A,V^*}	0.33	0.30	0.21	0.26	0.26	0.41	0.47	0.19	0.46	-0.03	0.16
MI^{B,V^*}	0.21	0.21	0.13	0.16	0.16	0.27	0.30	0.16	0.25	-0.05	0.12
$DI^A(k)$	-0.33	-0.34	-0.17	-0.27	-0.27	-0.35	-0.43	-0.24	-0.32	0.05	-0.23
$DI^B(k)$	-0.02	-0.07	-0.01	0.01	0.01	-0.09	-0.08	-0.04	-0.08	0.03	-0.02
$PI^A(q)$	0.24	0.24	0.12	0.17	0.17	0.36	0.41	0.09	0.45	-0.02	0.13
$PI^B(q)$	0.29	0.29	0.13	0.19	0.19	0.41	0.47	0.12	0.47	-0.04	0.15

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.05	1							
MI^{V^*}	0.02	-0.04	1						
MI^{A,V^*}	0.02	-0.04	0.50	1					
MI^{B,V^*}	0.01	-0.03	0.96	0.25	1				
$DI^A(k)$	-0.02	0.07	-0.40	-0.47	-0.30	1			
$DI^B(k)$	0.03	0.02	-0.23	0.01	-0.26	0.22	1		
$PI^A(q)$	0.01	-0.05	0.48	0.79	0.29	-0.52	-0.11	1	
$PI^B(q)$	0.00	-0.06	0.68	0.57	0.58	-0.63	-0.36	0.74	1

Table C.2: Correlation matrix of the 31 liquidity measures for Baer

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*	*LogSabs*	*SrelM*	*Srelp*
Q	1										
V	0.99	1									
D	0.03	0.04	1								
Dlog	0.00	0.01	0.75	1							
D$	0.02	0.04	0.99	0.72	1						
N	0.70	0.69	-0.04	-0.07	-0.06	1					
NO	0.60	0.57	-0.05	-0.07	-0.08	0.80	1				
Sabs	0.12	0.11	-0.03	-0.02	-0.05	0.16	0.25	1			
LogSabs	0.13	0.11	-0.03	0.00	-0.05	0.16	0.24	0.90	1		
SrelM	0.13	0.10	-0.04	-0.03	-0.08	0.18	0.28	0.98	0.88	1	
Srelp	0.14	0.10	-0.04	-0.03	-0.08	0.18	0.28	0.98	0.88	1.00	1
Srellog	0.13	0.10	-0.04	-0.03	-0.08	0.18	0.28	0.98	0.88	1.00	1.00
LogSrellog	0.14	0.10	-0.05	-0.02	-0.10	0.18	0.28	0.87	0.97	0.90	0.90
Seff	0.04	0.03	-0.07	-0.09	-0.08	0.09	0.21	0.64	0.51	0.63	0.63
Seffrelp	0.05	0.03	-0.07	-0.10	-0.10	0.11	0.24	0.64	0.51	0.65	0.65
SeffrelM	0.05	0.03	-0.07	-0.10	-0.10	0.11	0.24	0.64	0.51	0.66	0.66
QS	0.12	0.10	-0.12	-0.17	-0.13	0.16	0.25	0.97	0.85	0.95	0.95
LogQS	0.13	0.10	-0.13	-0.18	-0.16	0.18	0.28	0.96	0.84	0.98	0.98
LogQSadj	0.09	0.06	-0.09	-0.32	-0.12	0.15	0.22	0.75	0.63	0.76	0.76
CL	0.06	0.04	-0.17	-0.31	-0.16	0.08	0.12	0.36	0.24	0.37	0.37
LR1	0.58	0.62	0.04	0.02	0.05	0.47	0.33	-0.01	0.01	-0.03	-0.03
LR3	-0.01	-0.03	-0.08	-0.10	-0.11	-0.01	0.15	0.29	0.28	0.32	0.32
FR	0.88	0.88	0.00	-0.02	0.00	0.53	0.47	0.10	0.09	0.10	0.10
OR	-0.07	-0.07	0.05	0.03	0.05	-0.09	-0.07	-0.01	-0.01	-0.01	-0.01
MI^{V^*}	0.02	0.00	-0.13	-0.15	-0.14	0.07	0.08	0.13	0.13	0.18	0.18
MI^{A,V^*}	0.04	0.00	-0.24	-0.28	-0.26	0.11	0.16	0.26	0.24	0.32	0.32
MI^{B,V^*}	0.01	0.00	-0.08	-0.10	-0.09	0.04	0.05	0.08	0.09	0.11	0.11
$DI^A(k)$	0.01	0.06	0.27	0.22	0.33	-0.07	-0.16	-0.21	-0.23	-0.27	-0.27
$DI^B(k)$	0.04	0.07	0.27	0.23	0.30	-0.02	-0.08	-0.18	-0.18	-0.21	-0.21
$PI^A(q)$	0.06	0.02	-0.28	-0.36	-0.29	0.15	0.22	0.45	0.39	0.49	0.49
$PI^B(q)$	0.01	0.00	-0.09	-0.13	-0.09	0.05	0.07	0.13	0.13	0.16	0.16

	Srellog	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*	*QS*	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*
Srellog	1										
LogSrellog	0.90	1									
Seff	0.63	0.50	1								
Seffrelp	0.65	0.54	0.98	1							
SeffrelM	0.66	0.54	0.99	1.00	1						
QS	0.95	0.83	0.65	0.64	0.64	1					
LogQS	0.98	0.85	0.64	0.66	0.66	0.98	1				
LogQSadj	0.76	0.64	0.53	0.54	0.54	0.81	0.82	1			
CL	0.37	0.26	0.29	0.30	0.30	0.52	0.52	0.36	1		
LR1	-0.03	-0.02	-0.06	-0.08	-0.08	-0.01	-0.03	-0.02	-0.01	1	
LR3	0.32	0.31	0.30	0.32	0.32	0.30	0.33	0.36	0.09	-0.07	1
FR	0.10	0.09	0.04	0.05	0.05	0.10	0.10	0.07	0.05	0.41	-0.01
OR	-0.01	-0.01	0.01	0.00	0.00	-0.01	-0.02	0.00	-0.02	-0.06	0.04
MI^{V^*}	0.18	0.18	0.12	0.16	0.16	0.15	0.19	0.16	0.11	-0.04	0.11
MI^{A,V^*}	0.32	0.31	0.20	0.25	0.25	0.29	0.35	0.27	0.21	-0.07	0.17
MI^{B,V^*}	0.11	0.12	0.09	0.11	0.11	0.09	0.12	0.11	0.06	-0.03	0.07
$DI^A(k)$	-0.27	-0.33	-0.19	-0.23	-0.23	-0.23	-0.29	-0.22	-0.14	0.14	-0.19
$DI^B(k)$	-0.21	-0.24	-0.15	-0.18	-0.18	-0.20	-0.23	-0.19	-0.11	0.12	-0.14
$PI^A(q)$	0.49	0.45	0.32	0.37	0.37	0.50	0.54	0.45	0.33	-0.06	0.21
$PI^B(q)$	0.16	0.15	0.12	0.14	0.14	0.15	0.18	0.17	0.11	-0.03	0.08

	FR	*OR*	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.03	1							
MI^{V^*}	0.01	-0.01	1						
MI^{A,V^*}	0.01	-0.03	0.28	1					
MI^{B,V^*}	0.00	-0.01	0.98	0.08	1				
$DI^A(k)$	0.02	0.01	-0.14	-0.38	-0.06	1			
$DI^B(k)$	0.03	0.00	-0.19	-0.18	-0.15	0.17	1		
$PI^A(q)$	0.04	-0.03	0.28	0.79	0.12	-0.37	-0.21	1	
$PI^B(q)$	0.01	0.00	0.45	0.17	0.43	-0.09	-0.13	0.20	1

Table C.3: Correlation matrix of the 31 liquidity measures for Richemont

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*	*LogSabs*	*SrelM*	*Srelp*
Q	1										
V	1.00	1									
D	-0.06	-0.04	1								
Dlog	-0.12	-0.09	0.79	1							
D$	-0.07	-0.05	1.00	0.79	1						
N	0.76	0.74	-0.15	-0.23	-0.16	1					
NO	0.63	0.60	-0.19	-0.28	-0.20	0.84	1				
Sabs	0.11	0.10	0.02	0.10	0.01	0.13	0.17	1			
LogSabs	0.07	0.07	0.05	0.16	0.04	0.06	0.09	0.95	1		
SrelM	0.15	0.13	-0.05	0.01	-0.07	0.19	0.25	0.98	0.92	1	
Srelp	0.15	0.13	-0.05	0.01	-0.07	0.19	0.25	0.98	0.92	1.00	1
Srellog	0.15	0.13	-0.05	0.01	-0.07	0.19	0.25	0.98	0.92	1.00	1.00
LogSrellog	0.12	0.11	-0.03	0.06	-0.05	0.14	0.19	0.95	0.98	0.95	0.95
Seff	0.01	0.00	-0.06	-0.07	-0.06	0.03	0.09	0.21	0.21	0.22	0.22
Seffrelp	0.04	0.03	-0.11	-0.13	-0.12	0.08	0.15	0.23	0.22	0.26	0.26
SeffrelM	0.04	0.03	-0.11	-0.13	-0.12	0.08	0.15	0.23	0.22	0.26	0.26
QS	0.15	0.13	-0.22	-0.24	-0.23	0.20	0.27	0.93	0.86	0.94	0.94
LogQS	0.18	0.16	-0.26	-0.30	-0.27	0.25	0.34	0.88	0.81	0.93	0.93
LogQSadj	0.13	0.12	-0.21	-0.50	-0.21	0.20	0.24	0.38	0.34	0.43	0.43
CL	0.16	0.13	-0.35	-0.55	-0.35	0.25	0.31	0.20	0.15	0.29	0.29
LR1	0.66	0.65	-0.07	-0.12	-0.08	0.53	0.44	0.03	-0.02	0.06	0.06
LR3	-0.03	-0.03	-0.03	-0.05	-0.03	-0.02	0.07	0.13	0.12	0.15	0.15
FR	0.85	0.84	-0.05	-0.08	-0.05	0.66	0.55	0.08	0.05	0.11	0.11
OR	-0.08	-0.08	0.10	0.06	0.10	-0.10	-0.08	-0.02	-0.01	-0.03	-0.03
MI^{V^*}	0.15	0.12	-0.52	-0.60	-0.53	0.28	0.40	0.30	0.22	0.40	0.40
MI^{A,V^*}	0.12	0.09	-0.42	-0.48	-0.43	0.22	0.31	0.23	0.17	0.31	0.31
MI^{B,V^*}	0.12	0.09	-0.42	-0.48	-0.42	0.23	0.33	0.25	0.19	0.33	0.33
$DI^A(k)$	-0.14	-0.11	0.57	0.48	0.60	-0.21	-0.27	-0.23	-0.20	-0.33	-0.33
$DI^B(k)$	-0.08	-0.05	0.58	0.54	0.59	-0.17	-0.28	-0.17	-0.11	-0.26	-0.26
$PI^A(q)$	0.14	0.11	-0.46	-0.52	-0.47	0.26	0.35	0.26	0.19	0.36	0.36
$PI^B(q)$	0.14	0.11	-0.45	-0.52	-0.46	0.26	0.38	0.28	0.21	0.37	0.37

	Srellog	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*	*QS*	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*
Srellog	1										
LogSrellog	0.95	1									
Seff	0.22	0.21	1								
Seffrelp	0.26	0.25	0.99	1							
SeffrelM	0.26	0.25	0.99	1.00	1						
QS	0.94	0.90	0.25	0.29	0.29	1					
LogQS	0.93	0.88	0.24	0.31	0.31	0.98	1				
LogQSadj	0.43	0.39	0.16	0.20	0.20	0.61	0.63	1			
CL	0.29	0.24	0.13	0.20	0.20	0.44	0.51	0.32	1		
LR1	0.06	0.02	-0.03	-0.01	-0.01	0.06	0.09	0.08	0.12	1	
LR3	0.15	0.14	0.14	0.15	0.15	0.15	0.16	0.08	0.07	-0.01	1
FR	0.11	0.08	0.03	0.05	0.05	0.11	0.13	0.09	0.14	0.52	-0.02
OR	-0.03	-0.02	0.01	0.00	0.00	-0.04	-0.04	0.00	-0.04	-0.06	0.10
MI^{V^*}	0.40	0.35	0.18	0.26	0.26	0.50	0.57	0.38	0.51	0.11	0.13
MI^{A,V^*}	0.31	0.27	0.13	0.20	0.20	0.40	0.46	0.32	0.42	0.08	0.10
MI^{B,V^*}	0.33	0.29	0.15	0.22	0.22	0.40	0.46	0.29	0.40	0.09	0.11
$DI^A(k)$	-0.33	-0.33	-0.10	-0.18	-0.18	-0.36	-0.43	-0.25	-0.31	-0.09	-0.11
$DI^B(k)$	-0.26	-0.22	-0.08	-0.15	-0.15	-0.33	-0.39	-0.24	-0.36	-0.08	-0.07
$PI^A(q)$	0.36	0.31	0.12	0.21	0.21	0.44	0.51	0.35	0.46	0.10	0.12
$PI^B(q)$	0.37	0.33	0.16	0.24	0.24	0.45	0.51	0.33	0.45	0.11	0.13

	FR	*OR*	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.04	1							
MI^{V^*}	0.10	-0.06	1						
MI^{A,V^*}	0.08	-0.05	0.83	1					
MI^{B,V^*}	0.09	-0.04	0.77	0.29	1				
$DI^A(k)$	-0.09	0.06	-0.56	-0.53	-0.36	1			
$DI^B(k)$	-0.05	0.04	-0.59	-0.42	-0.54	0.56	1		
$PI^A(q)$	0.10	-0.06	0.82	0.93	0.35	-0.61	-0.48	1	
$PI^B(q)$	0.11	-0.05	0.76	0.34	0.92	-0.42	-0.62	0.41	1

