CFR-Working Paper NO. 06-04

Liquidity Commonality Beyond Best Prices

A. Kempf • D. Mayston

centre for financial research
Look deeper

Liquidity Commonality Beyond Best Prices ⋆

Alexander Kempf [a], Daniel Mayston [b]

[a] *University of Cologne, Department of Finance and Centre for Financial Research, Albertus-Magnus-Platz, D-50923 Cologne, Germany*

[b] *University of Cologne, Graduate School of Risk Management and Centre for Financial Research, Meister-Ekkehart-Str. 11, D-50923 Cologne, Germany*

Abstract

This paper investigates the commonality of liquidity in an open limit order book market. We find that commonality in liquidity becomes stronger the deeper we look into the limit order book. While commonality is only about 2% at the best prices, it increases up to about 20% inside the limit order book. Furthermore, we find strong time variation in commonality both on an intradaily basis and with the movement of the market return. Our study thus suggests that previous estimates of commonality do not hold for liquidity beyond best prices. Therefore, systematic liquidity risk in a limit order book market is much higher than previous evidence implies.

Key words: Order-Driven Markets, Liquidity Commonality
JEL: G10, G14

1 Introduction

Liquidity risk is a major concern to investors, because it implies that they might have to trade when markets are especially illiquid, and trading in illiquid markets is very costly. If the liquidity of different stocks also moves together,

⋆ We thank Deutsche Boerse AG for providing us with their extensive order book data. We are also indebted to Helena Beltran, Joachim Grammig and Stefan Frey for sharing their computer codes for the reconstruction of the limit order book. Daniel Mayston gratefully acknowledges financial support from the German Research Association.

liquidity risk will be an even greater concern to investors:[1] common liquidity movements imply that liquidity risk is market-wide and, apart from idiosyncratic shocks, cannot be diversified. Investors will have to bear the systematic component of liquidity risk and will therefore ask for compensation.

Empirical asset pricing papers such as Amihud (2002), Pástor and Stambaugh (2003) or Gibson and Mougeot (2004) show that investors receive a notable compensation for bearing liquidity risk. In contrast, empirical microstructure papers such as Chordia, Roll and Subrahmanyam (2000), Hasbrouck and Seppi (2001), Halka and Huberman (2001) and Brockman and Chung (2002) suggest that liquidity risk is almost entirely firm- specific. It implies that liquidity risk is diversifiable and should not be priced.

One possible explanation for the weak evidence of commonality in the microstructure literature is that earlier studies used poor proxies for liquidity. For example, Chordia, Roll and Subrahmanyam (2000), Hasbrouck and Seppi (2001), Halka and Huberman (2001) and Brockman and Chung (2002) all measure liquidity by looking at quotes and quantities at best prices. However, if investors want to trade large positions, their orders will walk up the book and therefore they will not only care about liquidity at best prices, but also about liquidity beyond best prices.

A second explanation is that best quotes are particularly noisy and therefore not well-suited for the study of commonality. Since liquidity suppliers compete fiercely for new price priority, the bid-ask spread and depth at best prices are subject to strong idiosyncratic variation. This hypothesis is consistent with Domowitz, Hansch and Wang (2005) who show that order type correlation has far more explanatory power for liquidity commonality inside the limit order book than at the best prices.

[1] The theoretical literature develops several kinds of mechanisms through which the liquidity supply of different stocks is linked. In these models, the correlation of liquidity preferences, intermediary behavior or informational shocks create contagion effects in the liquidity of different stocks. See Allen and Gale (2000), Kyle and Xiong (2001), Gromb and Vayanos (2002), Fernando (2003), Watanabe (2003) and Brunnermeier and Pedersen (2005).

A third explanation is time variation. Chordia, Roll and Subrahmanyam (2001) show that liquidity is time-varying and that it is particularly low in falling markets. If commonality exhibits a similar time variation, it might be low on average but higher in falling markets. The empirical evidence on this issue is ambiguous. For the US market, Coughenour and Saad (2004) find that in falling markets specialist behavior tends to be more strongly correlated across the stocks that they manage than in rising markets, while Domowitz, Hansch and Wang (2005) observe no systematic differences for the Australian market.

In our paper we focus on (i) the level of commonality in liquidity beyond best prices and (ii) the time variation of commonality in a pure limit order market. Our basic methodology follows the market model used in Chordia, Roll and Subrahmanyam (2000) and extends it to liquidity measures beyond the bid-ask spread and depth. Furthermore, we examine the link between commonality in the limit order book and movements of the market return.

Our paper is most closely related to the work of Bauer (2004) and Domowitz, Hansch and Wang (2005). Bauer (2004) performs a Principal Component Analysis (PCA) for liquidity measures of the limit order book and relates commonality to underlying financial variables. Domowitz, Hansch and Wang (2005) investigate the impact of order-type and order-flow correlations on return and liquidity commonality. We differ from these papers in three ways: firstly, we focus on how commonality in liquidity depends on how deep we look into the limit order book (as opposed to its relation with underlying financial variables or order-type and order-flow commonality). Secondly, from a methodological point of view, we apply the Chordia, Roll and Subrahmanyam (2000) market model instead of using a correlation or common factor approach. Our approach has the advantage that it allows us to control for external factors and that the common factor can directly be interpreted as market liquidity. Thirdly, we use data from the German stock market, one of the world's largest and most important markets, instead of the Swiss and Australian market. [2]

[2] The growing availability of limit order book data has produced many further studies on such markets. With regard to commonality, Chordia, Sarkar and Subrahmanyam (2005) study common liquidity movements across asset classes. Irvine,

Based on the Xetra limit order book, which is used at the Frankfurt Stock Exchange (FSE), we measure liquidity both at best prices (using the bid-ask spread and its depth) and beyond best prices (using depth deeper in the limit order book and the slope of the price-quantity schedule). Our study yields the following main results: (i) We find evidence of significant common variation in liquidity throughout the order book. The more the liquidity measures are extended beyond best prices, the stronger commonality is: at best prices, common variation in depth only accounts for roughly 2% of all liquidity variation, while it increases to a maximum level of about 20% deeper in the book. (ii) Commonality exhibits strong time variation associated both with the time of the day and the movement of the market. Most notably, liquidity commonality increases strongly with the absolute value of negative returns. This implies that diversifying liquidity risk becomes more difficult in falling markets when diversification is particularly important.

2 Market Structure, Data and Liquidity Measures

In the following sections we present the market structure of the Xetra trading facility and give some descriptive statistics for the data set. Furthermore, we explain the construction of our liquidity measures and eliminate trends from the data.

2.1 Market Structure of Xetra

Our study uses data from the electronic limit order book market at the Frankfurt Stock Exchange (FSE). The electronic system used in Frankfurt is called Xetra and allows trading to anyone who is connected to the Xetra computer system. Although trading through Xetra at the Frankfurt Stock Exchange

Benston and Kandel (2000) and Cao, Hansch and Wang (2004) study the information content of the limit order book. Coppejans, Domowitz, Madhavan (2003) focus on dynamic issues of the limit order book. Beltran, Giot and Grammig (2005) relate commonalities across price-volume pairs of the limit order book to underlying microstructural factors.

does face some competition from regional exchanges or floor trading facilities, Xetra accounts for roughly 98% of all blue-chip trading activity.

The FSE operates as an open limit order book market. Market participants can submit limit orders, market orders, market-to-limit orders and iceberg orders (which provide hidden liquidity). Trading is based on a continuous double auction mechanism with automatic matching of orders. Matching takes place on a price and time priority. Trading hours at the FSE extend from 9.00 to 17.30 CET. During these hours all limit orders that are submitted to the limit order book are displayed to all traders connected to the system. This is a considerable difference compared to other systems like NYSE where only specialists can access the complete book or Paris where only the best five orders are displayed. The blue-chip segment of the FSE (which we focus on) operates without any market makers and relies purely on the anonymous submission of limit orders. While the book is open, it gives all limits, the accumulated order volumes at each limit and the number of orders in the book at each limit.[3] The tick size is 1 Eurocent (0.01 Euros) which corresponds to the currency's smallest possible value.[4]

2.2 Raw Data and Order Book Reconstruction

Our data set consists of the thirty equities which make up the blue-chip index DAX 30. It ranges from 02 January 2004 to 31 March 2004. This period does not contain any extraordinary events nor was the market environment particularly volatile.

The raw data is the computerized trading protocol in which the FSE keeps track of all entries, cancellations, revisions, executions and expirations of or-

[3] The continuous trading phase begins after an opening auction at the beginning of the day and it is closed by a closing auction at the end of the day. During auctions, the order book is closed, yet during continuous trading, the limit order book is visible to all market participants. Note that only the visible peak of iceberg orders appear in the order book.

[4] For more details on the Xetra market model at the FSE see the Deutsche Boerse Group (2004) manual of the stock trading model.

Table 1
Summary Statistics

	Mean	Median	Max	Min
Market capitalization	18.20	10.39	61.29	2.95
Average daily trading volume	114.79	75.22	348.60	14.13
Absolute bid-ask spreads	0.04	0.03	0.09	0.01
Relative bid-ask spreads	0.09	0.10	0.15	0.05
Depth (at the best limit price)	180,487	148,461	979,214	65,773

Table 1 summarizes the main characteristics of the stocks in our data set. Market capitalization is in billions of Euros as of 02 January 2004. Trading volume is the average daily trading volume in millions of Euros between 02 January 2004 and 31 March 2004. The average spread and depth at the best bid and ask are computed from the time series of limit order books at 30-minutes intervals. Absolute spreads and depth at the best price are in Euros and relative spreads in %.

ders. The database has between 867,369 and 3,920,169 entries for each stock. Additionally, the stock exchange recorded the initial state of the order book at the beginning of our data range. From there, the order book was reconstructed by implementing the Xetra market model. This leads to an order book for each point in time when an order book event takes place. We take snapshots at 30-minute intervals from this sequence of order books. We exclude order books which have been preceded by an auction, since the supply mechanism for liquidity might be different in auctions. Finally, we end up with 17 order books per day and stock.

Table 1 gives some summary statistics. [5] The stocks' market capitalizations range from 2.95 billion to 61.29 billion Euros. Average daily trading volume varies between 14.13 million Euros and 348.60 million Euros. We use the 30-minute snapshots of the order book to compute a time series of the bid-ask spread and associated depth of all stocks. Average absolute spreads of a stock lie between 0.01 and 0.09 Euros. Relative spreads (absolute spreads scaled by the midquote) vary between 0.05% and 0.15%. The average depth is the number of shares at the best bid and ask multiplied by the best ask and bid price, respectively. It lies between 65,773 and 979,214 Euros on average.

