Designated Market Makers in Electronic Limit Order Books - A Closer Look

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Abstract

Many exchanges operating an electronic open limit order book employ designated market makers to improve liquidity, particularly for less liquid stocks. Previous research has shown that the existence of a market maker improves liquidity, and that the share price reacts favorably to the announcement that a firm hires a market maker. Little is known, however, about what market makers actually do. We try to fill this gap. Using a data set covering 110 German stocks we analyze the trading activity of market makers in detail. Their participation rates as a function of firm size (or, alternatively, trading volume) display a u-shaped pattern. They are highest for the smallest firms, then decreases in firm size but increases again for the largest size quintile. Market makers not only provide liquidity but also take liquidity. Other traders take liquidity supplied by market makers particularly in times of high volatility, high bid-ask spreads and high informational asymmetries. Finally, we demonstrate that market makers do, on average, not earn profits.

Keywords: Designated market makers, Electronic limit order book

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1 Introduction

Many exchanges operating an electronic open limit order book employ designated market makers to improve liquidity, particularly for less liquid stocks. In a typical arrangement the designated sponsor commits to making a market in a particular stock and to meet certain standards such as a minimum quotation time or a maximum spread. The issuing firm, in turn, pays the designated market maker an annual fee for the services provided. Previous papers (to be briefly reviewed below) have shown that the existence of a designated market maker improves liquidity, and that the share price reacts favorably to the announcement that a firm hires a designated market maker. The market making arrangement thus appears to be mutually beneficial.

Much less is known about what designated market makers actually do. How intense is their involvement in the trading process? How does their participation vary cross-sectionally and in time series? Are their market-making activities profitable or do they incur losses? Does the profitability depend on market conditions? In the present paper we try to answer these questions. We use a proprietary data set from Deutsche Börse AG. It covers 80 stocks and four months in 2007. It contains all trades executed in the electronic limit order book Xetra. We know whether a trade was buyer-initiated or seller initiated, and we know whether (and on which side) a designated market maker participated in the trade. This data set allows us to analyze the trading activities of designated market makers in detail.

Our paper is related to previous papers analyzing designated market makers in electronic limit order markets[1]. Bessembinder et al. (2011) and Sabourin (2006) develop theoretical models of designated market makers. Bessembinder et al. (2011) extend the Glosten and Milgrom (1985) sequential trade

[1]The specialists on the New York Stock Exchange (and similar intermediaries in other floor-based exchanges) share many similarities with designated market makers in electronic limit order books. Most importantly, both are intermediaries performing market making activities within a continuous auction market. Theoretical papers on the role of the specialist include Benveniste et al. (1992), Buti (2007), Dumitrescu (2010), Glosten (1989); Leach and Madhavan (1993), Ready (1999), and Seppi (1997). Several empirical studies have analyzed the implications of the existence of a specialist for market quality (e.g. Anand and Weaver (2006), Angel (1999), Bacidore et al. (2002), Benediktsdottir (2006), Chung et al. (2004), Fishe and Robe (2004), Freihube et al. (1999), Harris and Panchapagesan (2005), HASBROUCK and SOFIANOS (1993), Kavajecz (1999), Kehr et al. (2001), Madhavan and Panchapagesan (2000), Panayides (2007), Ready (1999), and Theissen (2003).

model and shows that the introduction of a designated market maker with a maximum spread constraint may increase trading volume and price efficiency. Sabourin (2006) extends the Foucault (1999) model and finds that, depending on parameter values, bid-ask spreads may either increase or decrease when a designated market maker is introduced.