Table C.4: Correlation matrix of the 31 liquidity measures for Ciba

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*	*LogSabs*	*SrelM*	*Srelp*
Q	1										
V	0.99	1									
D	0.03	0.04	1								
Dlog	0.02	0.03	0.71	1							
D$	0.00	0.02	0.99	0.69	1						
N	0.75	0.74	-0.04	-0.06	-0.07	1					
NO	0.63	0.61	-0.06	-0.07	-0.10	0.81	1				
Sabs	0.12	0.09	0.02	0.06	-0.02	0.14	0.27	1			
LogSabs	0.12	0.10	0.02	0.07	-0.03	0.14	0.25	0.94	1		
SrelM	0.14	0.10	0.01	0.05	-0.05	0.16	0.30	0.98	0.91	1	
Srelp	0.14	0.10	0.01	0.05	-0.05	0.16	0.30	0.98	0.91	1.00	1
Srellog	0.14	0.10	0.01	0.05	-0.05	0.16	0.30	0.98	0.91	1.00	1.00
LogSrellog	0.15	0.11	0.00	0.05	-0.07	0.17	0.29	0.93	0.98	0.93	0.93
Seff	0.06	0.05	-0.03	-0.03	-0.06	0.08	0.21	0.57	0.51	0.57	0.57
Seffrelp	0.08	0.05	-0.03	-0.03	-0.08	0.11	0.24	0.59	0.53	0.62	0.62
SeffrelM	0.08	0.05	-0.03	-0.03	-0.08	0.11	0.24	0.60	0.53	0.62	0.62
QS	0.11	0.09	-0.10	-0.14	-0.14	0.15	0.27	0.97	0.91	0.95	0.95
LogQS	0.13	0.09	-0.10	-0.14	-0.15	0.17	0.30	0.95	0.88	0.97	0.97
LogQSadj	0.11	0.08	-0.03	-0.30	-0.07	0.16	0.24	0.67	0.60	0.69	0.69
CL	0.03	0.01	-0.17	-0.33	-0.17	0.04	0.08	0.23	0.20	0.25	0.25
LR1	0.59	0.62	0.03	0.04	0.03	0.49	0.34	-0.01	0.00	-0.01	-0.01
LR3	0.07	0.04	-0.03	-0.03	-0.07	0.04	0.20	0.33	0.32	0.37	0.37
FR	0.89	0.88	0.02	0.01	0.00	0.66	0.55	0.08	0.08	0.08	0.08
OR	-0.03	-0.03	0.07	0.04	0.07	-0.04	-0.03	0.01	0.01	0.01	0.01
MI^{V^*}	0.09	0.04	-0.12	-0.12	-0.16	0.14	0.22	0.24	0.22	0.34	0.34
MI^{A,V^*}	0.07	0.02	-0.10	-0.09	-0.15	0.13	0.19	0.22	0.20	0.29	0.29
MI^{B,V^*}	0.08	0.04	-0.10	-0.10	-0.12	0.11	0.17	0.18	0.16	0.27	0.26
$DI^A(k)$	-0.05	0.00	0.24	0.20	0.31	-0.10	-0.21	-0.30	-0.30	-0.37	-0.37
$DI^B(k)$	-0.01	0.02	0.22	0.21	0.25	-0.07	-0.17	-0.25	-0.25	-0.30	-0.30
$PI^A(q)$	0.09	0.05	-0.20	-0.24	-0.24	0.17	0.26	0.37	0.32	0.43	0.43
$PI^B(q)$	0.07	0.03	-0.21	-0.24	-0.24	0.13	0.23	0.35	0.31	0.41	0.41

	Srellog	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*	*QS*	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*
Srellog	1										
LogSrellog	0.93	1									
Seff	0.57	0.52	1								
Seffrelp	0.62	0.55	0.99	1							
SeffrelM	0.62	0.56	0.99	1.00	1						
QS	0.95	0.90	0.57	0.59	0.59	1					
LogQS	0.97	0.90	0.57	0.62	0.62	0.98	1				
LogQSadj	0.69	0.62	0.43	0.46	0.46	0.77	0.78	1			
CL	0.25	0.22	0.17	0.19	0.19	0.39	0.40	0.24	1		
LR1	-0.01	0.00	-0.04	-0.04	-0.04	-0.02	-0.02	-0.01	-0.02	1	
LR3	0.37	0.37	0.27	0.30	0.30	0.33	0.36	0.24	0.10	-0.02	1
FR	0.08	0.09	0.04	0.05	0.05	0.07	0.08	0.07	0.01	0.46	0.02
OR	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.01	-0.01	-0.03	0.11
MI^{V^*}	0.34	0.31	0.17	0.24	0.24	0.27	0.36	0.26	0.16	-0.03	0.23
MI^{A,V^*}	0.29	0.29	0.18	0.24	0.24	0.24	0.31	0.24	0.13	-0.04	0.19
MI^{B,V^*}	0.27	0.23	0.12	0.18	0.18	0.20	0.29	0.19	0.13	-0.02	0.19
$DI^A(k)$	-0.37	-0.41	-0.23	-0.28	-0.28	-0.32	-0.39	-0.29	-0.15	0.08	-0.25
$DI^B(k)$	-0.30	-0.31	-0.20	-0.24	-0.24	-0.28	-0.32	-0.23	-0.14	0.07	-0.22
$PI^A(q)$	0.43	0.39	0.31	0.36	0.36	0.42	0.48	0.41	0.22	-0.03	0.23
$PI^B(q)$	0.41	0.38	0.25	0.31	0.31	0.40	0.46	0.37	0.21	-0.04	0.25

	FR	*OR*	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.02	1							
MI^{V^*}	0.03	-0.01	1						
MI^{A,V^*}	0.03	-0.01	0.53	1					
MI^{B,V^*}	0.03	-0.01	0.93	0.19	1				
$DI^A(k)$	-0.01	0.00	-0.33	-0.42	-0.21	1			
$DI^B(k)$	0.00	0.01	-0.34	-0.23	-0.29	0.30	1		
$PI^A(q)$	0.05	-0.01	0.48	0.70	0.25	-0.47	-0.27	1	
$PI^B(q)$	0.03	-0.01	0.62	0.27	0.60	-0.31	-0.44	0.34	1

Table C.5: Correlation matrix of the 31 liquidity measures for Clariant

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$	$LogSabs$	$SrelM$	$Srelp$
Q	1										
V	1.00	1									
D	0.13	0.13	1								
$Dlog$	0.07	0.07	0.55	1							
$D\$$	0.13	0.13	1.00	0.55	1						
N	0.66	0.66	0.02	-0.07	0.02	1					
NO	0.57	0.57	0.00	-0.10	0.00	0.82	1				
$Sabs$	0.07	0.07	-0.03	0.05	-0.03	0.13	0.20	1			
$LogSabs$	0.06	0.06	-0.02	0.07	-0.02	0.11	0.17	0.97	1		
$SrelM$	0.07	0.07	-0.03	0.04	-0.04	0.13	0.21	1.00	0.96	1	
$Srelp$	0.07	0.07	-0.03	0.04	-0.04	0.13	0.21	1.00	0.96	1.00	1
$Srellog$	0.07	0.07	-0.03	0.04	-0.04	0.13	0.21	1.00	0.96	1.00	1.00
$LogSrellog$	0.07	0.06	-0.03	0.05	-0.04	0.12	0.19	0.97	1.00	0.97	0.97
$Seff$	-0.01	-0.01	-0.03	-0.06	-0.03	0.05	0.13	0.41	0.35	0.42	0.42
$Seffrelp$	-0.01	-0.01	-0.04	-0.06	-0.04	0.06	0.14	0.42	0.36	0.43	0.43
$SeffrelM$	-0.01	-0.01	-0.04	-0.06	-0.04	0.06	0.14	0.42	0.36	0.43	0.43
QS	0.05	0.05	-0.17	-0.31	-0.18	0.16	0.25	0.90	0.87	0.91	0.91
$LogQS$	0.05	0.05	-0.18	-0.31	-0.18	0.17	0.25	0.90	0.86	0.91	0.91
$LogQSadj$	0.08	0.07	-0.02	-0.40	-0.02	0.16	0.22	0.52	0.49	0.53	0.53
CL	0.00	0.00	-0.19	-0.52	-0.19	0.12	0.17	0.26	0.24	0.27	0.27
$LR1$	0.74	0.74	0.11	0.07	0.11	0.47	0.40	0.04	0.05	0.04	0.04
$LR3$	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.08	0.16	0.17	0.16	0.16
FR	0.86	0.86	0.09	0.04	0.09	0.65	0.55	0.06	0.06	0.06	0.06
OR	-0.05	-0.05	0.25	0.13	0.25	-0.07	-0.06	-0.02	-0.02	-0.02	-0.02
MI^{V^*}	0.01	0.00	-0.27	-0.53	-0.27	0.17	0.26	0.39	0.36	0.41	0.41
MI^{A,V^*}	0.03	0.02	-0.22	-0.45	-0.22	0.17	0.24	0.32	0.29	0.35	0.35
MI^{B,V^*}	-0.01	-0.02	-0.22	-0.41	-0.22	0.11	0.18	0.31	0.29	0.32	0.32
$DI^A(k)$	0.01	0.02	0.18	0.26	0.18	-0.07	-0.10	-0.13	-0.13	-0.15	-0.15
$DI^B(k)$	0.13	0.14	0.59	0.26	0.60	0.06	0.04	-0.11	-0.11	-0.12	-0.12
$PI^A(q)$	0.00	0.00	-0.18	-0.29	-0.18	0.07	0.09	0.15	0.13	0.17	0.17
$PI^B(q)$	-0.01	-0.01	-0.11	-0.15	-0.11	0.02	0.06	0.15	0.15	0.16	0.16

	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$
$Srellog$	1										
$LogSrellog$	0.97	1									
$Seff$	0.42	0.36	1								
$Seffrelp$	0.43	0.37	1.00	1							
$SeffrelM$	0.43	0.37	1.00	1.00	1						
QS	0.91	0.87	0.41	0.42	0.42	1					
$LogQS$	0.91	0.87	0.42	0.43	0.43	1.00	1				
$LogQSadj$	0.53	0.49	0.27	0.28	0.28	0.70	0.70	1			
CL	0.27	0.25	0.19	0.20	0.20	0.58	0.58	0.40	1		
$LR1$	0.04	0.04	-0.03	-0.03	-0.03	0.02	0.02	0.04	-0.02	1	
$LR3$	0.16	0.17	0.17	0.17	0.17	0.16	0.16	0.10	0.08	-0.01	1
FR	0.06	0.06	0.02	0.02	0.02	0.05	0.05	0.07	0.02	0.56	-0.01
OR	-0.02	-0.02	0.01	0.01	0.01	-0.05	-0.05	0.00	-0.04	-0.04	0.05
MI^{V^*}	0.41	0.38	0.25	0.28	0.28	0.56	0.58	0.38	0.47	-0.02	0.13
MI^{A,V^*}	0.35	0.31	0.22	0.24	0.24	0.47	0.49	0.32	0.40	-0.01	0.10
MI^{B,V^*}	0.32	0.31	0.19	0.21	0.21	0.44	0.45	0.29	0.37	-0.03	0.11
$DI^A(k)$	-0.15	-0.15	-0.08	-0.10	-0.10	-0.20	-0.22	-0.12	-0.16	0.03	-0.07
$DI^B(k)$	-0.12	-0.12	-0.05	-0.06	-0.06	-0.17	-0.18	-0.08	-0.11	0.12	-0.04
$PI^A(q)$	0.17	0.15	0.13	0.14	0.14	0.24	0.26	0.17	0.22	-0.03	0.08
$PI^B(q)$	0.16	0.16	0.09	0.10	0.10	0.20	0.20	0.13	0.15	-0.01	0.06

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.03	1							
MI^{V^*}	0.03	-0.07	1						
MI^{A,V^*}	0.05	-0.06	0.82	1					
MI^{B,V^*}	0.00	-0.06	0.80	0.32	1				
$DI^A(k)$	-0.01	0.05	-0.33	-0.30	-0.23	1			
$DI^B(k)$	0.12	0.13	-0.27	-0.16	-0.29	0.07	1		
$PI^A(q)$	0.05	-0.05	0.44	0.42	0.30	-0.46	-0.16	1	
$PI^B(q)$	0.00	-0.03	0.30	0.15	0.35	-0.05	-0.35	0.15	1

Table C.6: Correlation matrix of the 31 liquidity measures for Givaudan

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*	*LogSabs*	*SrelM*	*Srelp*
Q	1										
V	0.99	1									
D	0.06	0.08	1								
Dlog	0.02	0.04	0.75	1							
D$	0.06	0.08	1.00	0.74	1						
N	0.69	0.66	-0.05	-0.12	-0.06	1					
NO	0.05	0.03	-0.12	-0.13	-0.13	0.08	1				
Sabs	0.06	0.04	-0.07	-0.05	-0.09	0.12	0.09	1			
LogSabs	0.05	0.04	-0.07	-0.04	-0.09	0.11	0.09	0.97	1		
SrelM	0.06	0.03	-0.12	-0.12	-0.15	0.14	0.14	0.98	0.94	1	
Srelp	0.06	0.03	-0.12	-0.12	-0.15	0.14	0.14	0.98	0.94	1.00	1
Srellog	0.06	0.03	-0.12	-0.12	-0.15	0.14	0.14	0.98	0.94	1.00	1.00
LogSrellog	0.06	0.03	-0.14	-0.13	-0.17	0.15	0.17	0.95	0.97	0.96	0.96
Seff	0.02	0.01	-0.10	-0.13	-0.11	0.08	0.05	0.37	0.32	0.38	0.38
Seffrelp	0.03	0.01	-0.14	-0.18	-0.15	0.11	0.09	0.39	0.35	0.43	0.43
SeffrelM	0.03	0.01	-0.14	-0.18	-0.15	0.11	0.09	0.39	0.35	0.43	0.43
QS	0.05	0.03	-0.26	-0.36	-0.27	0.15	0.12	0.93	0.90	0.94	0.94
LogQS	0.05	0.02	-0.28	-0.38	-0.30	0.16	0.16	0.90	0.87	0.95	0.95
LogQSadj	0.06	0.04	-0.17	-0.46	-0.18	0.15	0.09	0.61	0.57	0.64	0.64
CL	0.01	-0.01	-0.34	-0.59	-0.34	0.13	0.14	0.38	0.36	0.44	0.44
LR1	0.72	0.73	0.08	0.04	0.08	0.47	0.01	0.00	0.00	-0.02	-0.02
LR3	-0.02	-0.04	-0.13	-0.16	-0.14	-0.01	0.08	0.27	0.26	0.31	0.31
FR	0.81	0.82	0.03	0.02	0.03	0.56	0.05	0.03	0.03	0.03	0.03
OR	-0.06	-0.06	0.11	0.06	0.11	-0.08	-0.01	-0.03	-0.03	-0.03	-0.03
MI^{V^*}	0.00	-0.04	-0.46	-0.55	-0.47	0.16	0.20	0.35	0.34	0.45	0.45
MI^{A,V^*}	0.00	-0.03	-0.36	-0.43	-0.37	0.13	0.16	0.30	0.29	0.39	0.39
MI^{B,V^*}	-0.01	-0.04	-0.41	-0.49	-0.42	0.13	0.17	0.29	0.28	0.36	0.36
$DI^A(k)$	0.01	0.06	0.40	0.39	0.44	-0.14	-0.23	-0.22	-0.22	-0.33	-0.33
$DI^B(k)$	0.02	0.05	0.45	0.42	0.47	-0.11	-0.19	-0.22	-0.22	-0.29	-0.29
$PI^A(q)$	0.01	-0.04	-0.37	-0.42	-0.40	0.16	0.23	0.28	0.27	0.41	0.41
$PI^B(q)$	-0.02	-0.06	-0.39	-0.45	-0.42	0.12	0.21	0.29	0.28	0.39	0.39