[5] Detailed descriptive statistics are provided in Table A in the appendix.

These figures show that liquidity for blue chip stocks is fairly high on average. Nevertheless, there is considerable cross-sectional variation.

With regard to the order submission behavior we observe that 97.3 % of all submissions are limit orders. Of the submitted limit orders, 23 % get executed and 77 % cancelled. These figures show that the liquidity consumed by transactions is only a fraction of the liquidity provided to the book.[6] About 80% of all transactions take place within the best prices, while the remaining 20% consume more liquidity. Such transactions can actually be very large and walk up the book more than 100 ticks.

2.3 Time-of-Day Effects

Previous literature such as Wood, McInish and Ord (1985), Jain and Joh (1988), Foster and Viswanathan (1990) or McInish and Wood (1992) documents that liquidity shows strong seasonal patterns, in particular on an intraday basis. We plot time-specific averages of the spread and the corresponding depth against the time of day. Consistent with previous empirical evidence Figure 1 shows higher spreads and lower depth at the opening of the trading day. Spreads exhibit a pronounced L-shape over the time of the day, while depth exhibits the corresponding upside-down L-pattern.

Like Hasbrouck and Seppi (2001) we standardize liquidity by subtracting time-specific means and dividing by time-specific standard deviations. Thus we focus on unexpected liquidity which corresponds to the liquidity risk that investors bear. We illustrate the standardization procedure for the bid-ask spread: let A denote the best ask price, B the best bid price and MQ the midquote. We compute bid-ask spreads relative to the midquote, $SP = (A - B)/MQ$. Then let p denote the time of the day and k a specific trading day

[6] With regard to iceberg orders, we include visible peaks and exclude all hidden parts of the order. Therefore we take the exact limit order book which an investor observes and uses to condition his behavior on. However, the treatment of iceberg orders has no qualitative impact on the results in the later sections as the percentage of iceberg orders to overall order submissions is very low (0.55%).

Fig. 1. Intraday Pattern of Average Spreads and Depth

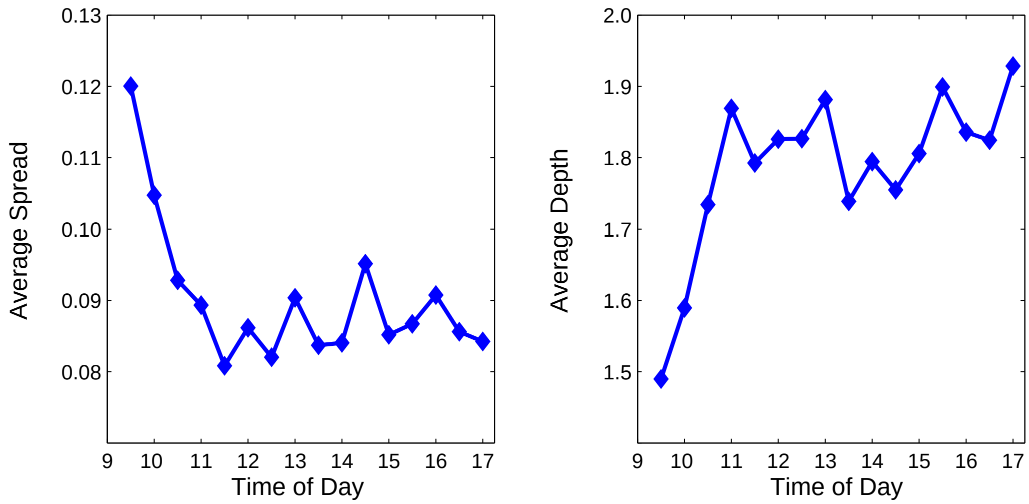

Figure 1 shows time-of-day effects for spreads and depth. The x-axis gives the time of day and the y-axis the average relative spread (in %) or the average depth (in 100,000 of Euros).

(with $k = 1, ..., n$). For every stock j, we take subsamples that include observations at one time of the day but over all days. From these subsamples we calculate the time-specific mean of the spread, $\mu_{j,p} = \Sigma_{k=1}^{n} SP_{j,p,k}/n$, and its standard deviation, $\sigma_{j,p} = \sqrt{\Sigma_{k=1}^{n}(SP_{j,p,k} - \mu_{j,p})^2/n}$. For all stocks we then demean and standardize each observation of the spread according to its time of the day. Let SP^* denote spreads adjusted for trends:

$$SP^*_{j,p,k} = \frac{SP_{j,p,k} - \mu_{j,p}}{\sigma_{j,p}} \tag{1}$$

The same procedure is applied to depth at the best prices. Let n^A be the number of shares quoted at the best ask and n^B at the best bid. We compute depth as $DE = n^A A + n^B B$ and then correct it for time-of-day effects to obtain DE^*. The detrended time series of the spread and depth are the input for the following analysis of commonality at best prices.

3 Commonality at Best Prices

Previous studies have implicitly assumed that best limit prices and quantities alone are sufficient to capture the liquidity of an asset. To relate our results to the literature, we analyze the commonality of liquidity for the bid-ask spread and for the depth of the order book at the best bid and ask prices.

The standard approach to estimate commonality is the market model in Chordia, Roll and Subrahmanyam (2000). It relates the liquidity of a single stock to the liquidity of the market in the same way as the CAPM does for returns. It employs a regression framework to measure the sensitivity of stock j's liquidity, L_j, to market liquidity, $L_{M,j}$.[7] Market liquidity is computed as the average liquidity across all stocks (leaving out the j-th stock), $L_{M,j} = \Sigma_{i=1,i\neq j}^{30} L_{i,t}/29$, where t is a time subscript.[8] The estimation includes lead and lag market liquidity ($L_{M,j,t+1}$ and $L_{M,j,t-1}$), contemporaneous, lead and lag market returns ($r_{M,t}$, $r_{M,t+1}$ and $r_{M,t-1}$) as well as individual stock return volatility $vol_{j,t}$ (proxied by the squared return) as additional regressors. With ε as an error term, we obtain the following specification:

$$L_{j,t} = \alpha_j + \beta_j^1 L_{M,j,t} + \beta_j^2 L_{M,j,t+1} + \beta_j^3 L_{M,j,t-1} + \delta_j^1 r_{M,t} + \delta_j^2 r_{M,t+1} + \delta_j^3 r_{M,t-1} + \eta_j vol_{j,t} + \varepsilon_{j,t} \qquad (2)$$

Tables 2 and 3 summarize the estimation results of Equation (2) for liquidity at best limit prices. Table 2 gives a detailed picture of all 30 β^1 coefficients. β^1 measures how strongly individual stock liquidity is determined by the market level of liquidity. For the spread the level of the coefficients varies between 0.1291 and 1.1994 with an average of 0.6472. For all stocks the coefficients are significantly different from zero. The R^2 values vary between 1% and 11%

[7] The Chordia, Roll and Subrahmanyam (2000) model is in first differences. We follow Hasbrouck and Seppi (2001) and use standardized variables instead.

[8] For each stock j's regression, stock j is dropped in the calculation of market liquidity, because it would lead to additional correlation otherwise. Further robustness checks show that the results are unchanged for value-weighted market liquidity instead of the arithmetic average.

Table 2
Market Model for Spreads and Depth at Best Prices – Individual Stocks

	Spreads			Depth		
Stock	β^1	t	R^2	β^1	t	R^2
Adidas-Salomon	0.6990	6.7864	0.0584	0.0753	1.1615	0.0109
Allianz	0.3734	6.0024	0.0579	0.2386	1.7794	0.0071
Altana	0.9078	6.5176	0.0512	0.0953	1.8156	0.0125
BASF	0.4568	6.8301	0.0720	0.4295	3.5770	0.0227
BMW	0.7256	7.8778	0.0822	0.4742	4.8448	0.0290
Bayer	0.5154	6.0242	0.0569	0.2042	2.0234	0.0275
Commerzbank	1.0406	9.9498	0.1098	0.2087	1.9895	0.0141
Continental	0.8969	6.2345	0.0497	0.1703	3.0950	0.0282
DaimlerChrysler	0.6308	8.6423	0.0885	0.3181	2.3183	0.0120
Deutsche Bank	0.3601	6.3999	0.0487	0.3441	1.9998	0.0299
Deutsche Boerse	0.6747	5.7529	0.0455	0.1925	2.7269	0.0201
Deutsche Post	0.7599	6.1584	0.0610	0.1286	1.3530	0.0104
Deutsche Telekom	0.3184	6.8685	0.0500	0.7755	1.1039	0.0420
E.ON	0.9983	8.7036	0.1132	0.2041	4.1170	0.0344
Fresenius	0.7957	5.2823	0.0357	0.2129	4.2120	0.0318
Henkel	0.4142	6.3119	0.0731	0.6281	5.1925	0.0409
HypoVereinsbank	0.1291	2.0315	0.0123	0.0179	0.1488	0.0087
Infineon Technologies	0.5589	6.5592	0.0468	1.0661	4.2320	0.0456
Linde	0.7843	6.4774	0.0574	0.2169	3.6965	0.0206
Lufthansa	0.9678	8.0727	0.0739	0.2359	2.6843	0.0195
MAN	1.1994	7.9897	0.0786	0.0931	1.5158	0.0197
Metro	0.8874	6.4716	0.0535	0.1176	1.6893	0.0193
Muenchener Rueck	0.5454	7.8595	0.0955	0.1777	1.0794	0.0055
RWE	0.5170	5.8814	0.0510	0.2081	1.9924	0.0066
SAP	0.3906	5.4891	0.0373	0.3358	3.0865	0.0239
Schering	0.5941	6.0253	0.0462	0.4035	5.4434	0.0552
Siemens	0.4222	6.5354	0.0715	0.1327	1.1256	0.0168
ThyssenKrupp	0.2495	3.8854	0.0273	0.0532	0.4538	0.0056
TUI	1.0952	6.4770	0.0465	0.2431	3.6895	0.0250
Volkswagen	0.5061	6.4617	0.0590	0.1066	1.2058	0.0148