Several papers analyze the impact of designated market makers on liquidity (Anand et al. (2009) for the Swedish market, Declerck and Hazart (2002) and Venkataraman and Waisburd (2007) for the French market, Eldor et al. (2006) for the options market in Israel, Hengelbrock (2012) for the German market, Menkveld and Wang (2011) for the Dutch market, Nimalendran and Petrella (2003) for the Italian market, and Ødegaard and Skjeltorp (2012) for the Norwegian market). These papers agree on the conclusion that the existence of designated sponsors increases liquidity. Because liquidity affects expected returns (e.g. Amihud and Mendelson (1986), Pástor and Stambaugh (2003), Acharya and Pedersen (2005) the introduction of designated market maker should result in lower expected returns and a corresponding increase in share prices.Anand et al. (2009), Menkveld and Wang (2011) and Ødegaard and Skjeltorp (2012) analyze how share prices react to the announcement that a firm hires a designated market maker. Using event study methodology these papers show that there is a significant positive share price reaction. Further, Menkveld and Wang (2011) and Ødegaard and Skjeltorp (2012) show that the liquidity risk decreases. The latter paper also shows that firms that are more likely to interact with the capital market in the future (to issue equity or repurchase shares) are more likely to hire a designated market maker.

We are aware of only one paper that uses a data set similar to ours. Menkveld and Wang (2011) analyze the trading activity of designated sponsors in the Dutch equity market. They find that market maker participation increases and market making profitability decreases on high-spread days. We extend this line of research by analyzing the trading activity of designated market makers during the continuous trading session in more detail than previous studies did. Several important findings emerge. First, market maker par-

ticipation rates as a function of firm size (or, alternatively, trading volume) display a u-shaped pattern. It is highest for the smallest firms, then decreases in firm size but increases again for the largest size quintile. Second, we demonstrate that market makers not only provide liquidity but also take liquidity. Third, we find that other traders take liquidity supplied by designated market makers particularly in times of high volatility, high bid-ask spreads and high informational asymmetries. Fourth, we find that the activity of market makers decreases during the trading day and that their ratio of liquidity taking to liquidity providing trades increases at the same time. Fifth, we demonstrate that the designated sponsors do, on average, not earn profits on their trading activities.

A distinguishing feature of our study is that we also analyze market maker trading activity during the call auctions. We find that their participation rates are higher in those auctions that take place when uncertainty and informational asymmetries are likely to be higher (opening auctions and call auctions to restart trading after a trading halt). Trades of designated market maker in call auctions appear to be profitable on average.

The remainder of the paper is organized as follows. In section 2 we describe the institutional background. Section 3 presents our data set, variable construction, as well as descriptive statistics. Section 4 provides on overview of designated market makers' market shares across firms and time. In section 5, we look at short-term market data as determinants of market making activity. Section 6 presents measures that allow the investigation of market makers' profitability, as well as information on average characteristics of the market environment at the time of their trades. Section 7 looks at market makers' trading around corporate news events. In section 8, we present our analysis of market making activity in call auctions. Section 9 concludes.

2 Institutional Background

Xetra is an anonymous electronic open limit order book. Trade execution is governed by price and time priority. Domestic large and mid-cap stocks (defined as the constituent stocks of the indices DAX, MDAX, TecDAX and

SDAX) are traded continuously. Other stocks can only be traded continuously if they are either sufficiently liquid[2] or have at least one designated market maker[3]. Consequently, there are four groups of stocks, namely illiquid stocks which have no designated market maker and are only traded in a call auction, illiquid stocks that do have a designated market maker and are thus traded continuously, liquid stocks which do have a designated market maker (on a voluntary basis), liquid stocks without designated market makers. Our sample contains stocks from all but the first group. Thus, all our sample stocks are traded continuously, but not all of them have a designated market maker. Trading in continuously traded stocks starts at 9 a.m. with an opening call auction and ends at 5.30 p.m. with a closing auction. A third call auction takes place between 1 p.m. and 1:17 p.m.[4] Trading is halted when the price hits a predefined (but undisclosed) price limit. After such a volatility interruption trading is restarted with a call auction.

Orders submitted to Xetra belong to one of three account types, "agency", "principal" and "market maker". Agency orders are submitted by Xetra members on behalf of other traders. The most important examples are orders submitted by Xetra members acting as brokers for their customers. Principal orders are orders submitted by Xetra members on their own behalf. Market maker orders are orders submitted by Xetra members in their capacity as designated market makers.