	Srellog	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*	*QS*	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*
Srellog	1										
LogSrellog	0.96	1									
Seff	0.38	0.33	1								
Seffrelp	0.43	0.39	0.98	1							
SeffrelM	0.43	0.39	0.98	1.00	1						
QS	0.94	0.90	0.39	0.43	0.43	1					
LogQS	0.95	0.91	0.39	0.45	0.45	0.98	1				
LogQSadj	0.64	0.60	0.30	0.34	0.34	0.75	0.76	1			
CL	0.44	0.42	0.22	0.28	0.28	0.61	0.66	0.42	1		
LR1	-0.02	-0.02	-0.01	-0.02	-0.02	-0.02	-0.03	0.00	-0.04	1	
LR3	0.31	0.31	0.21	0.25	0.25	0.30	0.33	0.24	0.23	-0.04	1
FR	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.00	0.55	-0.02
OR	-0.03	-0.04	-0.01	-0.01	-0.01	-0.04	-0.04	-0.01	-0.04	-0.04	0.03
MI^{V^*}	0.45	0.46	0.24	0.32	0.32	0.49	0.56	0.38	0.52	-0.07	0.30
MI^{A,V^*}	0.39	0.39	0.19	0.27	0.27	0.41	0.47	0.32	0.43	-0.06	0.25
MI^{B,V^*}	0.36	0.38	0.21	0.28	0.28	0.41	0.46	0.32	0.43	-0.06	0.25
$DI^A(k)$	-0.33	-0.37	-0.13	-0.22	-0.22	-0.30	-0.38	-0.27	-0.31	0.08	-0.20
$DI^B(k)$	-0.29	-0.32	-0.14	-0.20	-0.20	-0.31	-0.36	-0.25	-0.31	0.07	-0.19
$PI^A(q)$	0.41	0.44	0.19	0.30	0.30	0.38	0.49	0.34	0.44	-0.08	0.27
$PI^B(q)$	0.39	0.41	0.18	0.27	0.27	0.40	0.47	0.32	0.43	-0.08	0.27

	FR	*OR*	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$		
FR	1										
OR	-0.02	1									
MI^{V^*}	-0.01	-0.05	1								
MI^{A,V^*}	0.00	-0.04	0.87	1							
MI^{B,V^*}	-0.01	-0.05	0.79	0.38	1						
$DI^A(k)$	0.01	0.04	-0.53	-0.47	-0.41	1					
$DI^B(k)$	0.01	0.08	-0.52	-0.35	-0.54	0.36	1				
$PI^A(q)$	0.00	-0.05	0.77	0.76	0.50	-0.67	-0.46	1			
$PI^B(q)$	-0.02	-0.04	0.69	0.41	0.79	-0.49	-0.71	0.55	1		

Table C.7: Correlation matrix of the 31 liquidity measures of Holcim

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*	*LogSabs*	*SrelM*	*Srelp*
Q	1										
V	0.96	1									
D	0.06	0.04	1								
Dlog	0.06	0.04	0.45	1							
D$	0.04	0.04	0.99	0.45	1						
N	0.81	0.77	0.01	0.00	-0.02	1					
NO	0.08	0.07	0.01	0.02	-0.01	0.11	1				
Sabs	0.11	0.08	-0.04	0.07	-0.05	0.15	-0.01	1			
LogSabs	0.08	0.05	-0.05	0.07	-0.06	0.11	-0.01	0.93	1		
SrelM	0.16	0.07	0.00	0.11	-0.05	0.20	0.05	0.92	0.84	1	
Srelp	0.16	0.07	0.00	0.11	-0.05	0.20	0.05	0.92	0.84	1.00	1
Srellog	0.16	0.07	0.00	0.11	-0.05	0.20	0.05	0.92	0.84	1.00	1.00
LogSrellog	0.13	0.06	-0.01	0.10	-0.05	0.16	0.05	0.89	0.95	0.90	0.90
Seff	0.08	0.04	-0.04	0.00	-0.06	0.11	0.01	0.69	0.64	0.67	0.67
Seffrelp	0.13	0.05	-0.01	0.04	-0.06	0.16	0.06	0.66	0.61	0.76	0.76
SeffrelM	0.13	0.05	-0.01	0.04	-0.05	0.16	0.06	0.66	0.61	0.76	0.76
QS	0.09	0.07	-0.12	-0.18	-0.13	0.14	-0.01	0.95	0.88	0.86	0.86
LogQS	0.14	0.07	-0.08	-0.12	-0.12	0.20	0.05	0.89	0.81	0.95	0.95
LogQSadj	0.12	0.06	0.01	-0.25	-0.02	0.17	0.04	0.60	0.55	0.67	0.67
CL	0.03	0.00	-0.08	-0.30	-0.09	0.06	0.03	0.18	0.17	0.22	0.22
LR1	0.43	0.51	0.03	0.02	0.05	0.29	0.00	-0.08	-0.09	-0.11	-0.11
LR3	0.04	-0.03	0.00	0.04	-0.04	0.03	0.07	0.33	0.31	0.43	0.43
FR	0.76	0.78	0.00	-0.01	0.00	0.76	0.08	0.07	0.06	0.08	0.08
OR	-0.07	-0.07	0.10	0.06	0.10	-0.07	0.00	-0.02	-0.02	-0.01	-0.01
MI^{V^*}	0.11	0.00	-0.09	-0.09	-0.14	0.19	0.09	0.31	0.28	0.45	0.45
MI^{A,V^*}	0.12	0.03	-0.07	-0.09	-0.11	0.19	0.08	0.25	0.22	0.37	0.37
MI^{B,V^*}	0.05	-0.03	-0.07	-0.05	-0.12	0.10	0.06	0.24	0.22	0.33	0.33
$DI^A(k)$	-0.09	-0.02	0.10	0.12	0.13	-0.14	-0.04	-0.25	-0.24	-0.32	-0.32
$DI^B(k)$	0.01	0.08	0.33	0.09	0.36	-0.04	-0.03	-0.20	-0.19	-0.26	-0.26
$PI^A(q)$	0.13	0.05	-0.09	-0.14	-0.13	0.23	0.08	0.31	0.27	0.43	0.43
$PI^B(q)$	0.06	-0.03	-0.09	-0.11	-0.14	0.12	0.07	0.31	0.27	0.42	0.42

	Srellog	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*	*QS*	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*
Srellog	1										
LogSrellog	0.90	1									
Seff	0.67	0.64	1								
Seffrelp	0.76	0.69	0.94	1							
SeffrelM	0.76	0.69	0.94	1.00	1						
QS	0.86	0.84	0.66	0.63	0.63	1					
LogQS	0.95	0.87	0.65	0.73	0.73	0.92	1				
LogQSadj	0.67	0.60	0.45	0.52	0.52	0.70	0.77	1			
CL	0.22	0.20	0.16	0.19	0.19	0.36	0.41	0.27	1		
LR1	-0.11	-0.13	-0.08	-0.11	-0.11	-0.08	-0.11	-0.08	-0.04	1	
LR3	0.43	0.41	0.33	0.41	0.41	0.32	0.41	0.31	0.12	-0.12	1
FR	0.08	0.06	0.06	0.07	0.06	0.08	0.08	0.07	0.03	0.23	-0.01
OR	-0.01	-0.02	-0.01	0.00	0.00	-0.03	-0.02	0.01	-0.02	-0.05	0.05
MI^{V^*}	0.45	0.42	0.28	0.41	0.41	0.32	0.46	0.34	0.16	-0.15	0.32
MI^{A,V^*}	0.37	0.34	0.22	0.34	0.34	0.27	0.38	0.26	0.15	-0.10	0.26
MI^{B,V^*}	0.33	0.32	0.22	0.31	0.31	0.25	0.34	0.28	0.11	-0.14	0.26
$DI^A(k)$	-0.32	-0.33	-0.20	-0.27	-0.27	-0.26	-0.33	-0.22	-0.12	0.11	-0.23
$DI^B(k)$	-0.26	-0.26	-0.17	-0.23	-0.23	-0.21	-0.27	-0.19	-0.09	0.15	-0.19
$PI^A(q)$	0.43	0.38	0.27	0.38	0.38	0.33	0.45	0.30	0.18	-0.10	0.28
$PI^B(q)$	0.42	0.40	0.27	0.38	0.38	0.33	0.44	0.36	0.15	-0.15	0.30

	FR	*OR*	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$		
FR	1										
OR	-0.03	1									
MI^{V^*}	0.06	-0.03	1								
MI^{A,V^*}	0.07	-0.03	0.84	1							
MI^{B,V^*}	0.01	-0.01	0.74	0.26	1						
$DI^A(k)$	-0.05	0.03	-0.54	-0.60	-0.22	1					
$DI^B(k)$	0.01	0.02	-0.46	-0.18	-0.60	0.18	1				
$PI^A(q)$	0.09	-0.04	0.78	0.91	0.27	-0.63	-0.19	1			
$PI^B(q)$	0.01	-0.01	0.72	0.32	0.88	-0.27	-0.59	0.34	1		

Table C.8: Correlation matrix of the 31 liquidity measures for Kudelski

	Q	V	D	Dlog	D$	N	NO	Sabs	LogSabs	SrelM	Srelp
Q	1										
V	1.00	1									
D	0.03	0.04	1								
Dlog	0.00	0.02	0.75	1							
D$	0.02	0.04	1.00	0.76	1						
N	0.69	0.67	-0.07	-0.12	-0.08	1					
NO	0.07	0.06	-0.11	-0.13	-0.12	0.10	1				
Sabs	0.05	0.06	0.09	0.16	0.09	0.08	-0.02	1			
LogSabs	0.03	0.04	0.15	0.25	0.15	0.02	-0.08	0.91	1		
SrelM	0.07	0.06	0.02	0.05	0.01	0.12	0.04	0.97	0.86	1	
Srelp	0.07	0.06	0.02	0.05	0.01	0.12	0.04	0.97	0.86	1.00	1
Srellog	0.07	0.06	0.02	0.05	0.01	0.12	0.04	0.97	0.86	1.00	1.00
LogSrellog	0.05	0.05	0.08	0.15	0.08	0.07	-0.01	0.92	0.98	0.91	0.91
Seff	-0.01	-0.02	-0.05	-0.06	-0.06	0.03	-0.01	0.46	0.42	0.50	0.50
Seffrelp	0.00	-0.01	-0.10	-0.13	-0.11	0.07	0.04	0.49	0.42	0.56	0.56
SeffrelM	0.00	-0.01	-0.10	-0.13	-0.11	0.07	0.04	0.49	0.42	0.56	0.56
QS	0.05	0.04	-0.13	-0.17	-0.13	0.12	0.02	0.93	0.83	0.95	0.95
LogQS	0.06	0.04	-0.18	-0.24	-0.19	0.15	0.07	0.88	0.75	0.94	0.94
LogQSadj	0.04	0.03	-0.13	-0.46	-0.14	0.12	0.05	0.45	0.39	0.51	0.51
CL	0.02	0.00	-0.26	-0.47	-0.26	0.10	0.08	0.20	0.14	0.28	0.28
LR1	0.70	0.70	-0.01	-0.03	-0.02	0.48	0.07	0.01	-0.03	0.02	0.02
LR3	-0.01	-0.02	-0.07	-0.10	-0.08	0.03	0.05	0.10	0.06	0.13	0.13
FR	0.86	0.86	0.01	0.01	0.00	0.62	0.05	0.05	0.03	0.05	0.05
OR	-0.07	-0.07	0.11	0.07	0.11	-0.09	-0.03	-0.01	0.00	-0.02	-0.02
MI^{V^*}	0.04	0.02	-0.17	-0.23	-0.18	0.12	0.07	0.07	-0.02	0.14	0.14
MI^{A,V^*}	0.05	0.02	-0.26	-0.34	-0.28	0.15	0.13	0.10	-0.03	0.20	0.20
MI^{B,V^*}	0.03	0.01	-0.09	-0.12	-0.10	0.07	0.03	0.04	0.00	0.08	0.08
$DI^A(k)$	0.05	0.07	0.44	0.42	0.44	-0.03	-0.10	-0.03	0.07	-0.12	-0.12
$DI^B(k)$	0.08	0.11	0.48	0.45	0.49	-0.04	-0.06	-0.04	0.06	-0.12	-0.12
$PI^A(q)$	0.05	0.02	-0.30	-0.40	-0.31	0.16	0.16	0.11	-0.05	0.23	0.23
$PI^B(q)$	0.02	0.00	-0.12	-0.16	-0.12	0.07	0.03	0.06	0.01	0.12	0.12

	Srellog	LogSrellog	Seff	Seffrelp	SeffrelM	QS	LogQS	LogQSadj	CL	LR1	LR3
Srellog	1										
LogSrellog	0.91	1									
Seff	0.50	0.45	1								
Seffrelp	0.56	0.48	0.98	1							
SeffrelM	0.56	0.48	0.98	1.00	1						
QS	0.95	0.88	0.51	0.56	0.56	1					
LogQS	0.94	0.84	0.52	0.60	0.60	0.98	1				
LogQSadj	0.51	0.45	0.33	0.39	0.39	0.65	0.68	1			
CL	0.28	0.22	0.21	0.28	0.28	0.45	0.51	0.38	1		
LR1	0.02	-0.01	-0.02	0.00	0.00	0.01	0.03	0.02	0.03	1	
LR3	0.13	0.10	0.15	0.17	0.17	0.13	0.16	0.12	0.10	0.01	1
FR	0.05	0.04	-0.01	0.00	0.00	0.04	0.04	0.02	0.01	0.60	-0.02
OR	-0.02	-0.01	0.01	0.00	0.00	-0.03	-0.04	0.00	-0.03	-0.05	0.11
MI^{V^*}	0.14	0.06	0.08	0.13	0.13	0.15	0.20	0.18	0.16	0.02	0.09
MI^{A,V^*}	0.20	0.07	0.12	0.20	0.20	0.21	0.30	0.24	0.25	0.05	0.11
MI^{B,V^*}	0.08	0.04	0.04	0.07	0.07	0.08	0.11	0.11	0.08	0.00	0.06
$DI^A(k)$	-0.12	-0.02	-0.08	-0.15	-0.15	-0.16	-0.22	-0.16	-0.23	0.01	-0.09
$DI^B(k)$	-0.12	-0.02	-0.09	-0.15	-0.15	-0.17	-0.23	-0.17	-0.22	0.02	-0.09
$PI^A(q)$	0.23	0.07	0.15	0.24	0.24	0.25	0.35	0.28	0.31	0.06	0.15
$PI^B(q)$	0.12	0.06	0.07	0.12	0.12	0.13	0.18	0.17	0.12	0.01	0.08

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.04	1							
MI^{V^*}	0.03	-0.02	1						
MI^{A,V^*}	0.03	-0.03	0.41	1					
MI^{B,V^*}	0.02	-0.01	0.94	0.08	1				
$DI^A(k)$	0.03	0.03	-0.20	-0.33	-0.10	1			
$DI^B(k)$	0.06	0.05	-0.21	-0.25	-0.13	0.34	1		
$PI^A(q)$	0.02	-0.04	0.40	0.90	0.10	-0.40	-0.31	1	
$PI^B(q)$	0.01	-0.02	0.67	0.10	0.69	-0.13	-0.19	0.14	1