Table 2 reports the parameter estimates of the liquidity market model for spreads and depths for each stock (Equation 2). It gives the coefficients of market liquidity (β^1), their corresponding t-values and the adjusted R^2 values of the regression.

with an average of 6.04%. For depth at the best prices, β^1 varies between 0.02 and 1.06 with an average of 0.27 across stocks. The coefficients are significant in 70% of all regressions. The R^2 values vary between 0.01 and 0.06. The R^2 of

Table 3
Market Model for Spreads and Depth at the Best Limit Prices – Averages

		Spreads: Averages		Depth: Averages	
		Parameters	t-statistics	Parameters	t-statistics
Intercept	α	0.1309	0.2765	0.1186	3.6111
Market Liquidity	β^1	0.6472	6.5520	0.2703	2.5118
	β^2	0.0383	0.5094	0.1412	0.6699
	β^3	0.0508	0.6317	0.1268	1.0269
Market Return	δ^1	-0.0132	-0.2541	0.0053	0.0508
	δ^2	0.0064	0.0176	0.0797	0.4039
	δ^3	-0.0144	-0.0105	-0.1220	-0.2933
Return volatility	η	0.1115	0.6725	0.0049	0.0899
Adjusted R^2		0.0604		0.0220	

Table 3 reports the parameter estimates of the liquidity market model (Equation 2) for spreads and depths. It gives the mean parameter estimates across all 30 stocks and the corresponding average t-values for spreads and depth. The last row reports the average adjusted R^2 values of the regressions.

the regressions is a measure of commonality, since it explains the percentage of individual liquidity variation that is explained by market liquidity.[9] Thus, commonality in spreads is about 6% while it is lower at 2% for depth. Table 3 shows the average parameter estimates and t-values for all regressors. We follow Chordia, Roll and Subrahmanyam (2000) and Brockman and Chung (2002) by averaging parameters and t-values across all stocks. The averages are clearly insignificant for all variables except market liquidity.

The market model results that we obtain are very much along the lines of Chordia, Roll and Subrahmanyam (2000) and Brockman and Chung (2002). In their studies, only the market liquidity parameter is significant, while the additional regressors are not. They report adjusted R^2 values of anywhere between 2% and 3% for spreads and 1% and 2% for depth. We obtain a value of 6% for spreads and 2% for depth while all control variables are insignificant.

[9] See Chordia, Roll and Subrahmanyam (2000). R^2 captures the effects of all explanatory variables rather than market liquidity alone. However, leaving out the insignificant regressors does not lower the adjusted R^2 values much. Therefore its magnitude is nearly completely driven by the market liquidity coefficient.

Evidently, the depth market model leads to very similar results for our data, while, for the spread, commonality is stronger.

4 Commonality Beyond Best Prices

In this section we extend commonality to liquidity beyond best prices. Firstly, we construct liquidity measures for the limit order book. Secondly, we use a market model to compute the level of commonality. Thirdly, we employ principal components analysis (PCA) as a robustness check. We compare the level of commonality to the levels evidenced at the best prices.

4.1 Construction of Liquidity Measures

In limit order book markets, all orders are executed against the limit orders in the order book. If an order is very large, it hits unexecuted limit orders which have different price limits. The larger the order, the more price limits will be hit and the further a market order walks up the limit order book. Evidently, the spread and depth at best prices alone are not sufficient to characterize the liquidity of a limit order book market.

The bid-ask spread gives the price discrepancy between the best prices in the book, while depth at the spread is the corresponding volume in the order book. A natural extension is to move away from the best prices and to consider prices P and volumes x deeper in the order book. Because of possible asymmetries of the bid and ask side we construct separate measures for each order book side. In a first step we compute the price difference between all limit order prices (P) in the book and the midquote (MQ) at that point in time. In a second step we transform these price differences into price impacts relative to the midquote and link them to the cumulative volume in the order book, $I_j^A(x) = (P_j(x) - MQ_j)/MQ_j$ and $I_j^B(x) = (MQ_j - P_j(x))/MQ_j$. Finally, we compute the volumes that correspond to price impacts of 0.5%, 1%, 1.5% and 2%. We choose 2% as the cut-off value for this extended depth measure because in our data set market orders that are executed against the limit order book seldom incur higher price impacts. [10]

An advantage of this extended depth measure is that it is non-parametric and is not based on any restrictive assumptions. A disadvantage, however, is that it only characterizes one point on the price-quantity schedule at a time. We therefore introduce the slope of the price-quantity schedule as a second measure that summarizes all price-volume combinations in the limit order book simultaneously. Knowledge of the slope of the price-quantity schedule enables a trader to compute price impacts for any order size. Let m denote the pairs of price-volume combinations of the order book of stock j, let t denote the individual points in time for which we have order book snapshots and let x denote the volume in the order book. Denoting ε as the error term, we obtain the following equation for a linear model:

$$I_{j,t,m} = \lambda_{j,t} \cdot x_{j,t,m} + \varepsilon_{j,t,m} \tag{3}$$

As with the extended depth measures, we cut off the price-quantity schedule for price impacts higher than 2%. The indices indicate that we estimate the model in each point in time and for each stock. Furthermore, we do the estimation separately for the ask side and bid side. We also estimate Equation 3 with an additional quadratic term, $\rho_{j,t}x^2_{j,t,m}$, to check our specification of the price-quantity schedule. [11] Negative estimates of $\rho_{j,t}$ imply a concave order book function and positive estimates imply a convex relationship. We find neither a high number of significantly positive nor significantly negative estimates and therefore we choose the linear model. [12] We obtain two time series $\lambda_{j,t}$ for each

[10] The measure is similar to the cost of round trip measure in Irvine, Benston and Kandel (2000), the XLM measure in Gomber, Schweickert and Theissen (2004) or hypothetical price impacts as in Kumar (2003). Bauer (2004) measures the depth in a similar way and converts it into a percentage of a stock's free float.

[11] With regard to the specification, the empirical literature comes to mixed conclusions: Biais, Hillion and Spatt (1995) document linearity, while Coppejans, Domowitz, Madhavan (2003) or Cao, Hansch and Wang (2004) find evidence of some non-linearities.

[12] For stability we also estimate a polynomial model with a quadratic term and perform our later study for its coefficients. The linear coefficient taken from the

stock, one for the ask side, $\lambda^A_{j,t}$, and one for the bid side $\lambda^B_{j,t}$. The model does not include a constant to ensure that the estimated graph starts at the origin. Therefore, the state of the order book is summarized by one parameter. Since price impact functions are upward-sloping by construction, it is not surprising that the fits turn out to be very good and that the parameters estimates are highly significant.

Table B in the appendix gives some descriptive statistics of our liquidity proxies. The average volume associated with 2% price impacts is 4,219,230 Euros on the ask side and 4,032,470 Euros on the bid side, yet there is considerable variation in these figures. The average slope estimate is 0.8992 on the ask side and 0.9557 on the bid side. Again there is considerable cross-sectional variation across stocks: As the model of the order book slope has no constant, the slope is a direct measure of the level of liquidity: for example, an investor who wishes to buy a position of 500,000 Euros of Fresenius shares will incur a price impact of 1.1258%. In comparison, the half-spread is 0.0655%. Evidently, the spread is a poor liquidity proxy for large volumes.

4.2 Empirical Results

In this section we investigate market-wide liquidity movements of the entire limit order book. We use the same methodology as before, yet this time we substitute $L_{j,t}$ and $L_{M,t}$ in Equation 2 by our new measures of order book liquidity. Again we follow the standardization procedure of Equation 1 to eliminate trends from the data.

Tables 4 and 5 give the results for order book depth at 2% price impact. In Table 4 we list all individual β^1 coefficients, their corresponding t-statistics and the R^2. The coefficients lie between 0.2957 and 1.0261 (on the ask side) and 0.1019 and 1.0605 (on the bid side). Both on the ask side and on the bid side, β^1 is significant for 28 out 30 stocks (93.33%). Table 5 shows the average

linear and non-linear model behave in exactly the same way. The coefficient of the quadratic term also shows the same commonality.

Table 4
Market Model for the Extended Depth Measure – Individual Stocks

	Ask Side			Bid Side		
Stock	β^1	t	R^2	β^1	t	R^2
Adidas-Salomon	0.7766	3.6945	0.0579	0.9571	5.0424	0.1020
Allianz	1.0389	4.9800	0.1042	0.8625	5.0533	0.2375
Altana	0.6372	3.0701	0.0918	0.8732	4.4712	0.0410
BASF	0.8268	4.1595	0.1397	1.0128	5.5817	0.1301
BMW	0.5456	2.7432	0.1508	0.6165	3.2135	0.0588
Bayer	0.8077	5.2372	0.3513	0.5407	2.7524	0.0205
Commerzbank	0.7146	3.8567	0.1980	0.6950	3.8881	0.1745
Continental	0.9604	4.7992	0.1835	0.5895	3.0350	0.0426
DaimlerChrysler	0.8281	5.1474	0.2641	1.0605	5.9898	0.2049
Deutsche Bank	0.7954	4.0889	0.1865	0.5277	2.8419	0.0753
Deutsche Boerse	0.6987	3.2872	0.0702	0.7246	3.7491	0.0341
Deutsche Post	0.8217	4.7963	0.3750	0.6051	3.3161	0.0704
Deutsche Telekom	0.5922	2.9398	0.1522	0.5497	3.0045	0.1287
E.ON	0.2957	1.4514	0.0636	0.3482	1.8335	0.0388
Fresenius	0.9057	5.0962	0.1631	0.9372	4.8645	0.0396
Henkel	0.8850	4.1493	0.0705	0.8781	4.6440	0.0517
HypoVereinsbank	0.0117	0.0557	0.0190	0.1885	0.9859	0.0017
Infineon Technologies	0.3439	1.6709	0.0830	0.1019	0.5343	0.0159
Linde	1.0261	4.9520	0.1348	0.7600	3.8896	0.0393
Lufthansa	0.5429	2.7324	0.1600	0.5930	3.2281	0.0770
MAN	0.7349	3.4949	0.0731	0.9213	4.7641	0.0706
Metro	0.9738	4.9160	0.1847	0.6173	3.1637	0.0164
Muenchener Rueck	0.8404	4.6200	0.3087	0.8559	4.5013	0.0777
RWE	0.6269	2.9312	0.0564	0.6129	3.1520	0.0496
SAP	0.9122	4.6560	0.2048	0.7529	3.9907	0.0819
Schering	0.5815	2.8550	0.1180	0.4207	2.1680	0.0328
Siemens	0.8535	4.3360	0.2043	1.0537	5.8729	0.1852
ThyssenKrupp	0.6324	3.5943	0.3301	0.4752	2.3938	0.0097
TUI	0.6339	3.1542	0.0716	0.6700	3.7105	0.1365
Volkswagen	0.8125	4.0291	0.1541	0.9084	5.3488	0.2565

Table 4 reports the parameter estimates of the liquidity market model (Equation 2) for the extended depth measure at a price impact of 2.0% for each stock. It gives the coefficients of market liquidity, their corresponding t-values and the adjusted R^2 values of the regression for the ask and bid side.