Xetra allows for a variety of order types. The most important types in the context of our study are standard market and limit orders, marketable limit orders, iceberg orders, and quotes. A marketable limit order is a limit order with a price limit that allows for immediate execution of at least a part of the order (thus, a marketable buy limit order has a price limit equal to or higher than the current best ask). If a marketable limit order is not fully

[2]The liquidity is assessed using the Xetra Liquidity Measure (XLM). The XLM uses order book information to assess the execution cost of a roundtrip trade of a given size. See Gomber et al. (2011) for a detailed description and analysis. The exchange sorts stocks into three liquidity classes according to the three-months average XLM for an order volume of 10,000. Category 1 [2; 3] corresponds to an average XLM below 100 basis points [between 100 and 500 basis points; above 500 basis points]. Designated sponsor quotes are not included in the calculation of the XLM.

[3]The official name of designated market makers in Xetra is "designated sponsors".

[4]The intraday call auction is held between 1:00 and 1:02 for DAX and TecDAX stocks, between 1:05 and 1:07 for MDAX and SDAX stocks, and between 1:15 and 1:17 for other stocks.

executed, the remaining part is converted into a limit order and displayed in the order book. An iceberg order (or "hidden" order) is a limit order that does not disclose its full size. Rather, only a peak size is displayed. When the peak is executed, another, equal-sized part of the order becomes visible. This procedure is repeated until either the order is fully executed or the remaining part is cancelled. Finally, a quote is a combination of a buy limit order and a sell limit order. Only designated market makers can submit quotes. Quotes produce a lower system load than alternative order types because of one message containing two orders. Additionally, when evaluating whether a market maker fulfills its performance requirements, only quotes are considered. Finally, the financial benefits for non-quote order types are capped at the amount a market maker receives for their activity with quotes, i.e. at least half of the rebate earned must stem from executed quotes.

Designated market makers are required to submit buy and sell limit orders to the call auction and to quote bid and ask prices during the continuous trading session[5]. Their performance is evaluated regularly according to the quoted depth, quoted spread, participation rate during the continuous trading session (defined as the time during which the market maker has valid quotes in the order book relative to total trading time), participation rate in the opening, intra-daily and closing auctions as well as in call auctions held after volatility interruptions (defined as the number of auctions with valid market maker quotes relative to the total number of auctions).

A "valid" quote is a quote that satisfies the maximum spread and minimum depth requirements. The threshold levels for spread and depth depend on the liquidity of the stock and its price level. Based on the criteria listed above the exchange calculates and publishes a ranking. If a designated market maker does not meet the minimum standards, the admission can be revoked.

Designated market makers enjoy several privileges (beyond the fee which they receive from the issuer, and which is undisclosed). First, they receive

[5]Details can be found in the Designated Sponsor Guide available on the homepage of Deutsche Börse AG.

a rebate on execution fees[6]. Second, when other market participants request quotes from designated market makers[7], these can see the identity of the trader who initiated the request. This is potentially valuable information because the identity of a potential counterparty may reveal information about her trading motives.

3 Data and Summary Statistics

3.1 Data

Our main dataset comprises all transactions executed on the Xetra electronic trading system in the 110 stocks contained in the HDAX index during the period of January 2 and April 30 of 2007 (83 trading days). Each transaction is recorded twice and the data allow us to match the buying and selling side of each transaction. Our data include information as described subsequently. For each (possibly partially) executed order, we have information about transaction price, trade size measured by the number of shares, timestamps, precise to a hundredth of a second, for the order entry and the trade execution, order type, trading mechanism (continuous market vs. call auction) trade direction (buy vs. sell), and account type. The latter variable allows us to distinguish between trades executed by designated market makers, by exchange members as principals, and agency trades.

Due to the precise order timestamps and additional order numbers, we are able to sign the trades accurately so that we can identify the liquidity providing and the liquidity taking party of each trade.