Table C.9: Correlation matrix of the 31 liquidity measures for Lonza

	Q	V	D	Dlog	D$	N	NO	Sabs	LogSabs	SrelM	Srelp
Q	1										
V	0.99	1									
D	-0.07	-0.04	1								
Dlog	-0.08	-0.06	0.73	1							
D$	-0.10	-0.06	0.99	0.71	1						
N	0.81	0.78	-0.17	-0.16	-0.21	1					
NO	0.73	0.69	-0.21	-0.19	-0.25	0.89	1				
Sabs	0.12	0.10	0.08	0.13	0.06	0.13	0.14	1			
LogSabs	0.11	0.10	0.10	0.15	0.07	0.12	0.13	0.98	1		
SrelM	0.19	0.14	-0.02	0.05	-0.08	0.23	0.26	0.94	0.91	1	
Srelp	0.19	0.14	-0.02	0.05	-0.08	0.23	0.26	0.94	0.91	1.00	1
Srellog	0.19	0.14	-0.02	0.05	-0.08	0.23	0.26	0.94	0.91	1.00	1.00
LogSrellog	0.21	0.16	-0.03	0.04	-0.10	0.26	0.29	0.91	0.91	0.97	0.97
Seff	0.06	0.04	-0.07	-0.05	-0.09	0.10	0.13	0.39	0.35	0.44	0.44
Seffrelp	0.12	0.08	-0.13	-0.09	-0.18	0.19	0.23	0.44	0.40	0.58	0.58
SeffrelM	0.12	0.08	-0.13	-0.09	-0.18	0.19	0.23	0.44	0.40	0.58	0.58
QS	0.15	0.13	-0.16	-0.23	-0.18	0.18	0.21	0.93	0.90	0.90	0.90
LogQS	0.21	0.15	-0.21	-0.25	-0.26	0.28	0.31	0.86	0.83	0.95	0.95
LogQSadj	0.12	0.10	-0.23	-0.68	-0.25	0.16	0.18	0.30	0.28	0.36	0.36
CL	0.18	0.14	-0.41	-0.49	-0.41	0.28	0.30	0.24	0.22	0.35	0.35
LR1	0.59	0.63	0.00	-0.03	-0.01	0.48	0.39	0.03	0.03	0.02	0.02
LR3	-0.04	-0.08	-0.13	-0.09	-0.16	0.02	0.10	0.18	0.16	0.29	0.29
FR	0.89	0.88	-0.07	-0.07	-0.08	0.70	0.63	0.09	0.09	0.13	0.13
OR	-0.03	-0.03	0.02	0.01	0.02	-0.04	-0.04	-0.01	-0.01	-0.02	-0.02
MI^{V^*}	0.18	0.13	-0.44	-0.55	-0.46	0.32	0.35	0.32	0.30	0.45	0.45
MI^{A,V^*}	0.14	0.11	-0.33	-0.48	-0.35	0.21	0.24	0.21	0.20	0.29	0.29
MI^{B,V^*}	0.13	0.09	-0.33	-0.35	-0.34	0.26	0.29	0.27	0.25	0.37	0.37
$DI^A(k)$	-0.19	-0.13	0.44	0.37	0.50	-0.29	-0.36	-0.14	-0.13	-0.32	-0.32
$DI^B(k)$	-0.12	-0.06	0.43	0.36	0.47	-0.22	-0.27	-0.12	-0.11	-0.26	-0.26
$PI^A(q)$	0.20	0.14	-0.43	-0.49	-0.46	0.31	0.35	0.23	0.22	0.38	0.38
$PI^B(q)$	0.15	0.09	-0.40	-0.38	-0.43	0.30	0.34	0.28	0.26	0.43	0.43

	Srellog	LogSrellog	Seff	Seffrelp	SeffrelM	QS	LogQS	LogQSadj	CL	LR1	LR3
Srellog	1										
LogSrellog	0.97	1									
Seff	0.44	0.37	1								
Seffrelp	0.58	0.51	0.96	1							
SeffrelM	0.58	0.51	0.96	1.00	1						
QS	0.90	0.87	0.41	0.48	0.48	1					
LogQS	0.95	0.92	0.45	0.60	0.60	0.95	1				
LogQSadj	0.36	0.34	0.24	0.30	0.30	0.58	0.58	1			
CL	0.35	0.34	0.20	0.31	0.31	0.44	0.52	0.34	1		
LR1	0.02	0.03	0.00	-0.01	-0.01	0.03	0.02	0.03	0.01	1	
LR3	0.29	0.29	0.21	0.30	0.31	0.21	0.31	0.15	0.20	-0.12	1
FR	0.13	0.14	0.06	0.10	0.10	0.12	0.15	0.09	0.18	0.45	-0.02
OR	-0.02	-0.02	0.00	-0.01	-0.01	-0.02	-0.02	-0.01	-0.02	-0.02	0.03
MI^{V^*}	0.45	0.45	0.22	0.35	0.35	0.51	0.60	0.48	0.58	0.01	0.27
MI^{A,V^*}	0.29	0.31	0.13	0.21	0.22	0.38	0.42	0.41	0.43	0.02	0.15
MI^{B,V^*}	0.37	0.36	0.20	0.30	0.30	0.38	0.46	0.31	0.44	0.00	0.25
$DI^A(k)$	-0.32	-0.37	-0.16	-0.31	-0.31	-0.26	-0.41	-0.28	-0.35	-0.01	-0.27
$DI^B(k)$	-0.26	-0.30	-0.14	-0.26	-0.26	-0.24	-0.35	-0.25	-0.31	0.03	-0.23
$PI^A(q)$	0.38	0.41	0.18	0.32	0.32	0.40	0.52	0.41	0.50	0.01	0.27
$PI^B(q)$	0.43	0.43	0.23	0.37	0.37	0.41	0.53	0.33	0.49	-0.01	0.32

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.01	1							
MI^{V^*}	0.14	-0.02	1						
MI^{A,V^*}	0.10	-0.02	0.70	1					
MI^{B,V^*}	0.11	-0.01	0.78	0.10	1				
$DI^A(k)$	-0.14	0.04	-0.46	-0.38	-0.31	1			
$DI^B(k)$	-0.09	0.00	-0.41	-0.25	-0.35	0.41	1		
$PI^A(q)$	0.14	-0.02	0.71	0.86	0.22	-0.54	-0.39	1	
$PI^B(q)$	0.12	-0.01	0.74	0.17	0.89	-0.42	-0.47	0.33	1

Table C.10: Correlation matrix of the 31 liquidity measures of Swiss Re

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*	*LogSabs*	*SrelM*	*Srelp*
Q	1										
V	1.00	1									
D	0.04	0.05	1								
Dlog	0.00	0.01	0.75	1							
D$	0.04	0.05	1.00	0.75	1						
N	0.76	0.75	-0.05	-0.10	-0.06	1					
NO	0.64	0.64	-0.08	-0.10	-0.09	0.82	1				
Sabs	0.15	0.14	0.01	0.06	0.00	0.17	0.20	1			
LogSabs	0.14	0.14	0.03	0.08	0.02	0.17	0.19	0.98	1		
SrelM	0.15	0.14	-0.01	0.04	-0.02	0.18	0.21	1.00	0.97	1	
Srelp	0.15	0.14	-0.01	0.04	-0.02	0.18	0.21	1.00	0.97	1.00	1
Srellog	0.15	0.14	-0.01	0.04	-0.02	0.18	0.21	1.00	0.97	1.00	1.00
Seff	0.14	0.14	0.01	0.06	0.00	0.18	0.20	0.97	1.00	0.97	0.97
Seff	0.07	0.06	-0.07	-0.06	-0.08	0.08	0.13	0.38	0.34	0.38	0.38
Seffrelp	0.07	0.07	-0.08	-0.07	-0.09	0.09	0.14	0.39	0.35	0.40	0.40
SeffrelM	0.07	0.07	-0.08	-0.07	-0.09	0.09	0.14	0.39	0.35	0.40	0.40
QS	0.14	0.13	-0.19	-0.24	-0.19	0.20	0.23	0.94	0.91	0.95	0.95
LogQS	0.14	0.13	-0.19	-0.25	-0.20	0.21	0.23	0.93	0.90	0.94	0.94
LogQSadj	0.11	0.10	-0.13	-0.48	-0.14	0.18	0.18	0.53	0.49	0.54	0.54
CL	0.06	0.05	-0.42	-0.59	-0.42	0.15	0.16	0.39	0.35	0.41	0.41
LR1	0.73	0.73	0.05	0.02	0.05	0.51	0.40	0.07	0.07	0.07	0.07
LR3	-0.02	-0.02	-0.07	-0.07	-0.07	-0.03	0.07	0.22	0.22	0.23	0.23
FR	0.85	0.85	0.01	-0.01	0.00	0.65	0.57	0.10	0.09	0.10	0.10
OR	-0.11	-0.10	0.10	0.05	0.10	-0.13	-0.11	-0.04	-0.04	-0.04	-0.04
MI^{V^*}	0.06	0.05	-0.48	-0.53	-0.49	0.18	0.23	0.43	0.40	0.46	0.46
MI^{A,V^*}	0.03	0.02	-0.39	-0.43	-0.40	0.14	0.18	0.34	0.31	0.36	0.36
MI^{B,V^*}	0.08	0.07	-0.39	-0.44	-0.40	0.16	0.20	0.37	0.34	0.39	0.39
$DI^A(k)$	-0.02	0.00	0.32	0.27	0.34	-0.13	-0.18	-0.21	-0.20	-0.25	-0.25
$DI^B(k)$	0.01	0.02	0.39	0.34	0.41	-0.11	-0.17	-0.22	-0.21	-0.25	-0.25
$PI^A(q)$	0.00	-0.01	-0.32	-0.32	-0.33	0.12	0.17	0.29	0.26	0.33	0.33
$PI^B(q)$	0.04	0.03	-0.12	-0.15	-0.13	0.10	0.13	0.22	0.18	0.24	0.24

	Srellog	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*	*QS*	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*
Srellog	1										
LogSrellog	0.97	1									
Seff	0.38	0.34	1								
Seffrelp	0.40	0.36	1.00	1							
SeffrelM	0.40	0.36	1.00	1.00	1						
QS	0.95	0.91	0.38	0.40	0.40	1					
LogQS	0.94	0.91	0.39	0.41	0.41	1.00	1				
LogQSadj	0.54	0.50	0.24	0.25	0.25	0.70	0.70	1			
CL	0.41	0.37	0.20	0.22	0.22	0.62	0.64	0.46	1		
LR1	0.07	0.07	0.02	0.02	0.02	0.06	0.06	0.05	0.02	1	
LR3	0.23	0.22	0.20	0.21	0.21	0.24	0.24	0.16	0.15	-0.04	1
FR	0.10	0.09	0.07	0.07	0.07	0.10	0.10	0.07	0.05	0.62	-0.01
OR	-0.04	-0.05	0.00	0.00	0.00	-0.05	-0.05	0.00	-0.06	-0.08	0.04
MI^{V^*}	0.46	0.43	0.25	0.28	0.28	0.58	0.60	0.41	0.60	0.00	0.21
MI^{A,V^*}	0.36	0.34	0.19	0.21	0.21	0.45	0.47	0.33	0.46	-0.02	0.17
MI^{B,V^*}	0.39	0.36	0.22	0.24	0.24	0.49	0.50	0.34	0.52	0.02	0.18
$DI^A(k)$	-0.25	-0.25	-0.12	-0.15	-0.15	-0.28	-0.31	-0.18	-0.31	0.04	-0.11
$DI^B(k)$	-0.25	-0.25	-0.14	-0.17	-0.17	-0.30	-0.33	-0.21	-0.33	0.05	-0.13
$PI^A(q)$	0.33	0.30	0.18	0.21	0.21	0.39	0.41	0.29	0.40	-0.05	0.15
$PI^B(q)$	0.24	0.21	0.13	0.15	0.15	0.27	0.29	0.20	0.26	0.01	0.12

	FR	*OR*	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.05	1							
MI^{V^*}	0.06	-0.06	1						
MI^{A,V^*}	0.03	-0.05	0.82	1					
MI^{B,V^*}	0.07	-0.05	0.80	0.32	1				
$DI^A(k)$	-0.02	0.07	-0.50	-0.48	-0.33	1			
$DI^B(k)$	-0.01	0.04	-0.52	-0.40	-0.45	0.47	1		
$PI^A(q)$	0.01	-0.05	0.64	0.66	0.37	-0.73	-0.46	1	
$PI^B(q)$	0.02	-0.02	0.41	0.25	0.41	-0.21	-0.35	0.31	1

Table C.11: Correlation matrix of the 31 liquidity measures for Swisscom

	Q	V	D	Dlog	D$	N	NO	Sabs	LogSabs	SrelM	Srelp
Q	1										
V	0.97	1									
D	0.10	0.07	1								
Dlog	0.06	0.03	0.71	1							
D$	0.04	0.05	0.95	0.71	1						
N	0.85	0.83	0.06	0.01	0.00	1					
NO	0.76	0.74	0.05	0.00	-0.01	0.87	1				
Sabs	0.10	0.08	0.04	0.09	0.02	0.12	0.16	1			
LogSabs	0.07	0.06	0.05	0.10	0.03	0.08	0.12	0.95	1		
SrelM	0.18	0.11	0.10	0.11	0.00	0.19	0.23	0.94	0.88	1	
Srelp	0.18	0.11	0.10	0.11	0.00	0.19	0.23	0.94	0.88	1.00	1
Srellog	0.18	0.11	0.10	0.11	0.00	0.19	0.23	0.94	0.88	1.00	1.00
LogSrellog	0.13	0.08	0.09	0.12	0.00	0.15	0.19	0.91	0.96	0.92	0.93
Seff	0.08	0.05	0.03	0.04	-0.02	0.10	0.15	0.66	0.62	0.68	0.68
Seffrelp	0.15	0.08	0.08	0.07	-0.02	0.17	0.21	0.65	0.60	0.75	0.75
SeffrelM	0.15	0.08	0.08	0.07	-0.02	0.17	0.21	0.65	0.60	0.75	0.75
QS	0.09	0.08	-0.18	-0.27	-0.20	0.12	0.15	0.90	0.85	0.84	0.84
LogQS	0.15	0.10	-0.12	-0.22	-0.20	0.19	0.22	0.87	0.81	0.91	0.91
LogQSadj	0.13	0.09	-0.04	-0.34	-0.10	0.15	0.16	0.58	0.53	0.63	0.63
CL	0.09	0.06	-0.30	-0.49	-0.34	0.13	0.14	0.38	0.35	0.42	0.42
LR1	0.47	0.53	0.03	0.02	0.05	0.36	0.30	-0.06	-0.06	-0.08	-0.08
LR3	0.07	0.02	0.01	0.01	-0.07	0.06	0.16	0.29	0.27	0.37	0.37
FR	0.84	0.85	0.04	0.02	0.02	0.79	0.66	0.07	0.05	0.10	0.10
OR	-0.11	-0.12	0.10	0.06	0.10	-0.13	-0.12	0.00	0.01	0.00	0.00
MI^{V^*}	0.05	0.02	0.11	-0.14	0.05	0.11	0.11	0.25	0.22	0.28	0.28
MI^{A,V^*}	0.05	0.01	-0.19	-0.20	-0.24	0.10	0.13	0.32	0.28	0.36	0.36
MI^{B,V^*}	0.03	0.02	0.21	-0.07	0.17	0.08	0.07	0.14	0.12	0.16	0.16
$DI^A(k)$	-0.05	0.00	0.15	0.16	0.22	-0.08	-0.11	-0.25	-0.24	-0.30	-0.30
$DI^B(k)$	-0.05	0.01	0.07	0.10	0.17	-0.08	-0.12	-0.26	-0.25	-0.33	-0.33
$PI^A(q)$	0.07	0.02	-0.10	-0.11	-0.17	0.09	0.12	0.14	0.14	0.22	0.22
$PI^B(q)$	0.05	0.03	-0.10	-0.14	-0.13	0.12	0.13	0.23	0.22	0.25	0.25