Table 5
Market Model for the Extended Depth Measure – Averages

		Ask Side		Bid Side	
		Parameters	t-statistics	Parameters	t-statistics
Intercept	α	-0.0084	-0.3581	-0.0034	-0.1151
Market Liquidity	β^1	0.7219	3.7165	0.6903	3.6995
	β^2	0.0634	0.4276	-0.0048	0.0121
	β^3	0.0725	0.4719	0.0009	0.0515
Market Return	δ^1	0.0794	0.5497	-0.0230	-0.1714
	δ^2	0.0323	0.2202	-0.0729	-0.5156
	δ^3	-0.0240	-0.1726	-0.0177	-0.1301
Return volatility	η	0.0492	1.1742	0.0760	1.5074
Adjusted R^2		0.1609		0.0827	

Table 5 reports the parameter estimates of the liquidity market model (Equation 2) for the extended depth measure at a price impact of 2.0%. It gives the mean parameter estimates across all 30 stocks and the average t-values for the ask side and the bid side of the order book. The last row reports the average R^2 values of the regressions.

values. On average, β^1 is 0.7219 (on the ask side) and 0.6903 (on the bid side). The beta coefficient for contemporaneous market liquidity is the only coefficient with a significant t-value. Compared to the results of liquidity at the best limit price, however, the adjusted R^2 values are much higher. They climb to an average of 16.09% on the ask side and 8.27% on the bid side. In comparison, the corresponding R^2 value of depth at best prices was 2.20%. In other words, commonality increases strongly if we consider the aggregate liquidity supplied to the limit order book instead of focusing at best quotes and quantities alone.

Next we proceed to the slope of the price-quantity schedule which is also estimated for price impacts up to 2%. Tables 6 and 7 present the results. Table 6 shows that the β^1 coefficient varies between 0.1139 and 1.0966 on the ask side of the limit order book and 0.2043 and 0.9949 on the bid side. 29 out of 30 stocks have significant coefficients on the ask side and 28 out of 30 on the bid side. On average, the market liquidity coefficients are 0.7302 on the ask side

Table 6
Market Model for the Slope of the Price-Quantity Schedule – Individual Stocks

	Ask Side			Bid Side		
Stock	β^1	t	R^2	β^1	t	R^2
Adidas-Salomon	0.6706	4.2422	0.0812	0.8405	5.2077	0.1162
Allianz	1.0966	7.1134	0.1493	0.6913	4.8021	0.2748
Altana	0.8954	5.6654	0.0926	0.8583	5.1036	0.0495
BASF	0.8401	5.4983	0.1448	0.9949	6.4469	0.1969
BMW	0.4935	3.3006	0.1516	0.7096	4.3513	0.0897
Bayer	0.8649	6.1124	0.2614	0.6234	3.8197	0.0813
Commerzbank	0.9036	6.3157	0.2441	0.6266	4.4515	0.2953
Continental	0.8532	5.5842	0.1459	0.6429	3.7752	0.0211
DaimlerChrysler	0.6369	4.4276	0.2296	0.6894	4.4588	0.1678
Deutsche Bank	0.5673	3.7430	0.1380	0.5583	3.4095	0.0675
Deutsche Boerse	0.7413	4.7605	0.1053	0.7071	4.1456	0.0201
Deutsche Post	0.7483	5.7654	0.3705	0.5078	3.1506	0.0956
Deutsche Telekom	0.5207	3.6392	0.2253	0.4125	2.5542	0.0775
E.ON	0.2965	1.8984	0.0758	0.2043	1.2425	0.0384
Fresenius	0.7951	5.4021	0.1983	0.6289	3.7117	0.0283
Henkel	0.8211	5.1907	0.0945	0.7626	4.5393	0.0468
HypoVereinsbank	0.1139	0.7140	0.0173	0.3489	2.0703	0.0092
Infineon Technologies	0.3975	2.7986	0.2269	0.2417	1.4622	0.0308
Linde	0.7843	4.9910	0.0978	0.8434	4.9817	0.0434
Lufthansa	0.6055	3.9815	0.1325	0.5983	3.6188	0.0557
MAN	0.8529	5.4123	0.1103	0.8673	5.4119	0.1434
Metro	0.9083	6.0797	0.1832	0.6825	4.0259	0.0237
Muenchener Rueck	0.9139	6.8574	0.3416	0.9219	6.1417	0.2288
RWE	0.5247	3.3518	0.0853	0.4731	2.8092	0.0171
SAP	0.7750	5.1553	0.1674	0.7169	4.4542	0.1158
Schering	0.8488	5.7700	0.2030	0.7115	4.3647	0.0874
Siemens	0.8625	5.9839	0.2408	0.9600	6.6583	0.2860
ThyssenKrupp	0.8374	6.1046	0.3025	0.6241	3.6965	0.0342
TUI	0.8308	5.4249	0.1379	0.5796	3.7072	0.1507
Volkswagen	0.9060	6.1559	0.2029	0.9083	6.7677	0.3775

Table 6 reports the parameter estimates of the liquidity market model (Equation 2) for the slope of the price-quantity schedule for each stock. It gives the coefficients of market liquidity, their corresponding t-values and the adjusted R^2 values of the regression for the ask and bid side.

Table 7
Market Model for the Slope of the Price-Quantity Schedule – Averages

		Ask Side: Averages		Bid Side: Averages	
		Parameters	t-statistics	Parameters	t-statistics
Intercept	α	0.0017	0.0600	0.0010	0.0335
Market Liquidity	β^1	0.7302	4.9147	0.6645	4.1780
	β^2	0.0600	0.4901	0.0568	0.4831
	β^3	0.0854	0.6713	0.0704	0.5787
Market Return	δ^1	-0.1063	-0.7185	0.0592	0.4333
	δ^2	-0.0359	-0.2520	0.0558	0.4003
	δ^3	0.0332	0.2250	-0.0109	-0.0677
Return volatility	η	-0.0041	-0.2888	-0.0003	-0.1862
Adjusted R^2		0.1719		0.1090	

Table 7 reports the parameter estimates of the liquidity market model (Equation 2) for the slope of the price-quantity schedule. It gives the mean parameter estimates across all 30 stocks and the average t-values for both the bid side and the ask side of the order book. The last row reports the average adjusted R^2 values of the regressions.

and 0.6645 on the bid side; both are highly significant. All other coefficients are close to zero in a range between -0.1063 and 0.0704 with insignificant t-values. Commonality on the ask side is 17.19% and on the bid side 10.90%. Evidently, the results for slope parameters of the price-quantity schedule are very similar to those for depth. The slope model is minimally more powerful (17.19% versus 16.09% on the ask side and 10.90% versus 8.27% on the bid side). Compared to commonality at best prices, the extent of systematic liquidity risk is once again much higher. These results underline that the high extent of commonality for liquidity in the limit order book remains a robust result irrespective of the measure used.

Obviously systematic movements in liquidity are quite different for the liquidity flow at best prices and the liquidity flow up until ticks further beyond best prices. As we have only focused on liquidity at 2% price impacts so far, we now turn our attention to smaller price impacts. Table 8 shows how commonality changes for different cut-off points of aggregate order book depth. On the ask side, β^1 starts out at 0.53 for 0.5% impacts and increases continually to 0.72 for order book depth at a 2% price impact. The corresponding average t-values are clearly above the critical value. Turning to the level of commonality, we see that the adjusted R^2 value on the ask side is 9% for a price impact of 0.5%. It increases continually up to 16%. The pattern holds for the bid side of the order book as well where commonality increases to a value of 8%. In Figure 2 we illustrate the results graphically. In contrast to our previous liquidity measures, we have not cut liquidity off at 2% to show how commonality increases even further in the order book. It approaches levels beyond 20% on the ask side and beyond 10% on the bid side.

4.3 Robustness to Methodology

In the following section we approach commonality from a different angle. While Chordia, Roll and Subrahmanyam (2000) set up a model in which market liquidity explains individual stock liquidity, other studies such as Hasbrouck and Seppi (2001), Hansch (2001) or Bauer (2004) use principal component analysis (PCA). Instead of imposing any pre-specified restrictions on the common liquidity factor, they use PCA to extract the factor with the highest explanatory power for individual liquidity variation. We compare the results of these two methodologies for our data and conclude to what extent the methodology influences the findings. [13]

The main input of the PCA is the correlation matrix of our liquidity measures. Again we standardise all liquidity measures first as in Equation 1. PCA then extracts the linear combination of individual liquidity measures with the highest explanatory power for the variability in the data. This linear combination – called the first principal component – is effectively a weighting vector of individual liquidity and is given by the first eigenvector of the correlation

[13] Beltran, Giot and Grammig (2005) have also used principal components analysis in the context of limit order books. They apply PCA to price-quantity pairs to examine whether variation in such pairs can be attributed to one or more underlying factors. While they link variation within the order book of single stocks to microstructural factors, we focus on the variation of liquidity across stocks.

Table 8
Market Model for Increasing Depth of the Limit Order Book – Averages

	Ask Side			Bid Side		
Price impact	β^1	t	R^2	β^1	t	R^2
0.5%	0.53	3.19	0.09	0.46	2.74	0.06
1.0%	0.53	2.50	0.12	0.49	2.42	0.07
1.5%	0.67	3.33	0.14	0.62	3.22	0.08
2.0%	0.72	3.72	0.16	0.69	3.70	0.08

Table 8 reports parameter estimates of the liquidity market model (Equation 2) for increasing depth. The first column lists the price impact up to which depth is aggregated. The further columns give average parameter estimates, corresponding t-values and average adjusted R^2 values for the ask side and the bid side of the order book.

matrix. Its explanatory power is given by the corresponding eigenvalue. From the weighting vector we compute the value of the principal component for each point in time. We then regress this time series onto the time series of individual stock liquidity measures for each stock:

$$L_{j,t} = \xi_j + \psi_j \; PC_{j,t} + \varepsilon_{j,t}, \tag{4}$$

In the equation above, $PC_{j,t}$ denotes the realization of the first principal component in t. ξ_j and ψ_j are parameters and ε_j is an error term. To generate a test statistic, we bootstrap new time series from the regression residuals of all stocks, compute the correlation matrix and perform PCA. We repeat this procedure 10,000 times until we obtain a smooth empirical distribution of the first eigenvalue and sample the 95%-quantile as our critical value.

Table 9 summarizes the PCA results for aggregate depth. On the ask side, the first principal component of aggregate depth at 0.5% price impact is 4.0. With a critical value of 2.1 it is clearly significant and accounts for 13% of overall variation in depth. If we successively increase aggregate depth up to 2%, the amount of common variation rises continually from 13% to 20%. All first principal components remain strongly significant.[14] On the bid side of

[14] To make the results more comparable with the previous section, we eliminate the

Fig. 2. Commonality for Increasing Depth of the Limit Order Book

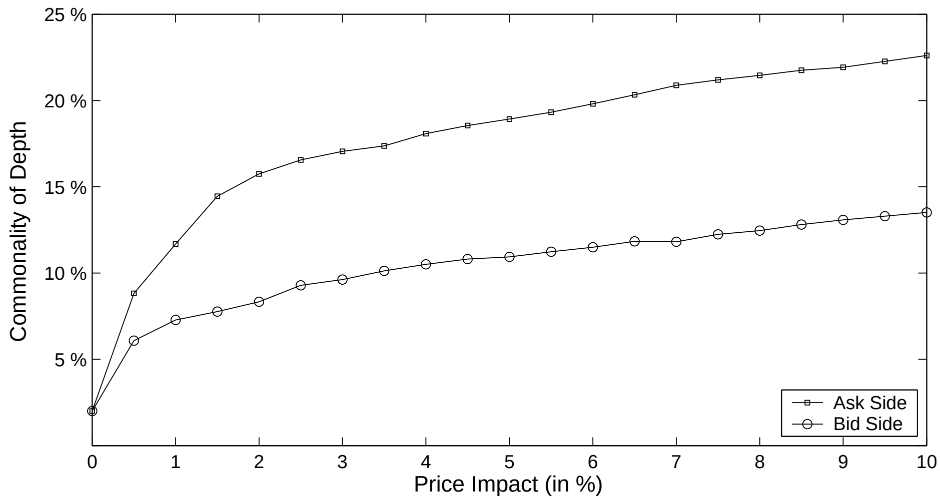

Figure 2 shows how the extent of commonality increases as more liquidity in the order book is considered. The x-axis gives the price impact up to which depth is aggregated and the y-axis gives the amount of commonality . Commonality is measured as the R^2 value of the market model (Equation 2) of liquidity .

the book, the pattern is identical. All first principal components for aggregate depth are significant. In level, commonality starts out at 11% and rises to 13% if we consider depth up to 2% price impacts.

Let us compare our results with the PCA results in Bauer (2004) for the Swiss market: using intradaily data, Bauer (2004) reports that for depth at 1% price impact the first principal component accounts for 11.3% of the overall variation (on the ask side) and 9.0% on the bid side. This is very similar to our values at 1% price impact (12% for the ask and 7% for the bid). In particular, our results confirm the asymmetric effect that, for depth-related liquidity measures, the explanatory power is slightly lower on the bid side than on the ask side.

Comparing these results to the regression approach in the previous section, we see that they are very similar. Firstly, commonality increases with order book depth. Secondly, commonality is stronger on the ask side of the book.

---

impact of the control variables on our liquidity measures. We regress the liquidity measures onto the same explanatory variables and then take the correlation matrix of the residuals for the further PCA procedure. This leads to minimally lower levels of commonality, yet qualitatively identical results.

Table 9
PCA Results for the Extended Depth Measures

PCA Output	Price Impacts			
	0.5%	1.0%	1.5%	2.0%
Ask Side				
First eigenvalue	4.00	4.85	5.69	6.04
Critical value	2.13	2.53	2.84	2.92
Proportion of variation	0.13	0.16	0.19	0.20
Bid Side				
First eigenvalue	3.24	3.57	3.66	3.80
Critical value	2.01	2.19	2.48	2.54
Proportion of variation	0.11	0.12	0.12	0.13

Table 9 gives the results of PCA for the extended depth measure at different price impacts. In the first section, the table lists the first eigenvalue, its critical values at the 95% confidence level and the proportion of total variability explained by the first principal component (in %) for the ask side of the order book. The second section gives the same information for the bid side.

In level, the PCA results are about 4 percentage points above the market index approach for ask side depth and 2 percentage points for the bid side. Somewhat higher PCA results are not surprising, since PCA is not restricted to a predetermined measure of market liquidity.

For the sake of brevity we have not reported the PCA results for the spread measures or the slope estimate of the price-quantity schedule. Qualitatively, they provide similar evidence as before: commonality around the bid-ask spread and best depth is lower than deeper in the limit order book (at 9% and 7%). In contrast, commonality of the slope estimates is considerably higher (24% on the ask side and 18% on the bid side). As with depth, PCA reinforces the patterns of the Chordia, Roll and Subrahmanyam (2000) market model.

5 Time Variation of Commonality

The previous section showed that the use of the bid-ask spread and depth at the best prices is one reason why the impact of commonality in liquidity has

Table 10
Impact of the Time of Day

	Ask						Bid					
	Morning		Midday		Evening		Morning		Midday		Evening	
Impact	β^1	R^2	β^1	R^2	β^1	R^2	β^1	R^2	β^1	R^2	β^1	R^2
0.5%	0.57	13	0.46	09	0.52	11	0.52	10	0.42	07	0.39	08
1.0%	0.51	15	0.41	12	0.54	14	0.46	13	0.37	08	0.54	09
1.5%	0.57	17	0.46	15	0.75	18	0.55	14	0.46	07	0.73	11
2.0%	0.56	19	0.47	16	0.82	19	0.60	15	0.51	07	0.81	12

Table 10 reports the average coefficients of market liquidity and the corresponding R^2 values of the regressions (in %) for the morning period (until 11 a.m.), the midday period (from 11.30 a.m. until 3.30 p.m.) and the evening period (from 4 p.m. until 5.30 p.m.). The results are reported for the depth measure of the limit order book at different price impacts. The table gives the results for the bid side and the ask side of the book.

been so low in the past. A second reason is that commonality might be time-varying. In the following section we explore the time variation with regard to intradaily patterns and with regard to the movement of the market.

5.1 Time of Day

It is widely recognized that liquidity exhibits strong time-of-day effects. In particular, liquidity is low in the morning at the opening of the market. This is illustrated very clearly in the L-shape over the bid-ask spread and the upside-down L-shape of depth. To examine the time-of-day effects we investigate commonality on an intradaily basis. We split our data into three subsamples: a morning sample (order book liquidity until 11 a.m.), a midday sample (from 11.30 a.m. until 3.30 p.m.) and an evening sample (from 4 p.m. to 5.30 p.m.). We then reestimate Equation 2 separately for all three subsamples.

Table 10 summarizes the results for the extended depth measure. Although time-of-day effects have been eliminated from individual liquidity levels, the systematic movement of liquidity across stocks shows clear intraday patterns. For example, the adjusted R^2 value for ask side depth at a price impact of 2%

is 19% in the morning, drops to 16% in the course of the day and goes back up to 19% in the late trading period. On the bid side, the R^2 value is 15% in the morning, 7% during the trading day and 12% at the close of the day. There is a clear U-shape in the commonality of liquidity: commonality is higher in the morning, falls to lower levels during the day and rises again in the evening before the exchange closes. This pattern is visible for every depth measure from 0.5% to 2% price impacts. It is also robust with regard to the ask and bid side of the limit order book. We obtain the same qualitative results if we use the slope of the price-quantity schedule as our measure of the liquidity in the limit order book. For the sake of brevity we do not repeat the results here.

Evidently commonality in liquidity exhibits a strong U-shape. We should stress that we obtain this result although we have already eliminated time-of-day effects from the liquidity proxies. We hypothesize that this pattern is linked to the dissemination process of information: firm-specific information which leads to heavier trading of an individual stock is typically released in press releases over the trading day. Therefore, liquidity movements over the trading day are predominantly idiosyncratic. In contrast, information from the overnight period typically concerns other markets and is more macro-economic in its nature. Likewise, shortly before the European market closes the US market opens which leads to a flow of information that is market-wide. As a consequence, liquidity movements are more strongly correlated. We find this link between the type of information and the strength of commonality an interesting question for future research.

5.2 Market Movements

While time-of-day effects are an explanation of variation in commonality over an intraday horizon, market movements are a possible explanation for variation over an inter-day horizon. High commonality in falling markets implies that trading becomes more expensive in situations in which investors typically wish to rebalance their portfolios or seek to limit their losses by selling off stock positions.

Numerous studies provide evidence that the correlation of stock returns is strongest in falling markets (see Conrad, Gultekin and Kaul (1991), Kroner and Ng (1998), Bekaert and Wu (2000), Longin and Solnik (2001) or Ang and Chen (2002)). In such environments, a flight to quality reduces the liquidity of equity markets in favor of safer investments. More specifically, Coughenour and Saad (2004) argue that liquidity providers are more likely to feel capital constraints in falling markets and, in an effort to manage their wealth, withdraw liquidity across many different stocks. In consequence, liquidity commonality increases with the absolute size of negative returns. While their empirical results support this view, Domowitz, Hansch and Wang (2005) find little evidence of systematic differences in commonality for extreme up and down markets. Therefore, we examine the relationship between the market return and commonality more closely for subsamples of varying market conditions.

Let w with $w = 1, 2, 3, ..., 53$ denote rolling ten-day intervals. For each such interval we calculate the equally weighted portfolio return of our sample stocks, R_w, and estimate Equation 2.[15] We take the R^2 of each interval as measure of commonality, C_w. The highest ten-day return is 1.48% and the lowest is -4.60%. In a first step, we present the results for these two subsamples in Table 11. If we compare the R^2 values for the upwards and downwards trending markets we see that there is strong evidence of a momentum effect: liquidity comoves far more strongly in falling markets than in rising markets. At a price impact of 2% commonality is about 15% in the rising market and 22% in the falling market. On the bid side commonality in the rising market is 10% and in the falling market 14%.