	Srellog	LogSrellog	Seff	Seffrelp	SeffrelM	QS	LogQS	LogQSadj	CL	LR1	LR3
Srellog	1										
LogSrellog	0.92	1									
Seff	0.68	0.63	1								
Seffrelp	0.75	0.67	0.96	1							
SeffrelM	0.75	0.67	0.96	1.00	1						
QS	0.84	0.82	0.60	0.58	0.58	1					
LogQS	0.91	0.84	0.62	0.68	0.68	0.95	1				
LogQSadj	0.63	0.57	0.44	0.49	0.49	0.74	0.79	1			
CL	0.42	0.39	0.28	0.32	0.32	0.68	0.71	0.49	1		
LR1	-0.08	-0.08	-0.08	-0.09	-0.09	-0.06	-0.08	-0.06	-0.04	1	
LR3	0.37	0.35	0.33	0.39	0.39	0.27	0.34	0.24	0.19	-0.08	1
FR	0.10	0.07	0.07	0.09	0.09	0.07	0.09	0.08	0.05	0.30	0.02
OR	0.00	0.01	0.03	0.02	0.02	-0.02	-0.02	0.03	-0.05	-0.09	0.09
MI^{V^*}	0.28	0.26	0.21	0.24	0.24	0.29	0.32	0.29	0.23	-0.08	0.16
MI^{A,V^*}	0.36	0.34	0.26	0.30	0.30	0.39	0.42	0.30	0.35	-0.10	0.20
MI^{B,V^*}	0.16	0.14	0.12	0.14	0.14	0.15	0.17	0.20	0.11	-0.04	0.09
$DI^A(k)$	-0.30	-0.31	-0.23	-0.26	-0.26	-0.29	-0.33	-0.24	-0.25	0.11	-0.21
$DI^B(k)$	-0.33	-0.36	-0.24	-0.29	-0.29	-0.28	-0.35	-0.26	-0.23	0.12	-0.24
$PI^A(q)$	0.22	0.23	0.14	0.20	0.20	0.17	0.24	0.18	0.19	-0.07	0.18
$PI^B(q)$	0.25	0.26	0.17	0.18	0.18	0.27	0.29	0.21	0.21	-0.06	0.15

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.05	1							
MI^{V^*}	0.04	-0.02	1						
MI^{A,V^*}	0.04	-0.03	0.48	1					
MI^{B,V^*}	0.03	-0.01	0.92	0.11	1				
$DI^A(k)$	-0.04	0.01	-0.28	-0.52	-0.08	1			
$DI^B(k)$	-0.03	0.02	-0.31	-0.29	-0.22	0.34	1		
$PI^A(q)$	0.03	-0.02	0.17	0.26	0.08	-0.44	-0.25	1	
$PI^B(q)$	0.07	-0.05	0.29	0.25	0.22	-0.26	-0.57	0.09	1

Table C.12: Correlation matrix of the 31 liquidity measures for Serono

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$	$LogSabs$	$SrelM$	$Srelp$
Q	1										
V	0.99	1									
D	0.03	0.03	1								
$Dlog$	0.05	0.05	0.22	1							
$D\$$	0.03	0.03	1.00	0.21	1						
N	0.72	0.71	0.02	-0.02	0.02	1					
NO	0.63	0.62	0.00	-0.04	-0.01	0.83	1				
$Sabs$	0.11	0.11	-0.01	0.13	-0.01	0.07	0.18	1			
$LogSabs$	0.09	0.09	-0.02	0.15	-0.02	0.03	0.13	0.90	1		
$SrelM$	0.14	0.12	-0.01	0.12	-0.02	0.11	0.23	0.99	0.88	1	
$Srelp$	0.14	0.12	-0.01	0.12	-0.02	0.11	0.23	0.99	0.88	1.00	1
$Srellog$	0.14	0.12	-0.01	0.12	-0.02	0.11	0.23	0.99	0.88	1.00	1.00
$LogSrellog$	0.11	0.10	-0.03	0.15	-0.03	0.07	0.17	0.90	0.99	0.90	0.90
$Seff$	0.03	0.03	-0.01	0.03	-0.01	0.01	0.15	0.65	0.55	0.64	0.64
$Seffrelp$	0.05	0.04	-0.02	0.03	-0.02	0.04	0.18	0.65	0.55	0.66	0.66
$SeffrelM$	0.05	0.04	-0.02	0.03	-0.02	0.04	0.18	0.65	0.55	0.66	0.66
QS	0.09	0.09	-0.05	-0.15	-0.05	0.08	0.19	0.93	0.83	0.92	0.92
$LogQS$	0.12	0.11	-0.05	-0.16	-0.05	0.12	0.23	0.92	0.81	0.93	0.93
$LogQSadj$	0.11	0.10	-0.01	-0.28	-0.01	0.12	0.20	0.64	0.57	0.66	0.66
CL	0.06	0.05	-0.06	-0.42	-0.05	0.10	0.16	0.38	0.30	0.41	0.41
$LR1$	0.60	0.61	0.03	0.04	0.03	0.50	0.38	0.01	0.00	0.02	0.02
$LR3$	0.10	0.09	-0.01	0.00	-0.01	0.11	0.21	0.24	0.24	0.25	0.25
FR	0.86	0.87	0.02	0.04	0.01	0.64	0.55	0.08	0.07	0.10	0.10
OR	-0.03	-0.03	0.09	0.10	0.09	-0.04	-0.03	-0.01	-0.01	-0.01	-0.01
MI^{V^*}	0.08	0.05	-0.05	-0.19	-0.05	0.14	0.21	0.28	0.22	0.31	0.31
MI^{A,V^*}	-0.01	-0.02	-0.06	-0.21	-0.06	0.06	0.14	0.24	0.21	0.26	0.26
MI^{B,V^*}	0.09	0.07	-0.03	-0.12	-0.03	0.13	0.18	0.22	0.17	0.24	0.24
$DI^A(k)$	0.07	0.08	0.87	0.17	0.87	0.03	-0.01	-0.09	-0.09	-0.10	-0.10
$DI^B(k)$	0.14	0.15	0.11	0.23	0.11	0.07	0.04	-0.16	-0.14	-0.16	-0.16
$PI^A(q)$	0.01	0.01	-0.05	-0.13	-0.05	0.01	0.04	0.18	0.18	0.17	0.18
$PI^B(q)$	-0.04	-0.05	-0.03	-0.11	-0.03	0.01	0.06	0.14	0.10	0.17	0.17

	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$
$Srellog$	1										
$LogSrellog$	0.90	1									
$Seff$	0.64	0.55	1								
$Seffrelp$	0.66	0.56	0.99	1							
$SeffrelM$	0.66	0.56	0.99	1.00	1						
QS	0.92	0.83	0.62	0.62	0.62	1					
$LogQS$	0.93	0.83	0.61	0.62	0.63	0.99	1				
$LogQSadj$	0.66	0.59	0.42	0.44	0.44	0.76	0.77	1			
CL	0.41	0.32	0.28	0.30	0.31	0.63	0.66	0.41	1		
$LR1$	0.02	0.01	-0.05	-0.03	-0.03	0.00	0.01	0.02	0.01	1	
$LR3$	0.25	0.25	0.21	0.22	0.22	0.23	0.24	0.19	0.12	0.04	1
FR	0.10	0.08	0.04	0.05	0.05	0.07	0.08	0.08	0.03	0.40	0.04
OR	-0.01	-0.01	0.00	0.00	0.00	-0.03	-0.03	0.00	-0.03	-0.03	0.06
MI^{V^*}	0.31	0.25	0.24	0.26	0.26	0.33	0.36	0.31	0.25	-0.02	0.11
MI^{A,V^*}	0.26	0.24	0.21	0.23	0.23	0.29	0.31	0.22	0.22	-0.04	0.11
MI^{B,V^*}	0.24	0.18	0.18	0.20	0.20	0.25	0.27	0.26	0.19	0.00	0.08
$DI^A(k)$	-0.10	-0.10	-0.07	-0.08	-0.08	-0.11	-0.12	-0.08	-0.08	0.06	-0.04
$DI^B(k)$	-0.16	-0.14	-0.13	-0.13	-0.13	-0.20	-0.20	-0.13	-0.15	0.14	-0.04
$PI^A(q)$	0.17	0.19	0.15	0.14	0.14	0.22	0.20	0.18	0.10	-0.04	0.03
$PI^B(q)$	0.17	0.13	0.11	0.14	0.14	0.17	0.20	0.15	0.16	-0.06	0.06

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.02	1							
MI^{V^*}	0.07	-0.02	1						
MI^{A,V^*}	-0.01	-0.04	0.50	1					
MI^{B,V^*}	0.09	-0.01	0.92	0.14	1				
$DI^A(k)$	0.05	0.08	-0.17	-0.28	-0.07	1			
$DI^B(k)$	0.09	0.02	-0.30	-0.13	-0.29	0.14	1		
$PI^A(q)$	0.03	-0.03	0.25	0.33	0.14	-0.20	-0.17	1	
$PI^B(q)$	-0.03	0.02	0.35	0.11	0.35	-0.08	-0.53	0.03	1

Table C.13: Correlation matrix of the 31 liquidity measures for Surveillance

	Q	V	D	Dlog	D$	N	NO	Sabs	LogSabs	SrelM	Srelp
Q	1										
V	1.00	1									
D	0.05	0.06	1								
Dlog	0.03	0.03	0.57	1							
D$	0.06	0.06	0.99	0.58	1						
N	0.60	0.59	0.03	-0.03	0.02	1					
NO	0.46	0.45	0.01	-0.05	-0.01	0.73	1				
Sabs	0.06	0.05	0.00	0.03	-0.01	0.10	0.20	1			
LogSabs	0.07	0.06	0.01	0.05	0.00	0.09	0.17	0.95	1		
SrelM	0.05	0.04	-0.01	0.00	-0.03	0.11	0.20	0.98	0.89	1	
Srelp	0.05	0.04	-0.01	0.00	-0.03	0.11	0.20	0.97	0.89	1.00	1
Srellog	0.05	0.04	-0.01	0.00	-0.03	0.11	0.20	0.98	0.89	1.00	1.00
LogSrellog	0.06	0.05	0.01	0.01	-0.02	0.12	0.20	0.93	0.97	0.91	0.91
Seff	0.01	0.00	-0.05	-0.10	-0.06	0.04	0.13	0.66	0.59	0.67	0.68
Seffrelp	0.01	0.00	-0.05	-0.11	-0.07	0.05	0.13	0.66	0.57	0.70	0.71
SeffrelM	0.01	0.00	-0.05	-0.11	-0.07	0.05	0.14	0.67	0.58	0.71	0.72
QS	0.06	0.05	-0.13	-0.25	-0.14	0.11	0.20	0.94	0.88	0.93	0.92
LogQS	0.05	0.03	-0.12	-0.25	-0.14	0.12	0.21	0.92	0.83	0.95	0.95
LogQSadj	0.04	0.03	0.00	-0.38	-0.02	0.11	0.17	0.62	0.56	0.65	0.65
CL	0.02	0.01	-0.23	-0.49	-0.24	0.09	0.14	0.46	0.40	0.50	0.50
LR1	0.65	0.66	0.05	0.03	0.05	0.46	0.35	-0.01	0.00	-0.02	-0.02
LR3	0.09	0.08	-0.03	-0.10	-0.05	0.13	0.19	0.27	0.24	0.30	0.30
FR	0.83	0.84	0.05	0.03	0.05	0.51	0.41	0.04	0.05	0.04	0.04
OR	-0.04	-0.04	0.21	0.09	0.20	-0.04	-0.03	-0.01	-0.01	0.00	0.00
MI^{V^*}	0.02	-0.01	-0.07	-0.13	-0.10	0.06	0.11	0.27	0.23	0.35	0.35
MI^{A,V^*}	-0.02	-0.04	-0.02	-0.16	-0.07	0.07	0.12	0.23	0.22	0.32	0.32
MI^{B,V^*}	0.02	0.01	-0.07	-0.09	-0.09	0.05	0.08	0.23	0.19	0.29	0.29
$DI^A(k)$	0.04	0.07	0.10	0.25	0.16	-0.06	-0.10	-0.18	-0.18	-0.25	-0.25
$DI^B(k)$	0.02	0.03	0.34	0.17	0.35	0.02	-0.03	-0.11	-0.11	-0.13	-0.13
$PI^A(q)$	-0.01	-0.03	0.00	-0.19	-0.05	0.03	0.10	0.18	0.19	0.25	0.25
$PI^B(q)$	-0.01	-0.03	-0.23	-0.21	-0.25	0.02	0.09	0.22	0.19	0.27	0.27

	Srellog	LogSrellog	Seff	Seffrelp	SeffrelM	QS	LogQS	LogQSadj	CL	LR1	LR3
Srellog	1										
LogSrellog	0.91	1									
Seff	0.67	0.59	1								
Seffrelp	0.70	0.60	0.98	1							
SeffrelM	0.71	0.61	0.98	1.00	1						
QS	0.93	0.88	0.67	0.67	0.68	1					
LogQS	0.95	0.86	0.68	0.71	0.72	0.98	1				
LogQSadj	0.65	0.59	0.49	0.51	0.52	0.76	0.78	1			
CL	0.50	0.44	0.44	0.48	0.48	0.68	0.70	0.50	1		
LR1	-0.02	-0.02	-0.04	-0.04	-0.04	-0.01	-0.03	-0.01	-0.02	1	
LR3	0.30	0.28	0.21	0.23	0.23	0.30	0.33	0.27	0.24	0.04	1
FR	0.04	0.05	0.01	0.01	0.01	0.04	0.03	0.02	0.01	0.53	0.04
OR	0.00	0.00	-0.01	0.00	0.00	-0.03	-0.02	0.03	-0.04	-0.04	0.06
MI^{V^*}	0.35	0.32	0.20	0.24	0.25	0.30	0.37	0.26	0.29	-0.04	0.24
MI^{A,V^*}	0.32	0.35	0.17	0.22	0.23	0.26	0.34	0.29	0.25	-0.07	0.20
MI^{B,V^*}	0.29	0.25	0.17	0.20	0.21	0.25	0.31	0.19	0.24	-0.02	0.20
$DI^A(k)$	-0.25	-0.32	-0.14	-0.18	-0.19	-0.23	-0.29	-0.23	-0.24	0.12	-0.14
$DI^B(k)$	-0.13	-0.13	-0.08	-0.09	-0.09	-0.14	-0.15	-0.03	-0.15	0.05	-0.07
$PI^A(q)$	0.25	0.32	0.13	0.17	0.18	0.23	0.29	0.24	0.23	-0.07	0.15
$PI^B(q)$	0.27	0.27	0.17	0.20	0.20	0.26	0.31	0.18	0.27	-0.07	0.17

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.02	1							
MI^{V^*}	0.00	0.00	1						
MI^{A,V^*}	-0.02	0.07	0.52	1					
MI^{B,V^*}	0.01	-0.02	0.96	0.26	1				
$DI^A(k)$	0.03	-0.02	-0.29	-0.56	-0.14	1			
$DI^B(k)$	0.01	0.09	-0.19	-0.08	-0.19	0.22	1		
$PI^A(q)$	-0.01	0.03	0.28	0.55	0.14	-0.60	-0.07	1	
$PI^B(q)$	0.00	-0.06	0.48	0.21	0.47	-0.38	-0.63	0.27	1