In a second step we relate the degree of commonality to the portfolio return in the same time window. With ε as the error term we estimate the following regression:

$$C_w = \alpha + \beta \; R_w + \varepsilon_w \tag{5}$$

In the above equation, β measures the relation between commonality and

[15] The results are qualitatively identical for value-weighted portfolio returns.

Table 11
Impact of Market Movements

	Ask				Bid			
	Up		Down		Up		Down	
Price impact	β^1	R^2	β^1	R^2	β^1	R^2	β^1	R^2
0.5%	0.51	0.10	0.63	0.15	0.31	0.06	0.53	0.15
1.0%	0.49	0.14	0.62	0.18	0.40	0.07	0.56	0.20
1.5%	0.61	0.14	0.74	0.21	0.55	0.09	0.72	0.18
2.0%	0.72	0.15	0.78	0.22	0.63	0.10	0.73	0.14

Table 11 reports the average parameter estimates of the market liquidity parameter and R^2 values for rising markets ("up") and falling markets ("down"). It lists the results for the ask side and the bid side of the order book and also differentiates with regard to the price impact up to which order book depth is aggregated.

market momentum. For the extended depth measure at 2% price impacts β is -1.125 with a Newey-West adjusted t-statistic of -2.110. On the bid side, β is -0.602 with a Newey-West corrected t-statistic of -3.853. Clearly, the coefficients on both sides of the book are significantly negative. The significance is just as strong for all other depth measures as well. This implies that commonality is stronger if momentum is negative and weaker if it is positive. The results are virtually identical if we measure liquidity by means of the slope of the limit order book.

6 Conclusion

This paper is motivated by the observation that market-wide liquidity apparently gets priced, yet there is only weak evidence that stock liquidity movement does actually exhibit a market-wide component. Two reasons for the weak evidence are, firstly, the mismeasurement of liquidity and, secondly, the time variation of commonality. We examine these hypotheses with the help of an extensive order book data set from the Frankfurt Stock Exchange (FSE).

In our methodology we follow the Chordia, Roll and Subrahmanyam (2000) market model which we extend to liquidity measures beyond best prices. In a reference scenario, we analyze commonality for liquidity at the best price. Although we document significant commonality, it is fairly weak as in the literature (2% for depth and 6% for spreads). However, once we take the liquidity supply in the order book into account, commonality increases strongly. If depth measures at 2% price impacts are used, commonality rises up to 16% on the ask side and 8% on the bid side. A closer examination of the results also reveals that ask side commonality is stronger than on the bid side. Measures of the price-quantity schedule lead to similar results. Obviously, the commonality of liquidity provision is far higher than the spread or depth at the best prices suggest.

In addition, we also examine the time variation of commonality. We find that commonality is far stronger at the opening and closing of the trading day than during the day. This finding occurs even after controlling for time-of-day effects in liquidity. A likely explanation is that the information flows from the overnight period and the opening of the US market are more market-wide and therefore induce increased levels of commonality at the open and the close of the trading day. Furthermore, we find that commonality is associated with the general movement of the market: in down markets commonality is much higher than in up markets. The values of 16% and 8% over the whole sample rise to 22% and 14% for a falling market environment. In all, our results provide strong evidence of time variation in liquidity commonality.

In sum, our study suggests that commonality in liquidity and thus liquidity risk is much higher than estimated in previous papers. It is important that the estimation of commonality takes liquidity beyond best prices into account so that an investor's systematic liquidity risk is not underestimated.

References

Acharya, V. and L. Pedersen, 2005, Asset Pricing with Liquidity Risk, Journal of Financial Economics 77, 375-410.

Allen, F. and D. Gale, Financial Contagion, Journal of Political Economy 108, 1-33.

Amihud, Y. and H. Mendelson, 1986, Asset Pricing and the Bid-Ask Spread, Journal of Financial Economics 17, 311-353.

Amihud, Y., 2002, Illiqudity and Stock Returns, Journal of Financial Markets 5, 31-56.

Ang, A. and J. Chen, 2002, Asymmetric Correlations of Equity Portfolios, Journal of Financial Economics 63, 443-494.

Bauer, W., 2004, Commonality in Liquidity in Pure Order-Driven Markets, Working Paper, March 2004.

Bekaert, G. and G. Wu, 2000, Asymmetric Risk and Volatility in Equity Markets, Review of Financial Studies 13, 1-42.

Beltran, H., P. Giot and J. Grammig, 2005, Commonalities in the Order Book, Working Paper, Version 26th January 2005.

Bernstein, P., 1987, Liquidity, Stock Markets, and Market Makers, Financial Management 16, 54-62.

Biais, B., P. Hillion and C. Spatt, 1995, An Empirical Analysis of the Limit Order Book and the Order Flow in the Paris Bourse, Journal of Finance 50, 1655-1689.

Brockman, P. and D. Chung, 2002, Commonality in Liquidity: Evidence from an Order-Driven Market Structure, Journal of Financial Research 25, 521-539.

Brunnermeier, M. and L. Pedersen, 2005, Predatory Trading, Journal of Finance 60, 1825-1863.

Cao, C., O. Hansch and X. Wang, 2004, The Informational Content of an Open Limit Order Book, EFA 2004 Maastricht Meetings Paper 4311, Version 15th March 2004.

Chordia, T., R. Roll and A. Subrahmanyam, 2000, Commonality in Liquidity, Journal of Financial Economics 56, 3-28.

Chordia, T., R. Roll and A. Subrahmanyam, 2001, Market Liquidity and Trading Activity, Journal of Finance 56, 501-530.

Chordia, T., A. Sarkar and A. Subrahmanyam, 2005, An Empirical Analysis of Stock and Bond Market Liquidity, Review of Financial Studies 18, 85-129.

Conrad, J., M. Gultekin and G. Kaul, 1991, Asymmetric Predictability of Conditional Variances, Review of Financial Studies 4, 597-622.

Coppejans, M., I. Domowitz and A. Madhavan, 2003, Resiliency in an Automated Auction, Working Paper, Version July 2003.

Coughenour, J. and M. Saad, 2004, Common Market Makers and Commonality in Liquidity, Journal of Financial Economics 73, 37-70.

Deutsche Boerse Group, 2004, Market Model Stock Trading, Release 7.1.

Diebold, F. and C. Li, 2002, Forecasting the Term Structure of Government Bond Yields, Working Paper, Version October 2003.

Domowitz, I., O. Hansch and X. Wang, 2005, Liquidity Commonality and Return Co-Movement, Journal of Financial Markets 8, 351-376.

Fernando, C., 2003, Commonality in Liquidity: Transmission of Liquidity Shocks across Investors and Securities, Journal of Financial Intermediation 12, 233-254.

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

Gibson, R. and N. Mougeot, 2004, The Pricing of Systematic Liquidity Risk: Empirical Evidence from the US Stock Market, Journal of Banking and Finance 28, 157-178.

Gomber, P., U. Schweickert and E. Theissen, 2004, Zooming in on Liquidity, EFA 2004 Maastricht Meetings Paper No. 1805, Version February 2004.

Grammig, J., A. Heinen and E. Rengifo, 2004, Trading Activity and Liquidity Supply in a Pure Limit Order Book Market – An Empirical Analysis using a Multivariate Count Data Model, Working Paper, Version August 2004.

Gromb, D. and D. Vayanos, 2002, Equilibrium and Welfare in Markets with Financially Constrained Arbitrageurs, Journal of Financial Economics 66, 361-407.

Halka, D. and G. Huberman, 2001, Systematic Liquidity, Journal of Financial

Research 24, 161-178.

Hasbrouck, J., R. Schwartz, 1988, Liquidity and Execution Costs in Equity Markets, Journal of Portfolio Management 14, 10-16.

Hansch, O., 2001, Island Tides: Exploring ECN Liquidity, Working Paper, Version January 2003.

Hasbrouck, J. and D. Seppi, 2001, Common Factors in Prices, Order Flows and Liquidity, Journal of Financial Economics 59, 383-411.

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

Irvine, P., G. Benston and E. Kandel, 2000, Liquidity beyond the Inside Spread: Measuring and Using Information in the Limit Order Book, Working Paper, Version July 2000.

Jain, P. and G. Joh, 1988, The Dependence between Hourly Price and Trading Volume, Journal of Financial and Quantitative Analysis 23, 269-283.

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

Kroner, K. and V. Ng, 1998, Modeling Asymmetric Comovements of Asset Returns, Review of Financial Studies 11, 817-844.

Kumar, S., 2003, Liquidity: Persistence and Forecast in Open Electronic Limit Order Book Market, Working Paper, Version July 2003.

Kyle, A. and W. Xiong, 2001, Contagion as a Wealth Effect, Journal of Finance 56, 1401-1440.

Longin, F. and B. Solnik, 2001, Extreme Correlation of International Equity Markets, Journal of Finance 56, 649-676.

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

McInish, T. and R. Wood, 1992, An Analysis of Intraday Patterns in Bid/Ask Spreads for NYSE Stocks, Journal of Finance 47, 753-764.

O'Hara, M., 2003, Presidential Address: Liquidity and Price Discovery, Journal of Finance 58, 1335-1354.

Pástor, L., and R. Stambaugh, 2003, Liquidity Risk and Expected Stock Returns, Journal of Political Economy 111, 642-685.

Watanabe, M., 2003, A Model of Stochatic Liquidity, Working Paper, Version June 2003.

Wood, R., T. McInish and J. Ord, 1985, An Investigation of Transaction Data for NYSE Stocks, Journal of Finance 25, 723-739.

A Descriptive Statistics of Spread and Depth Measures at the Best Limit Prices in the Limit Order Book

Stock	Market Capital.	Trading Volume	Absolute Spread	Relative Spread	Best Price Depth
Adidas-Salomon	4.17	34.76	0.086	0.093	94,230
Allianz	38.50	295.99	0.056	0.057	194,850
Altana	6.73	33.47	0.052	0.106	79,820
BASF	25.39	135.67	0.027	0.063	182,560
BMW	23.08	97.23	0.021	0.091	156,100
Bayer	17.05	94.15	0.026	0.075	152,060
Commerzbank	9.36	56.29	0.017	0.108	157,800
Continental	4.09	27.82	0.038	0.119	88,490
DaimlerChrysler	37.36	201.79	0.025	0.068	221,550
Deutsche Bank	38.34	324.95	0.036	0.053	252,420
Deutsche Boerse	4.87	36.55	0.046	0.098	109,200
Deutsche Post	18.23	45.42	0.020	0.111	144,860
Deutsche Telekom	61.29	348.60	0.012	0.074	979,210
E.ON	36.15	178.47	0.069	0.104	76,630
Fresenius	3.94	14.13	0.071	0.131	65,770
Henkel	3.70	19.61	0.033	0.063	218,860
HypoVereinsbank	9.19	101.00	0.020	0.111	198,140
Infineon Technologies	8.01	153.05	0.012	0.106	361,810
Linde	5.15	24.03	0.047	0.107	82,390
Lufthansa	4.96	45.19	0.017	0.121	135,730
MAN	3.42	28.34	0.035	0.128	89,570
Metro	11.42	42.63	0.043	0.123	96,300
Muenchener Rueck	22.13	221.43	0.058	0.062	201,930
RWE	16.49	106.93	0.028	0.083	165,730
SAP	42.49	201.83	0.080	0.061	171,560
Schering	7.91	53.69	0.037	0.092	106,230
Siemens	57.16	339.02	0.030	0.050	263,520
ThyssenKrupp	8.19	40.37	0.020	0.110	134,610
TUI	2.95	26.53	0.028	0.149	89,860
Volkswagen	14.19	114.85	0.028	0.073	142,820
Averages	18.20	114.793	0.037	0.093	180,487

Table A reports descriptive statistics of our data set. The columns report market capitalization as of 02 January 2004 (in billions of Euros), average daily trading volume (in 1,000 Euros), absolute spreads in Euros, relative spreads in % and depth at the best limit prices in Euros.

B Descriptive Statistics for the Depth of the Order Book at 2% Price Impact and for the Slope of the Order Book

	Depth		Slopes	
Stock	Ask Side	Bid Side	Ask Side	Bid Side
Adidas-Salomon	2,437.00	2,044.00	0.8522	0.9701
Allianz	8,833.00	8,657.00	0.2263	0.2332
Altana	1,776.00	1,602.00	1.2289	1.2673
BASF	3,924.00	4,360.00	0.4721	0.4463
Bayer	3,273.00	2,922.00	0.6139	0.6919
BMW	3,075.00	3,186.00	0.6809	0.6602
Commerzbank	2,885.00	2,295.00	0.7663	0.9186
Continental	1,239.00	1,036.00	1.6666	1.9632
DaimlerChrysler	5,789.00	5,547.00	0.3326	0.3441
Deutsche Boerse	11,145.00	10,916.00	0.1836	0.1866
Deutsche Bank	1,830.00	1,861.00	1.1555	1.1305
Deutsche Post	2,411.00	2,060.00	0.8619	1.0021
Deutsche Telekom	17,655.00	16,668.00	0.1084	0.1133
E.ON	1,173.00	997.00	1.6551	1.7904
Fresenius	823.00	831.00	2.2516	2.2441
Henkel	5,459.00	5,303.00	0.3422	0.3631
HypoVereinsbank	3,943.00	3,408.00	0.6082	0.7217
Infinineon	7,150.00	5,614.00	0.3391	0.395
Linde	1,079.00	1,123.00	1.8555	1.8497
Lufthansa	1,734.00	1,621.00	1.1827	1.3244
MAN	1,046.00	945.00	2.0172	2.1075
Metro	1,485.00	1,429.00	1.4324	1.4314
Muenchener Rueck	7,815.00	7,048.00	0.2832	0.3002
RWE	2,770.00	2,705.00	0.7139	0.7267
SAP	6,423.00	6,915.00	0.2982	0.284
Schwering	2,200.00	2,467.00	1.0523	0.9295
Siemens	11,007.00	11,107.00	0.1747	0.1752
ThyssenKrupp	1,762.00	1,318.00	1.2102	1.4617
TUI	1,223.00	1,102.00	1.7401	2.0498
Volkswagen	3,213.00	3,887.00	0.6709	0.5903
Average	4,219.23	4,032.47	0.8992	0.9557

Table B gives descriptive statistics of the liquidity of the order book. The second and third column give the aggregate depth (in 1,000.00 Euros) of the order book up to a price impact of 2%. The fourth and fifth column give parameter estimates of a linear model of the order book function.

cfr working paper series

centre for financial research
cologne

cfr working papers are available for download from **www.cfr-cologne.de**.

Hardcopies can be ordered from: centre for financial research (cfr),
Albertus Magnus Platz, 50923 Koeln, Germany.

2012

No.	Author(s)	Title
12-06	A. Kempf, A. Pütz, F. Sonnenburg	Fund Manager Duality: Impact on Performance and Investment Behavior
12-05	R. Wermers	Runs on Money Market Mutual Funds
12-04	R. Wermers	A matter of style: The causes and consequences of style drift in institutional portfolios
12-03	C. Andres, A. Betzer, I. van den Bongard, C. Haesner, E. Theissen	Dividend Announcements Reconsidered: Dividend Changes versus Dividend Surprises
12-02	C. Andres, E. Fernau, E. Theissen	Is It Better To Say Goodbye? When Former Executives Set Executive Pay
12-01	L. Andreu, A. Pütz	Are Two Business Degrees Better Than One? Evidence from Mutual Fund Managers' Education

2011

No.	Author(s)	Title
11-16	V. Agarwal, J.-P. Gómez, R. Priestley	Management Compensation and Market Timing under Portfolio Constraints
11-15	T. Dimpfl, S. Jank	Can Internet Search Queries Help to Predict Stock Market Volatility?
11-14	P. Gomber, U. Schweickert, E. Theissen	Liquidity Dynamics in an Electronic Open Limit Order Book: An Event Study Approach
11-13	D. Hess, S. Orbe	Irrationality or Efficiency of Macroeconomic Survey Forecasts? Implications from the Anchoring Bias Test
11-12	D. Hess, P. Immenkötter	Optimal Leverage, its Benefits, and the Business Cycle
11-11	N. Heinrichs, D. Hess, C. Homburg, M. Lorenz, S. Sievers	Extended Dividend, Cash Flow and Residual Income Valuation Models – Accounting for Deviations from Ideal Conditions
11-10	A. Kempf, O. Korn, S. Saßning	Portfolio Optimization using Forward - Looking Information

11-09	V. Agarwal, S. Ray	Determinants and Implications of Fee Changes in the Hedge Fund Industry
11-08	G. Cici, L.-F. Palacios	On the Use of Options by Mutual Funds: Do They Know What They Are Doing?
11-07	V. Agarwal, G. D. Gay, L. Ling	Performance inconsistency in mutual funds: An investigation of window-dressing behavior
11-06	N. Hautsch, D. Hess, D. Veredas	The Impact of Macroeconomic News on Quote Adjustments, Noise, and Informational Volatility
11-05	G. Cici	The Prevalence of the Disposition Effect in Mutual Funds' Trades
11-04	S. Jank	Mutual Fund Flows, Expected Returns and the Real Economy
11-03	G.Fellner, E.Theissen	Short Sale Constraints, Divergence of Opinion and Asset Value: Evidence from the Laboratory
11-02	S.Jank	Are There Disadvantaged Clienteles in Mutual Funds?
11-01	V. Agarwal, C. Meneghetti	The Role of Hedge Funds as Primary Lenders

2010

No.	Author(s)	Title
10-20	G. Cici, S. Gibson, J.J. Merrick Jr.	Missing the Marks? Dispersion in Corporate Bond Valuations Across Mutual Funds
10-19	J. Hengelbrock, E. Theissen, C. Westheide	Market Response to Investor Sentiment
10-18	G. Cici, S. Gibson	The Performance of Corporate-Bond Mutual Funds: Evidence Based on Security-Level Holdings
10-17	D. Hess, D. Kreutzmann, O. Pucker	Projected Earnings Accuracy and the Profitability of Stock Recommendations
10-16	S. Jank, M. Wedow	Sturm und Drang in Money Market Funds: When Money Market Funds Cease to Be Narrow
10-15	G. Cici, A. Kempf, A. Puetz	The Valuation of Hedge Funds’ Equity Positions
10-14	J. Grammig, S. Jank	Creative Destruction and Asset Prices
10-13	S. Jank, M. Wedow	Purchase and Redemption Decisions of Mutual Fund Investors and the Role of Fund Families
10-12	S. Artmann, P. Finter, A. Kempf, S. Koch, E. Theissen	The Cross-Section of German Stock Returns: New Data and New Evidence
10-11	M. Chesney, A. Kempf	The Value of Tradeability
10-10	S. Frey, P. Herbst	The Influence of Buy-side Analysts on Mutual Fund Trading
10-09	V. Agarwal, W. Jiang, Y. Tang, B. Yang	Uncovering Hedge Fund Skill from the Portfolio Holdings They Hide
10-08	V. Agarwal, V. Fos, W. Jiang	Inferring Reporting Biases in Hedge Fund Databases from Hedge Fund Equity Holdings
10-07	V. Agarwal, G. Bakshi,	Do Higher-Moment Equity Risks Explain Hedge Fund

	J. Huij	Returns?
10-06	J. Grammig, F. J. Peter	Tell-Tale Tails
10-05	K. Drachter, A. Kempf	Höhe, Struktur und Determinanten der Managervergütung- Eine Analyse der Fondsbranche in Deutschland
10-04	J. Fang, A. Kempf, M. Trapp	Fund Manager Allocation
10-03	P. Finter, A. Niessen-Ruenzi, S. Ruenzi	The Impact of Investor Sentiment on the German Stock Market
10-02	D. Hunter, E. Kandel, S. Kandel, R. Wermers	Endogenous Benchmarks
10-01	S. Artmann, P. Finter, A. Kempf	Determinants of Expected Stock Returns: Large Sample Evidence from the German Market