Table C.14: Correlation matrix of the 31 liquidity measures of Sulzer

	Q	*V*	*D*	*Dlog*	*D$*	*N*	*NO*	*Sabs*	*LogSabs*	*SrelM*	*Srelp*
Q	1										
V	1.00	1									
D	0.05	0.05	1								
Dlog	0.06	0.07	0.41	1							
D$	0.04	0.05	1.00	0.41	1						
N	0.69	0.67	0.01	0.00	0.00	1					
NO	0.58	0.56	-0.01	-0.01	-0.02	0.83	1				
Sabs	0.08	0.08	0.12	0.22	0.12	0.11	0.21	1			
LogSabs	0.06	0.05	0.12	0.23	0.12	0.07	0.16	0.90	1		
SrelM	0.10	0.08	0.10	0.19	0.09	0.14	0.24	0.99	0.88	1	
Srelp	0.10	0.08	0.10	0.19	0.09	0.14	0.24	0.99	0.88	1.00	1
Srellog	0.10	0.08	0.10	0.19	0.09	0.14	0.24	0.99	0.88	1.00	1.00
LogSrellog	0.07	0.06	0.11	0.22	0.10	0.09	0.19	0.90	0.99	0.89	0.89
Seff	0.02	0.01	0.07	0.12	0.07	0.06	0.16	0.69	0.65	0.69	0.69
Seffrelp	0.03	0.02	0.05	0.10	0.05	0.08	0.19	0.70	0.63	0.71	0.71
SeffrelM	0.03	0.02	0.05	0.10	0.05	0.08	0.19	0.70	0.63	0.71	0.71
QS	0.07	0.06	0.02	-0.02	0.02	0.12	0.21	0.96	0.87	0.96	0.96
LogQS	0.09	0.07	0.01	-0.03	0.00	0.14	0.25	0.95	0.84	0.96	0.96
LogQSadj	0.07	0.06	0.04	-0.22	0.04	0.13	0.19	0.68	0.60	0.69	0.69
CL	0.02	0.01	-0.14	-0.45	-0.14	0.06	0.10	0.27	0.24	0.29	0.29
LR1	0.53	0.54	0.01	0.03	0.01	0.42	0.29	-0.07	-0.09	-0.06	-0.06
LR3	0.00	-0.01	0.02	0.01	0.02	0.00	0.17	0.34	0.33	0.35	0.35
FR	0.88	0.87	0.02	0.03	0.02	0.56	0.46	0.05	0.04	0.06	0.06
OR	-0.07	-0.07	0.07	0.06	0.07	-0.09	-0.08	0.02	0.03	0.01	0.01
MI^{V^*}	0.08	0.05	-0.09	-0.16	-0.10	0.16	0.22	0.32	0.24	0.38	0.38
MI^{A,V^*}	0.06	0.04	-0.07	-0.13	-0.08	0.13	0.18	0.23	0.17	0.29	0.29
MI^{B,V^*}	0.07	0.05	-0.08	-0.13	-0.08	0.14	0.18	0.31	0.23	0.35	0.35
$DI^A(k)$	-0.04	-0.01	0.41	0.16	0.43	-0.08	-0.16	-0.13	-0.10	-0.19	-0.19
$DI^B(k)$	-0.05	-0.03	0.12	0.11	0.13	-0.09	-0.17	-0.13	-0.10	-0.18	-0.18
$PI^A(q)$	0.07	0.04	-0.07	-0.14	-0.09	0.14	0.21	0.25	0.19	0.31	0.31
$PI^B(q)$	0.08	0.06	-0.08	-0.13	-0.08	0.16	0.21	0.36	0.28	0.41	0.41

	Srellog	*LogSrellog*	*Seff*	*Seffrelp*	*SeffrelM*	*QS*	*LogQS*	*LogQSadj*	*CL*	*LR1*	*LR3*
Srellog	1										
LogSrellog	0.89	1									
Seff	0.69	0.65	1								
Seffrelp	0.71	0.65	0.99	1							
SeffrelM	0.71	0.65	0.99	1.00	1						
QS	0.96	0.87	0.68	0.68	0.68	1					
LogQS	0.96	0.86	0.67	0.69	0.69	0.99	1				
LogQSadj	0.69	0.61	0.50	0.52	0.52	0.78	0.78	1			
CL	0.29	0.25	0.20	0.23	0.23	0.45	0.47	0.32	1		
LR1	-0.06	-0.09	-0.08	-0.08	-0.08	-0.07	-0.07	-0.05	-0.03	1	
LR3	0.35	0.34	0.32	0.33	0.33	0.34	0.35	0.26	0.15	-0.08	1
FR	0.06	0.05	0.02	0.02	0.02	0.05	0.06	0.06	0.02	0.36	-0.01
OR	0.01	0.02	0.04	0.03	0.03	0.01	0.00	0.04	-0.03	-0.05	0.01
MI^{V^*}	0.38	0.28	0.26	0.31	0.31	0.37	0.43	0.31	0.29	-0.05	0.21
MI^{A,V^*}	0.29	0.21	0.19	0.24	0.24	0.28	0.33	0.24	0.23	-0.04	0.18
MI^{B,V^*}	0.35	0.26	0.25	0.28	0.28	0.36	0.40	0.29	0.24	-0.03	0.17
$DI^A(k)$	-0.19	-0.16	-0.11	-0.16	-0.16	-0.17	-0.22	-0.14	-0.15	0.03	-0.14
$DI^B(k)$	-0.18	-0.14	-0.09	-0.13	-0.14	-0.16	-0.21	-0.14	-0.14	-0.01	-0.08
$PI^A(q)$	0.31	0.23	0.21	0.27	0.27	0.29	0.35	0.25	0.24	-0.04	0.19
$PI^B(q)$	0.41	0.31	0.28	0.32	0.32	0.41	0.45	0.34	0.27	-0.03	0.19

	FR	*OR*	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.03	1							
MI^{V^*}	0.06	-0.03	1						
MI^{A,V^*}	0.05	-0.02	0.91	1					
MI^{B,V^*}	0.05	-0.02	0.68	0.30	1				
$DI^A(k)$	-0.03	0.03	-0.35	-0.35	-0.17	1			
$DI^B(k)$	-0.02	0.04	-0.32	-0.20	-0.37	0.19	1		
$PI^A(q)$	0.05	-0.03	0.87	0.95	0.32	-0.39	-0.22	1	
$PI^B(q)$	0.05	-0.02	0.68	0.34	0.94	-0.21	-0.42	0.36	1

Table C.15: Correlation matrix of the 31 liquidity measures for Syngenta

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$	$LogSabs$	$SrelM$	$Srelp$
Q	1										
V	0.99	1									
D	0.10	0.10	1								
$Dlog$	0.06	0.06	0.59	1							
$D\$$	0.09	0.10	0.99	0.59	1						
N	0.67	0.66	0.03	-0.03	0.02	1					
NO	0.54	0.53	0.03	0.00	0.01	0.77	1				
$Sabs$	0.08	0.06	0.01	0.09	-0.01	0.11	0.20	1			
$LogSabs$	0.06	0.04	0.02	0.11	-0.01	0.08	0.16	0.94	1		
$SrelM$	0.09	0.06	0.01	0.09	-0.03	0.12	0.22	0.98	0.91	1	
$Srelp$	0.09	0.06	0.01	0.09	-0.03	0.12	0.22	0.98	0.91	1.00	1
$Srellog$	0.09	0.06	0.01	0.09	-0.03	0.12	0.22	0.98	0.91	1.00	1.00
$LogSrellog$	0.07	0.04	0.02	0.11	-0.03	0.10	0.19	0.92	0.98	0.93	0.93
$Seff$	0.01	-0.01	-0.03	0.00	-0.05	0.04	0.15	0.64	0.57	0.64	0.64
$Seffrelp$	0.03	0.00	-0.03	0.01	-0.06	0.06	0.18	0.65	0.57	0.68	0.68
$SeffrelM$	0.03	0.00	-0.03	0.01	-0.06	0.06	0.18	0.65	0.57	0.68	0.68
QS	0.07	0.05	-0.11	-0.14	-0.13	0.12	0.20	0.96	0.90	0.94	0.94
$LogQS$	0.08	0.04	-0.10	-0.13	-0.14	0.13	0.22	0.94	0.87	0.97	0.97
$LogQSadj$	0.07	0.05	-0.04	-0.34	-0.07	0.14	0.18	0.62	0.56	0.64	0.64
CL	0.02	-0.01	-0.25	-0.49	-0.27	0.11	0.14	0.38	0.35	0.41	0.41
$LR1$	0.70	0.72	0.11	0.07	0.11	0.49	0.37	-0.02	-0.03	-0.04	-0.04
$LR3$	-0.01	-0.03	-0.04	-0.01	-0.07	-0.02	0.11	0.34	0.33	0.38	0.38
FR	0.86	0.86	0.06	0.03	0.06	0.61	0.47	0.07	0.05	0.07	0.07
OR	-0.07	-0.07	0.13	0.08	0.13	-0.09	-0.07	-0.01	-0.01	-0.01	-0.01
MI^{V^*}	-0.01	-0.05	-0.23	-0.28	-0.27	0.05	0.14	0.40	0.37	0.47	0.47
MI^{A,V^*}	-0.01	-0.04	-0.17	-0.21	-0.20	0.02	0.10	0.33	0.31	0.39	0.39
MI^{B,V^*}	-0.01	-0.03	-0.21	-0.23	-0.24	0.06	0.12	0.30	0.28	0.34	0.34
$DI^A(k)$	0.02	0.05	0.17	0.19	0.20	-0.01	-0.09	-0.22	-0.21	-0.26	-0.26
$DI^B(k)$	0.07	0.08	0.31	0.21	0.33	0.00	-0.03	-0.19	-0.18	-0.22	-0.22
$PI^A(q)$	-0.01	-0.02	-0.11	-0.14	-0.13	0.03	0.09	0.17	0.15	0.18	0.18
$PI^B(q)$	0.00	-0.02	-0.19	-0.20	-0.22	0.09	0.14	0.28	0.26	0.34	0.34

	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$
$Srellog$	1										
$LogSrellog$	0.93	1									
$Seff$	0.64	0.57	1								
$Seffrelp$	0.68	0.60	0.98	1							
$SeffrelM$	0.68	0.60	0.98	1.00	1						
QS	0.94	0.89	0.62	0.63	0.63	1					
$LogQS$	0.97	0.90	0.62	0.67	0.67	0.98	1				
$LogQSadj$	0.64	0.58	0.43	0.46	0.46	0.73	0.75	1			
CL	0.41	0.38	0.26	0.30	0.30	0.54	0.57	0.41	1		
$LR1$	-0.04	-0.04	-0.09	-0.09	-0.09	-0.04	-0.05	-0.02	-0.06	1	
$LR3$	0.38	0.36	0.29	0.33	0.33	0.34	0.37	0.24	0.19	-0.05	1
FR	0.07	0.05	0.03	0.04	0.04	0.06	0.06	0.06	0.01	0.57	-0.02
OR	-0.01	0.00	0.03	0.03	0.03	-0.03	-0.02	0.01	-0.05	-0.06	0.07
MI^{V^*}	0.47	0.45	0.29	0.35	0.35	0.47	0.53	0.39	0.42	-0.10	0.27
MI^{A,V^*}	0.39	0.37	0.23	0.28	0.28	0.39	0.44	0.33	0.34	-0.09	0.23
MI^{B,V^*}	0.34	0.33	0.23	0.27	0.27	0.35	0.39	0.28	0.31	-0.08	0.19
$DI^A(k)$	-0.26	-0.26	-0.17	-0.20	-0.20	-0.25	-0.29	-0.21	-0.24	0.09	-0.16
$DI^B(k)$	-0.22	-0.21	-0.14	-0.17	-0.17	-0.23	-0.25	-0.17	-0.20	0.10	-0.14
$PI^A(q)$	0.18	0.17	0.11	0.12	0.12	0.20	0.21	0.14	0.20	-0.03	0.11
$PI^B(q)$	0.34	0.32	0.22	0.27	0.27	0.33	0.38	0.28	0.30	-0.07	0.19

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.03	1							
MI^{V^*}	-0.01	-0.02	1						
MI^{A,V^*}	-0.01	-0.01	0.87	1					
MI^{B,V^*}	0.00	-0.01	0.68	0.23	1				
$DI^A(k)$	0.02	0.01	-0.52	-0.56	-0.19	1			
$DI^B(k)$	0.03	0.03	-0.40	-0.19	-0.49	0.13	1		
$PI^A(q)$	-0.01	-0.02	0.38	0.44	0.10	-0.37	-0.11	1	
$PI^B(q)$	0.01	-0.01	0.62	0.25	0.84	-0.20	-0.53	0.10	1

Table C.16: Correlation matrix of the 31 liquidity measures for Swatch bearer share

	Q	V	D	$Dlog$	$D\$$	N	NO	$Sabs$	$LogSabs$	$SrelM$	$Srelp$
Q	1										
V	0.99	1									
D	0.06	0.04	1								
$Dlog$	0.04	0.03	0.72	1							
$D\$$	0.05	0.04	0.98	0.73	1						
N	0.71	0.69	0.04	-0.02	0.02	1					
NO	0.54	0.52	0.07	0.01	0.05	0.69	1				
$Sabs$	0.05	0.04	0.17	0.21	0.17	0.07	0.18	1			
$LogSabs$	0.05	0.04	0.18	0.23	0.18	0.05	0.14	0.93	1		
$SrelM$	0.06	0.04	0.21	0.22	0.18	0.09	0.20	0.97	0.89	1	
$Srelp$	0.06	0.04	0.21	0.22	0.18	0.09	0.20	0.97	0.89	1.00	1
$Srellog$	0.06	0.04	0.21	0.22	0.18	0.09	0.20	0.97	0.89	1.00	1.00
$LogSrellog$	0.06	0.04	0.24	0.26	0.21	0.08	0.18	0.91	0.98	0.91	0.91
$Seff$	0.04	0.02	0.12	0.11	0.10	0.03	0.14	0.63	0.56	0.65	0.65
$Seffrelp$	0.05	0.02	0.15	0.13	0.11	0.05	0.16	0.63	0.55	0.68	0.68
$SeffrelM$	0.05	0.02	0.15	0.13	0.11	0.05	0.16	0.63	0.55	0.68	0.68
QS	0.04	0.04	0.02	-0.01	0.02	0.07	0.18	0.97	0.89	0.94	0.94
$LogQS$	0.06	0.03	0.07	0.02	0.04	0.10	0.21	0.95	0.86	0.97	0.97
$LogQSadj$	0.05	0.03	0.12	-0.19	0.09	0.10	0.19	0.65	0.57	0.68	0.69
CL	0.01	0.00	-0.27	-0.46	-0.29	0.05	0.08	0.22	0.19	0.24	0.24
$LR1$	0.67	0.69	0.00	0.01	0.01	0.47	0.34	-0.02	-0.02	-0.03	-0.03
$LR3$	0.03	0.02	0.10	0.05	0.07	0.04	0.15	0.22	0.22	0.25	0.25
FR	0.85	0.86	0.03	0.02	0.03	0.63	0.45	0.04	0.04	0.04	0.04
OR	-0.05	-0.05	0.08	0.06	0.08	-0.05	-0.03	0.00	0.01	0.01	0.01
MI^{V^*}	0.05	0.02	0.01	-0.04	-0.03	0.09	0.08	0.12	0.09	0.17	0.17
MI^{A,V^*}	0.03	0.01	-0.26	-0.19	-0.29	0.06	0.10	0.15	0.14	0.19	0.19
MI^{B,V^*}	0.04	0.02	0.04	-0.02	0.00	0.09	0.07	0.10	0.07	0.15	0.15
$DI^A(k)$	0.00	0.02	0.25	0.16	0.29	-0.03	-0.06	-0.14	-0.13	-0.17	-0.17
$DI^B(k)$	0.00	0.04	-0.11	0.01	-0.03	-0.09	-0.07	-0.13	-0.11	-0.21	-0.21
$PI^A(q)$	0.04	0.01	-0.33	-0.30	-0.36	0.09	0.13	0.26	0.23	0.31	0.31
$PI^B(q)$	0.03	0.00	0.13	-0.03	0.08	0.10	0.11	0.21	0.15	0.27	0.27

	$Srellog$	$LogSrellog$	$Seff$	$Seffrelp$	$SeffrelM$	QS	$LogQS$	$LogQSadj$	CL	$LR1$	$LR3$
$Srellog$	1										
$LogSrellog$	0.91	1									
$Seff$	0.65	0.57	1								
$Seffrelp$	0.68	0.59	0.98	1							
$SeffrelM$	0.68	0.59	0.98	1.00	1						
QS	0.94	0.87	0.61	0.61	0.61	1					
$LogQS$	0.97	0.87	0.63	0.66	0.66	0.97	1				
$LogQSadj$	0.68	0.59	0.45	0.48	0.48	0.74	0.77	1			
CL	0.24	0.21	0.17	0.19	0.19	0.37	0.40	0.27	1		
$LR1$	-0.03	-0.03	-0.04	-0.05	-0.05	-0.02	-0.03	-0.02	-0.02	1	
$LR3$	0.25	0.26	0.21	0.24	0.24	0.21	0.25	0.19	0.09	-0.02	1
FR	0.04	0.04	0.08	0.07	0.07	0.04	0.04	0.02	0.01	0.53	0.00
OR	0.01	0.02	0.01	0.01	0.01	-0.01	0.00	0.01	-0.02	-0.04	0.09
MI^{V^*}	0.17	0.15	0.12	0.16	0.16	0.13	0.19	0.16	0.13	-0.02	0.11
MI^{A,V^*}	0.19	0.18	0.11	0.14	0.14	0.20	0.24	0.13	0.21	-0.03	0.11
MI^{B,V^*}	0.15	0.13	0.11	0.15	0.15	0.11	0.17	0.15	0.11	-0.02	0.10
$DI^A(k)$	-0.17	-0.17	-0.10	-0.13	-0.13	-0.18	-0.21	-0.11	-0.19	0.04	-0.08
$DI^B(k)$	-0.21	-0.20	-0.14	-0.20	-0.20	-0.14	-0.22	-0.21	-0.13	0.07	-0.15
$PI^A(q)$	0.31	0.28	0.21	0.25	0.25	0.34	0.38	0.25	0.32	-0.03	0.15
$PI^B(q)$	0.27	0.21	0.19	0.24	0.24	0.23	0.29	0.32	0.16	-0.04	0.13

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.02	1							
MI^{V^*}	0.02	0.00	1						
MI^{A,V^*}	0.01	-0.03	0.20	1					
MI^{B,V^*}	0.02	0.00	0.99	0.10	1				
$DI^A(k)$	0.01	0.03	-0.13	-0.66	-0.07	1			
$DI^B(k)$	0.02	-0.02	-0.39	-0.09	-0.39	0.10	1		
$PI^A(q)$	0.02	-0.04	0.15	0.67	0.08	-0.52	-0.09	1	
$PI^B(q)$	0.01	0.02	0.47	0.05	0.47	-0.03	-0.50	0.05	1

Table C.17: Correlation matrix of the liquidity measures for Swatch registered share

	Q	V	D	Dlog	D$	N	NO	Sabs	LogSabs	SrelM	Srelp
Q	1										
V	0.99	1									
D	0.09	0.10	1								
Dlog	0.05	0.06	0.72	1							
D$	0.08	0.10	0.99	0.71	1						
N	0.74	0.72	0.00	-0.03	-0.01	1					
NO	0.46	0.44	-0.04	-0.06	-0.05	0.61	1				
Sabs	0.06	0.05	0.03	0.11	0.01	0.07	0.22	1			
LogSabs	0.04	0.03	0.03	0.13	0.01	0.03	0.20	0.90	1		
SrelM	0.06	0.04	0.00	0.07	-0.04	0.09	0.23	0.98	0.87	1	
Srelp	0.06	0.04	0.00	0.07	-0.04	0.09	0.23	0.98	0.87	1.00	1
Srellog	0.06	0.04	0.00	0.07	-0.04	0.09	0.23	0.98	0.87	1.00	1.00
LogSrellog	0.05	0.02	0.00	0.10	-0.04	0.06	0.22	0.89	0.98	0.89	0.89
Seff	0.00	-0.01	-0.07	-0.04	-0.09	0.03	0.17	0.57	0.46	0.57	0.57
Seffrelp	0.01	-0.01	-0.08	-0.05	-0.11	0.05	0.19	0.58	0.46	0.61	0.60
SeffrelM	0.01	-0.01	-0.08	-0.05	-0.11	0.05	0.19	0.58	0.46	0.61	0.61
QS	0.05	0.04	-0.14	-0.17	-0.16	0.08	0.24	0.94	0.85	0.93	0.93
LogQS	0.06	0.03	-0.15	-0.18	-0.19	0.10	0.25	0.92	0.82	0.95	0.95
LogQSadj	0.05	0.03	-0.08	-0.36	-0.10	0.09	0.19	0.59	0.53	0.62	0.62
CL	0.04	0.01	-0.32	-0.49	-0.33	0.09	0.16	0.34	0.29	0.38	0.38
LR1	0.69	0.71	0.10	0.07	0.11	0.49	0.26	-0.02	-0.02	-0.03	-0.03
LR3	0.06	0.04	-0.06	-0.06	-0.08	0.07	0.20	0.24	0.23	0.26	0.26
FR	0.83	0.84	0.05	0.03	0.05	0.66	0.39	0.03	0.02	0.03	0.03
OR	-0.07	-0.07	0.11	0.06	0.11	-0.08	-0.05	-0.01	-0.01	-0.02	-0.02
MI^{V^*}	0.01	-0.02	-0.16	-0.17	-0.19	0.09	0.17	0.22	0.18	0.29	0.29
MI^{A,V^*}	-0.02	-0.04	-0.14	-0.14	-0.17	0.05	0.10	0.16	0.14	0.22	0.22
MI^{B,V^*}	0.01	-0.01	-0.13	-0.14	-0.16	0.08	0.15	0.19	0.16	0.25	0.25
$DI^A(k)$	0.06	0.09	0.25	0.21	0.29	-0.04	-0.11	-0.19	-0.20	-0.24	-0.25
$DI^B(k)$	0.05	0.08	0.29	0.22	0.33	-0.06	-0.12	-0.19	-0.19	-0.25	-0.25
$PI^A(q)$	-0.04	-0.06	-0.15	-0.15	-0.18	0.03	0.09	0.12	0.10	0.17	0.17
$PI^B(q)$	-0.02	-0.05	-0.22	-0.20	-0.26	0.07	0.15	0.25	0.22	0.32	0.32

	Srellog	LogSrellog	Seff	Seffrelp	SeffrelM	QS	LogQS	LogQSadj	CL	LR1	LR3
Srellog	1										
LogSrellog	0.89	1									
Seff	0.57	0.47	1								
Seffrelp	0.61	0.49	0.99	1							
SeffrelM	0.61	0.49	0.99	1.00	1						
QS	0.93	0.85	0.57	0.58	0.58	1					
LogQS	0.95	0.85	0.56	0.60	0.60	0.98	1				
LogQSadj	0.62	0.55	0.37	0.40	0.40	0.73	0.75	1			
CL	0.38	0.33	0.25	0.28	0.28	0.55	0.59	0.39	1		
LR1	-0.03	-0.04	-0.06	-0.07	-0.07	-0.03	-0.04	-0.02	-0.04	1	
LR3	0.26	0.25	0.22	0.24	0.24	0.25	0.27	0.19	0.15	0.00	1
FR	0.03	0.02	0.01	0.01	0.01	0.03	0.02	0.02	0.02	0.57	0.01
OR	-0.02	-0.02	0.00	-0.01	-0.01	-0.03	-0.03	0.01	-0.04	-0.05	0.02
MI^{V^*}	0.29	0.26	0.20	0.25	0.25	0.28	0.34	0.25	0.29	-0.06	0.16
MI^{A,V^*}	0.22	0.21	0.11	0.16	0.16	0.19	0.25	0.17	0.20	-0.07	0.11
MI^{B,V^*}	0.25	0.22	0.18	0.22	0.22	0.24	0.30	0.22	0.26	-0.05	0.14
$DI^A(k)$	-0.24	-0.27	-0.16	-0.20	-0.20	-0.24	-0.28	-0.19	-0.21	0.12	-0.12
$DI^B(k)$	-0.25	-0.26	-0.16	-0.20	-0.20	-0.24	-0.29	-0.19	-0.22	0.11	-0.15
$PI^A(q)$	0.17	0.16	0.09	0.13	0.12	0.16	0.20	0.13	0.17	-0.07	0.08
$PI^B(q)$	0.32	0.31	0.21	0.27	0.27	0.29	0.36	0.24	0.29	-0.10	0.17

	FR	OR	MI^{V^*}	MI^{A,V^*}	MI^{B,V^*}	$DI^A(k)$	$DI^B(k)$	$PI^A(q)$	$PI^B(q)$
FR	1								
OR	-0.03	1							
MI^{V^*}	-0.01	-0.03	1						
MI^{A,V^*}	-0.02	-0.01	0.35	1					
MI^{B,V^*}	0.00	-0.02	0.97	0.10	1				
$DI^A(k)$	0.05	0.04	-0.27	-0.39	-0.19	1			
$DI^B(k)$	0.05	0.04	-0.38	-0.20	-0.34	0.30	1		
$PI^A(q)$	-0.03	-0.02	0.30	0.81	0.10	-0.46	-0.20	1	
$PI^B(q)$	-0.02	-0.04	0.72	0.21	0.71	-0.33	-0.64	0.21	1

Table C.18: Correlation matrix of the 31 liquidity measures for Unaxis

Abbreviations

Abbreviation	Description
ACD	autoregressive conditional duration
a.m.	before noon
AMEX	American Stock Exchange
B	buy
CHF	Swiss Franc
CP	counterparty
Cpty	counterparty
ECN	electronic communications network
e.g.	for example
et al.	and others
ETHZ	Eidgenössische Technische Hochschule Zürich
f.	following page
ff.	following pages
FX	foreign exchange
ID	identification
mio.	million
N	nostro
NASDAQ	North American Security Dealers Automated Quotation System
Norm	normal
NYSE	New York Stock Exchange
OH	order history
OHR	order history report
OTC	Over the counter
p.	page
PCA	principal component analysis
p.m.	afternoon
Rnd	round
SIA	Securities Industry Association
SMI	Swiss Market Index
Std. Dev.	standard deviation
SWX	Swiss Exchange
U.S.	United States
USD	United States Dollar
VAR	vector autoregression

Ticker Symbols of the Stocks used

Ticker	Stock
ADEN	Adecco
BAER	Julius Baer
CFR	Richemont
CIBN	Ciba
CLN	Clariant
GIVN	Givaudan
HOLN	Holcim
KUD	Kudelski
LONN	Lonza
RUKN	Swiss Re
SCMN	Swisscom
SEO	Serono
SGSN	Surveillance
SUN	Sulzer
SYNN	Syngenta
UHR	Swatch baerer share
UHRN	Swatch registered share
UNAX	Unaxis

Notation

As far as possible a single coherent notation was used. Nevertheless, sometimes a certain variable may have different meanings.

Symbol	Description
\$	United States dollar
b	component of the eigenvector
CL	Composite liquidity
D	Depth
d	First difference
$D\$$	Dollar depth
DI^A	Depth for price impact on the ask-side
DI^B	Depth for price impact on the bid-side
di	difference in ranks
$Dlog$	Log depth
$DurQ$	Volume duration
$DurV$	Turnover duration
F	Factor scores
FR	Flow ratio
I	Direction of trade Indicator
i	Counter
K	Number of prices in the order book
k	lag
k	Number
Ku	Kurtosis
l	Value of the log likelihood function
LHH	Hui-Heubel liquidity ratio
$\ln$	Natural logarithm
$LogQS$	Log quote slope
$LogQSadj$	Adjusted log quote slope
$LogSabs$	Log absolute spread
$LogSrellog$	Log relative spread calculated with log prices
LP	Long period
$LR1$	Liquidity ratio 1
$LR2$	Liquidity ratio 2
$LR3$	Liquidity ratio 3

Symbol	Description
M	Number of equations
M	Martin Index
m	Liquidity measure
MI	Market impact
MI^A	Market impact on the ask-side
MI^B	Market impact on the bid-side
N	Number of trades in a given time period
Ne	Total number of shares of a company
NO	Number of orders in a given time space
No	Number of shares owned by the company
OR	Order ratio
p	Lag
p	Price
p^A	Ask price
p^B	Bid price
p^M	Mid price
PI^A	Price impact on the ask-side
PI^B	Price impact on the bid-side
Q	Q-statistic
Q	Trading volume in a given time period
Q^*	Predefined number of shares
q	Number of shares of a trade or of a quote
q^A	Ask volume
q^B	Bid volume
QS	Quote slope
r	Return
rk	Spearman rank correlation
S	Skewness
Sabs	Absolute spread
Seff	Effective spread
SeffrelM	Relative effective spread calculated with mid price
Seffrelp	Relative effective spread calculated with last trade
SIC	Schwarz information criterion
SP	Short period
$Srellog$	Relative spread calculated with log prices
$SrelM$	Relative spread calculated with mid price
$Srelp$	Relative spread calculated with last trade
T	Number of observations
t	Time
tr	Time of a trade
V	Turnover in a given time period
V^*	Predefined turnover
$VNET$	Net directional volume

Symbol	Description
VR	Variance ratio
WT	Waiting time
x	Vector of liquidity measures
ε	White noise
ϕ	Parameter matrix
ρ	Partial autocorrelation
σ	Volatility
τ	Autorcorrelation

Bibliography

Acker, D., Stalker, M. & Tonks, I. (2002), 'Daily closing inside spreads and trading volumes around earnings announcements', *Journal of Business Finance & Accounting* **29**(9/10), 1149–1179.

Amihud, Y. (2002), 'Illiquidity and stock returns: Cross-section and time-series effects', *Journal of Financial Markets* **5**, 31–56.

Amihud, Y. & Mendelson, H. (1991), 'Liquidity, maturity and the yields on U.S. Treasury securities', *Journal of Finance* **46**(4), 1411–1425.