2009

No.	Author(s)	Title
09-17	E. Theissen	Price Discovery in Spot and Futures Markets: A Reconsideration
09-16	M. Trapp	Trading the Bond-CDS Basis – The Role of Credit Risk and Liquidity
09-15	A. Betzer, J. Gider, D.Metzger, E. Theissen	Strategic Trading and Trade Reporting by Corporate Insiders
09-14	A. Kempf, O. Korn, M. Uhrig-Homburg	The Term Structure of Illiquidity Premia
09-13	W. Bühler, M. Trapp	Time-Varying Credit Risk and Liquidity Premia in Bond and CDS Markets
09-12	W. Bühler, M. Trapp	Explaining the Bond-CDS Basis – The Role of Credit Risk and Liquidity
09-11	S. J. Taylor, P. K. Yadav, Y. Zhang	Cross-sectional analysis of risk-neutral skewness
09-10	A. Kempf, C. Merkle, A. Niessen-Ruenzi	Low Risk and High Return – Affective Attitudes and Stock Market Expectations
09-09	V. Fotak, V. Raman, P. K. Yadav	Naked Short Selling: The Emperor`s New Clothes?
09-08	F. Bardong, S.M. Bartram, P.K. Yadav	Informed Trading, Information Asymmetry and Pricing of Information Risk: Empirical Evidence from the NYSE
09-07	S. J. Taylor , P. K. Yadav, Y. Zhang	The information content of implied volatilities and model-free volatility expectations: Evidence from options written on individual stocks
09-06	S. Frey, P. Sandas	The Impact of Iceberg Orders in Limit Order Books
09-05	H. Beltran-Lopez, P. Giot, J. Grammig	Commonalities in the Order Book
09-04	J. Fang, S. Ruenzi	Rapid Trading bei deutschen Aktienfonds: Evidenz aus einer großen deutschen Fondsgesellschaft
09-03	A. Banegas, B. Gillen, A. Timmermann, R. Wermers	The Performance of European Equity Mutual Funds

09-02	J. Grammig, A. Schrimpf, M. Schuppli	Long-Horizon Consumption Risk and the Cross-Section of Returns: New Tests and International Evidence
09-01	O. Korn, P. Koziol	The Term Structure of Currency Hedge Ratios

2008

No.	Author(s)	Title
08-12	U. Bonenkamp, C. Homburg, A. Kempf	Fundamental Information in Technical Trading Strategies
08-11	O. Korn	Risk Management with Default-risky Forwards
08-10	J. Grammig, F.J. Peter	International Price Discovery in the Presence of Market Microstructure Effects
08-09	C. M. Kuhnen, A. Niessen	Public Opinion and Executive Compensation
08-08	A. Pütz, S. Ruenzi	Overconfidence among Professional Investors: Evidence from Mutual Fund Managers
08-07	P. Osthoff	What matters to SRI investors?
08-06	A. Betzer, E. Theissen	Sooner Or Later: Delays in Trade Reporting by Corporate Insiders
08-05	P. Linge, E. Theissen	Determinanten der Aktionärspräsenz auf Hauptversammlungen deutscher Aktiengesellschaften
08-04	N. Hautsch, D. Hess, C. Müller	Price Adjustment to News with Uncertain Precision
08-03	D. Hess, H. Huang, A. Niessen	How Do Commodity Futures Respond to Macroeconomic News?
08-02	R. Chakrabarti, W. Megginson, P. Yadav	Corporate Governance in India
08-01	C. Andres, E. Theissen	Setting a Fox to Keep the Geese - Does the Comply-or-Explain Principle Work?

2007

No.	Author(s)	Title
07-16	M. Bär, A. Niessen, S. Ruenzi	The Impact of Work Group Diversity on Performance: Large Sample Evidence from the Mutual Fund Industry
07-15	A. Niessen, S. Ruenzi	Political Connectedness and Firm Performance: Evidence From Germany
07-14	O. Korn	Hedging Price Risk when Payment Dates are Uncertain
07-13	A. Kempf, P. Osthoff	SRI Funds: Nomen est Omen
07-12	J. Grammig, E. Theissen, O. Wuensche	Time and Price Impact of a Trade: A Structural Approach
07-11	V. Agarwal, J. R. Kale	On the Relative Performance of Multi-Strategy and Funds of Hedge Funds
07-10	M. Kasch-Haroutounian, E. Theissen	Competition Between Exchanges: Euronext versus Xetra
07-09	V. Agarwal, N. D. Daniel, N. Y. Naik	Do hedge funds manage their reported returns?

07-08	N. C. Brown, K. D. Wei, R. Wermers	Analyst Recommendations, Mutual Fund Herding, and Overreaction in Stock Prices
07-07	A. Betzer, E. Theissen	Insider Trading and Corporate Governance: The Case of Germany
07-06	V. Agarwal, L. Wang	Transaction Costs and Value Premium
07-05	J. Grammig, A. Schrimpf	Asset Pricing with a Reference Level of Consumption: New Evidence from the Cross-Section of Stock Returns
07-04	V. Agarwal, N.M. Boyson, N.Y. Naik	Hedge Funds for retail investors? An examination of hedged mutual funds
07-03	D. Hess, A. Niessen	The Early News Catches the Attention: On the Relative Price Impact of Similar Economic Indicators
07-02	A. Kempf, S. Ruenzi, T. Thiele	Employment Risk, Compensation Incentives and Managerial Risk Taking - Evidence from the Mutual Fund Industry -
07-01	M. Hagemeister, A. Kempf	CAPM und erwartete Renditen: Eine Untersuchung auf Basis der Erwartung von Marktteilnehmern

2006

No.	Author(s)	Title
06-13	S. Čeljo-Hörhager, A. Niessen	How do Self-fulfilling Prophecies affect Financial Ratings? - An experimental study
06-12	R. Wermers, Y. Wu, J. Zechner	Portfolio Performance, Discount Dynamics, and the Turnover of Closed-End Fund Managers
06-11	U. v. Lilienfeld-Toal, S. Ruenzi	Why Managers Hold Shares of Their Firm: An Empirical Analysis
06-10	A. Kempf, P. Osthoff	The Effect of Socially Responsible Investing on Portfolio Performance
06-09	R. Wermers, T. Yao, J. Zhao	Extracting Stock Selection Information from Mutual Fund holdings: An Efficient Aggregation Approach
06-08	M. Hoffmann, B. Kempa	The Poole Analysis in the New Open Economy Macroeconomic Framework
06-07	K. Drachter, A. Kempf, M. Wagner	Decision Processes in German Mutual Fund Companies: Evidence from a Telephone Survey
06-06	J.P. Krahnen, F.A. Schmid, E. Theissen	Investment Performance and Market Share: A Study of the German Mutual Fund Industry
06-05	S. Ber, S. Ruenzi	On the Usability of Synthetic Measures of Mutual Fund Net-Flows
06-04	A. Kempf, D. Mayston	Liquidity Commonality Beyond Best Prices
06-03	O. Korn, C. Koziol	Bond Portfolio Optimization: A Risk-Return Approach
06-02	O. Scaillet, L. Barras, R. Wermers	False Discoveries in Mutual Fund Performance: Measuring Luck in Estimated Alphas
06-01	A. Niessen, S. Ruenzi	Sex Matters: Gender Differences in a Professional Setting

2005

No.	Author(s)	Title
05-16	E. Theissen	An Analysis of Private Investors´ Stock Market Return Forecasts

05-15	T. Foucault, S. Moinas, E. Theissen	Does Anonymity Matter in Electronic Limit Order Markets
05-14	R. Kosowski, A. Timmermann, R. Wermers, H. White	Can Mutual Fund „Stars“ Really Pick Stocks? New Evidence from a Bootstrap Analysis
05-13	D. Avramov, R. Wermers	Investing in Mutual Funds when Returns are Predictable
05-12	K. Griese, A. Kempf	Liquiditätsdynamik am deutschen Aktienmarkt
05-11	S. Ber, A. Kempf, S. Ruenzi	Determinanten der Mittelzuflüsse bei deutschen Aktienfonds
05-10	M. Bär, A. Kempf, S. Ruenzi	Is a Team Different From the Sum of Its Parts? Evidence from Mutual Fund Managers
05-09	M. Hoffmann	Saving, Investment and the Net Foreign Asset Position
05-08	S. Ruenzi	Mutual Fund Growth in Standard and Specialist Market Segments
05-07	A. Kempf, S. Ruenzi	Status Quo Bias and the Number of Alternatives - An Empirical Illustration from the Mutual Fund Industry
05-06	J. Grammig, E. Theissen	Is Best Really Better? Internalization of Orders in an Open Limit Order Book
05-05	H. Beltran-Lopez, J. Grammig, A.J. Menkveld	Limit order books and trade informativeness
05-04	M. Hoffmann	Compensating Wages under different Exchange rate Regimes
05-03	M. Hoffmann	Fixed versus Flexible Exchange Rates: Evidence from Developing Countries
05-02	A. Kempf, C. Memmel	Estimating the Global Minimum Variance Portfolio
05-01	S. Frey, J. Grammig	Liquidity supply and adverse selection in a pure limit order book market

2004

No.	Author(s)	Title
04-10	N. Hautsch, D. Hess	Bayesian Learning in Financial Markets – Testing for the Relevance of Information Precision in Price Discovery
04-09	A. Kempf, K. Kreuzberg	Portfolio Disclosure, Portfolio Selection and Mutual Fund Performance Evaluation
04-08	N.F. Carline, S.C. Linn, P.K. Yadav	Operating performance changes associated with corporate mergers and the role of corporate governance
04-07	J.J. Merrick, Jr., N.Y. Naik, P.K. Yadav	Strategic Trading Behaviour and Price Distortion in a Manipulated Market: Anatomy of a Squeeze
04-06	N.Y. Naik, P.K. Yadav	Trading Costs of Public Investors with Obligatory and Voluntary Market-Making: Evidence from Market Reforms
04-05	A. Kempf, S. Ruenzi	Family Matters: Rankings Within Fund Families and Fund Inflows
04-04	V. Agarwal, N.D. Daniel, N.Y. Naik	Role of Managerial Incentives and Discretion in Hedge Fund Performance
04-03	V. Agarwal, W.H. Fung, J.C. Loon, N.Y. Naik	Risk and Return in Convertible Arbitrage: Evidence from the Convertible Bond Market
04-02	A. Kempf, S. Ruenzi	Tournaments in Mutual Fund Families

04-01	I. Chowdhury, M. Hoffmann, A. Schabert	Inflation Dynamics and the Cost Channel of Monetary Transmission

centre for financial research
cfr/university of cologne
Albertus-Magnus-Platz
D-50923 cologne
fon +49(0)221-470-6995
fax +49(0)221-470-3992
kempf@cfr-cologne.de
www.cfr-cologne.de