Andersen, T. G. & Bollerslev, T. (1997), 'Intraday periodicity and volatility persistence in financial markets', *Journal of Empirical Finance* **4**(2-3), 115–158.

Andersen, T. G. & Bollerslev, T. (1998), 'Deutsche mark-dollar volatility: Intraday activity patterns, macroeconomic announcements and longer run dependencies.', *The Journal of Finance* **53**(1), 219–265.

Bacidore, J. M. (1997), 'The impact of decimalization on market quality: An empirical investigation of the Toronto stock exchange', *Journal of Financial Intermediation* **6**(2), 92–120.

Bacidore, J. M., Battalio, R. H. & Jennings, R. H. (2002), 'Depth improvement and adjusted price improvement on the New York Stock Exchange', *Journal of Financial Markets* **5**, 169–195.

Baillie, R. T. & Dacorogna, M. M. (1997), 'High frequency data in finance', *Journal of Empirical Finance* **4**(2-3), 69–72.

Baker, H. K. (1996), 'Trading location and liquidity: An analysis of U.S. dealer and agency markets for comon stocks', *Financial Markets, Institutions & Instruments* **5**(4), 1–51.

Ball, C. A. & Chordia, T. (2001), 'True spreads and equilibrium prices', *The Journal of Finance* **56**(5), 1801–1835.

Barclay, M. J., Christie, W. G., Harris, J. H., Kandel, E. & Schultz, P. H. (1999), 'Effects of market reform on the trading costs and depths of NASDAQ stocks', *The Journal of Finance* **54**(1), 1–34.

Battalio, R., Greene, J. & Jennings, R. (1998), 'Order flow distribution, bid-ask spreads, and liquidity costs: Merril Lynch's decision to cease routinely routing orders to regional stock exchanges', *Journal of Financial Intermediation* **7**, 338–358.

Box, G. E. P. & Jenkins, G. M. (1976), *Time Series Analysis, Forecasting and Control*, Holden-Day, San Francisco.

Breedon, F. & Holland, A. (1997), Electronic versus open outcry markets: The case of the Bund futures contract. Working Paper, Bank of England.

Brockman, P. & Chung, D. Y. (2000), 'An empirical investigation of trading on asymmetric information and heterogeneous prior beliefs', *Journal of Empirical Finance* **7**, 417–454.

Brunner, A. (1996), 'Messkonzepte zur Liquidität auf Wertpapiermärkten'. Beiträge zur Theorie der Finanzmärkte, Universität Frankfurt.

Butler, A. W., Grullon, G. & Weston, J. P. (2002), Stock market liquidity and the cost of raising capital. Working Paper.

Campbell, J. Y., Lo, A. & MacKinlay, C. (1997), *The Econometrics of Financial Markets*, Princeton University Press, Princeton.

Chan, H. W.-H. & Pinder, S. M. (2000), 'The value of liquidity: Evidence from the derivatives market', *Pacific-Basin Finance Journal* **8**, 483–503.

Chan, K., Chung, Y. P. & Fong, W.-M. (2002), 'The informational role of stock and option volume', *The Review of Financial Studies* **15**(4), 1049–1075.

Chordia, T., Roll, R. & Subrahmanyam, A. (2000), 'Commonality in liquidity', *Journal of Financial Economics* **56**, 3–28.

Chordia, T., Roll, R. & Subrahmanyam, A. (2001), 'Market liquidity and trading activity', *The Journal of Finance* **56**(2), 501–530.

Chordia, T., Subrahmanyam, A. & Anshuman, V. R. (2001), 'Trading activity and expected stock returns', *Journal of Financial Economics* **59**, 3–32.

Chordia, T. & Swaminathan, B. (2000), 'Trading volume and cross-autocorrelations in stock returns', *The Journal of Finance* **55**(2), 913–935.

Christie, W. G. & Schultz, P. H. (1998), 'Dealer markets under stress: The performance of NASDAQ market makers during the november 15, 1991, market break', *Journal of Finacial Services Research* **13**(3), 205–229.

Chung, K. H., Van Ness, B. F. & Van Ness, R. A. (1999), 'Limit orders and the bid-ask spread', *Journal of Financial Economics* **53**, 255–287.

Chung, K. H. & Van Ness, R. A. (2001), 'Order handling rules, tick size, and the intraday pattern of bid-ask spreads for NASDAQ stocks', *Journal of Financial Markets* **4**, 143–161.

Chung, M. M. C., Han, K. C. & Tse, M. K. S. (1996), 'Interrelationship among the price indexes of the NYSE, AMEX and OTC', *International Review of Economics and Finance* **5**(1), 63–75.

Clyman, D. R., Allen, C. S. & Jaycobs, R. (1997), 'Liquidity without volume: The case of FINEX, Dublin', *The Journal of Futures Markets* **17**(3), 247–277.

Clyman, D. R. & Jaycobs, R. (1998), 'Liquidity without volume. II. using block orders to measure market resiliency', *The Journal of Futures Markets* **18**(3), 281–296.

Coppejans, M. & Domowitz, I. (2002), An empirical analysis of trades, orders, and cancellations in a limit order market. Working Paper.

Coppejans, M., Domowitz, I. & Madhavan, A. (2003), Resiliency in an automated auction. Working Paper.

Corwin, S. A. (1999), 'Differences in trading behavior across NYSE specialist firms', *The Journal of Finance* **54**(2), 721–745.

Corwin, S. A. & Lipson, M. L. (2000), 'Order flow and liquidity around NYSE trading halts', *The Journal of Finance* **55**(4), 1771–1805.

Dacorogna, M. M., Gençay, R., Müller, U., Olsen, R. B. & Pictet, O. V. (2001), *An Introduction to High-Frequency Finance*, Academic Press, San Diego.

Daníelsson, J. & Payne, R. (2002), 'Real trading patterns and prices in spot foreign exchange markets', *Journal of International Money and Finance* **21**, 203–222.

Elyasiani, E., Hauser, S. & Lauterbach, B. (2000), 'Market response to liquidity improvements: Evidence from exchange listings', *The Financial Review* **41**, 1–14.

Engle, R. F. & Lange, J. (2001), 'Predicting VNET: A model of the dynamics of market depth', *Journal of Financial Markets* **4**, 113–142.

Fernandez, F. A. (1999), Liquidity risk. SIA Working Paper.

Fleming, M. J. & Remolona, E. M. (1999), 'Price formation and liquidity in the U.S. Treasury market: The response to public information', *The Journal of Finance* **54**(5), 1901–1915.

George, T. J. & Hwang, C.-Y. (1998), 'Endogenous market statistics and security pricing: An empirical investigation', *Journal of Financial Markets* **1**, 285–319.

Gervais, S., Kaniel, R. & Mingelgrin, D. H. (2001), 'The high-volume return premium', *The Journal of Finance* **56**(3), 877–919.

Goldstein, M. A. & Kavajecz, K. A. (2000), 'Eighths, sixteenths and market depth: Changes in tick size and liquidity provision on the NYSE', *Journal of Financial Economics* **56**, 125–149.

Gomber, P. & Schweickert, U. (2002), 'Der Market Impact: Liquiditätsmass im elektronischen Wertpapierhandel', *Die Bank* **7**, 485–489.

Gouriéroux, C., Jasiak, J. & Le Fol, G. (1999), 'Intra-day market activity', *Journal of Financial Markets* **2**, 193–226.

Grammig, J., Schiereck, D. & Theissen, E. (2001), 'Knowing me, knowing you: Trader anonymity and informed trading in parallel markets', *Journal of Financial Markets* **4**, 385–412.

Greene, J. & Smart, S. (1999), 'Liquidity provision and noise trading: Evidence from the "investment dartboard" column', *The Journal of Finance* **54**(5), 1885–1899.

Gwilym, O. A. & Sutcliffe, C. (1999), *High-Frequency Financial Market Data*, Risk Books, London.

Hamao, Y. & Hasbrouck, J. (1995), 'Securities trading in the absence of dealers: Trades and quotes on the Tokyo Stock Exchange', *The Review of Financial Studies* **8**(3), 849–878.

Hamilton, J. D. (1994), *Time Series Analysis*, Princeton University Press, Princeton.

Harris, F. H. d., McInish, T. H. & Wood, R. A. (2002), 'Security price adjustment across exchanges: An investigation of common factor components for Dow stocks', *Journal of Financial Markets* **5**(3), 277–308. Working Paper.

Hasbrouck, J. (1999), 'The dynamics of discrete bid and ask quotes', *The Journal of Finance* **54**(6), 2109–2142.

Hasbrouck, J. (2003), Intraday price formation in U.S. equity index markets. forthcoming in the Journal of Finance, December.

Hasbrouck, J. & Saar, G. (2002), Limit orders and volatility in a hybrid market: The Island ECN. Working Paper.

Hasbrouck, J. & Seppi, D. J. (2001), 'Common factors in prices, order flows and liquidity', *Journal of Financial Economics* **59**, 383–411.

Hotelling, H. (1933), 'Analysis of a complex of statistical varables into principal components', *Journal of Educational Psychology* **24**, 417–441,498–520.

Huberman, G. & Halka, D. (2001), 'Systematic liquidity', *The Journal of Financial Research* **24**(2), 161–178.

Irvine, P., Benston, G. & Kandel, E. (2000), Liquidity beyond the inside spread: Measuring and using information in the limit order book. Working Paper.

Ito, T., Lyons, R. K. & Melvin, M. T. (1998), 'Is there private information in the FX market? The Tokyo experiment', *The Journal of Finance* **53**(3), 1111–1130.

Jones, C. M. & Lipson, M. L. (1999), Price impacts and quote adjustment on the NASDAQ and NYSE/AMEX. Working Paper.

Kaiser, H. F. (1958), 'The varimax criterion of analytic rotation in factor analysis', *Psychometrika* **23**, 187–200.

Kamara, A. & Koski, J. L. (2001), 'Volatility, autocorrelations, and trading activity after stock splits', *Journal of Financial Markets* **4**, 163–184.

Kanji, G. K. (1999), *100 Statistical Tests*, Sage, London.

Karagozoglu, A. K. (2000), Microstructure model of futures markets: Theory and evidence for optimal hedging strategies. Working Paper.

Kavajecz, K. A. (1999), 'A specialist's quoted depth and the limit order book', *The Journal of Finance* **54**(2), 747–771.

Kavajecz, K. A. & Odders-White, E. R. (2001), 'Volatility and market structure', *Journal of Financial Markets* **4**, 359–384.

Kluger, B. D. & Stephan, J. (1997), 'Alternative liquidity measures and stock returns', *Review of Quantitative Finance and Accounting* **8**(1), 19–36.

Lee, C. M. C., Mucklow, B. & Ready, M. J. (1993), 'Spreads, depths and the impact of earnings information: An intraday analysis', *The Review of Financial Studies* **6**(2), 345–374.

Lee, C. M. C. & Swaminathan, B. (2000), 'Price momentum and trading volume', *The Journal of Finance* **55**(5), 2017–2069.

Lee, Y.-T., Fok, R. C. W. & Liu, Y.-J. (2001), 'Explaining intraday pattern of trading volume from the order flow data', *Journal of Business Finance & Accounting* **28**(1), 199–230.

Levin, E. J. & Wright, R. E. (1999), 'Explaining the intra-day variation in the bid-ask spread in competitive dealership markets – A research note', *Journal of Financial Markets* **2**, 179–191.

Lin, J.-C., Sanger, G. C. & Booth, G. G. (1995), 'Trade size and components of the bid-ask spread', *The Review of Financial Studies* **8**(4), 1153–1183.

Ljung, G. M. & Box, G. (1978), 'On a measure of lack of fit in time series models', *Biometrika* **65**, 297–303.

Loderer, C. & Roth, L. (2001), The pricing discount for limited liquidity: Evidence from Switzerland. Working Paper.

Madhavan, A. (2000), 'Market microstructure: A survey', *Journal of Financial Markets* **3**, 205–258.

Menyah, K. & Paudyal, K. (2000), 'The components of bid-ask spreads on the London stock exchange', *Journal of Banking and Finance* **24**, 1767–1785.

O'Hara, M. (1995), *Market Microstructure Theory*, Blackwell, Malden.

Pearson, K. (1901), 'On lines and planes of closest fit to systems of points in space', *Philosophical Magazine* **6**(2), 559–572.

Peng, L. (2001), Trading takes time. Working Paper, Yale University.

Ranaldo, A. (2000), Intraday Trading Activity on Financial Markets: The Swiss Evidence, PhD thesis, University of Fribourg.

Ranaldo, A. (2001), 'Intraday market liquidity on the Swiss stock exchange', *Financial Markets and Portfolio Management* **15**(3), 309–327.

Ranaldo, A. (2002), 'Transaction costs on the Swiss stock exchange', *Financial Markets and Portfolio Management* **16**(1), 53–68.

Ranaldo, A. (2003), Intraday market dynamics around public information arrivals. Working Paper.

Ranaldo, A. (2004), 'Order aggressiveness in limit order book markets', *Journal of Financial Markets* **7**(1), 53–74.

Sarin, A., Shastri, K. A. & Shastri, K. (1996), Ownership structure and stock market liqudity. Working Paper, Santa Clara University.

Schoch, J. (2001), Über das Pricing von Liquidität auf Aktienmärkten, Master's thesis, University of St. Gallen.

Schultz, P. (2000), 'Stock splits, tick size, and sponsorship', *The Journal of Finance* **55**(1), 429–451.

Schwarz, G. (1978), 'Estimating the dimension of a model', *The Annals of Statistics* **6**(2), 461–464.

Shen, P. & Starr, R. M. (2002), 'Market-makers' supply and pricing of financial market liquidity', *Economics Letters* **1**.

Stier, W. (2001), *Methoden der Zeitreihenanalyse*, Springer–Verlag, Berlin.

Stoll, H. R. & Whaley, R. E. (1990), 'Stock market structure and volatility', *The Review of Financial Studies* **3**(1), 37–71.

Swiss Exchange (2001*a*), 'Directive 1: Exchange hours'. www.swx.com.

Swiss Exchange (2001*b*), 'Directive 4: Orders'. www.swx.com.

Swiss Exchange (2001*c*), 'General conditions'. www.swx.com.

Swiss Exchange (2002), 'SWX guide – equity products'. www.swx.com.

Theissen, E. (2002), 'Price discovery in floor and screen trading systems', *Journal of Empirical Finance* **9**(4), 455–474. Working Paper, University of Bonn.

Trapletti, A., Geyer, A. & Leisch, F. (2002), 'Forecasting exchange rates using cointegration models and intra-day data', *Journal of Forecasting* **21**(3), 151–166. Working Paper, Vienna University or Economics.

Van Ness, B. F., Van Ness, R. A. & Pruitt, S. W. (2000), 'The impact of the reduction in tick increments in major U.S. markets on spreads, depth, and volatility', *Review of Quantitative Finance and Accounting* **15**, 153–167.

Walsh, D. M. (1998), 'Evidence of price change volatility induced by the number and proportion of orders of a given size', *Australian Journal of Management* **23**(1), 39–55.

Wang, X. (2002), On an open limit order book – how can we use it or... can we? Working Paper.

Yang, Z., Li, Z. & Liu, F. (2001), Ownership structure, bid-ask spreads, and market liquidity – evidence from Chinese stock markets. Working Paper, Tsinghua University.

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