Furthermore, we have information on the Xetra liquidity class of each stock which determines whether market makers receive rebates on their exchange fees as a compensation for market making. This rebate is not granted for the most liquid stocks.

Since our focus is on the role of the designated market makers and the latter are not active in the stocks contained in the blue chip index DAX30,

[6]This does not apply to the most liquid stocks (those in liquidity class 1 as defined above).

[7]Traders have the right to send such a quote request to the designated sponsors at any time during the continuous trading session. Designated market makers have to reply within a specified time limit.

we remove data referring to trades in these stocks. Among the remaining 80 stocks in our sample, designated market makers are active in all but nine of them. The dataset for our remaining 80 stocks comprises about 6.8 million trades for a total volume of ca. 84 billion euros.

Additionally, we use best bid and ask prices and depths on Xetra for the period of January 2006 to April 2007, as well as trade price and volumes for the year 2006, to generate some variables as explained in the next subsection. We obtain data to construct several firm characteristics from Datastream.

Another data set we use is a hand collected list of corporate news published between January and April 2007. We collected a total of 683 news events, both those that firms were required to file ('ad hoc' news) and voluntary announcements, from all relevant newswire services used by German companies and companies' websites. For 617 of these news items we obtained time stamps with one minute precision.

3.2 Variable construction

As measures of market quality, we compute the price impact, relative bid-ask spread, and stock price realized volatility. Price impact is defined as

$$q \cdot \frac{m_{t+\Delta t}}{m_t} \tag{1}$$

where q is the sign of a trade (buy or sell) conducted by the trade initiator, i.e., the trader who hits an order already existing in the order book,m_t is the mid-price of best bid and best ask at time t, Δt is a time interval of either five minutes or one hour. The relative bid-ask spread is defined as

$$\frac{a_t - b_t}{m_t} \tag{2}$$

where a_t is the best ask price at time t, b_t the best bid price at time t. Realized volatility we compute, typically over a 30 minute time window with Δt equal to five minutes, as

$$\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(r_{t-i\Delta t,t-(i-1)\Delta t})^2} \tag{3}$$

Table 1: Descriptive statistics

	mean	median	standard dev.	5th pct	95th pct
Trade statistics					
Bid-ask	0.136%	0.088%	0.158%	0.0169%	0.392%
Price impact 5m	0.076%	0.042%	0.335%	-0.314%	0.549%
Price impact 1h	0.068%	0.041%	0.819%	-1.030%	1.242%
Volatility	0.063%	0.039%	0.092%	0.000%	0.206%
Company and stock statistics					
Price (euros)	36.92994	25.115	37.99618	7.9665	99.15
Market cap. (mio euros)	2565.853	1533.9	3128.456	369.945	6579.8
Tobin's q	2.332547	1.717502	1.432951	1.023123	5.425884
Turnover (mio euros)	2232.128	297.2158	12982.64	96.16539	4722.607

This table shows descriptive statistics for the firms in our sample. Data are based on the year 2006. Bid-ask indicates a stock's average quoted bid-ask spread, price impact 5m and price impact 1h the average price impacts for periods of 5 minutes and one hour, volatility the average realized volatility. Price is the stock price at the end of the year, Market cap. the market capitalization of equity at the same point in time, Tobin's q is the ratio of the sum of market value of equity and book value of debt, divided by the sum of the book values of equity and debt. Turnover is the aggregate stock trading volume in 2006.

where n is the number of shorter time intervals comprising the time window, $r_{t-i\Delta t,t-(i-1)}$ is the stock return, based on the mid-prices, between two subsequent end points of the short time intervals.

We use several control variables in our analyses and ascertain that these are predetermined by choosing their values for the year 2006, which ends immediately prior to our sample period. We use the year 2006 trading volume, and the end of year 2006 stock price, market capitalization of equity, and Tobin's q. The latter is computed as the sum of market value of equity and book value of debt, divided by the sum of the book values of equity and debt.

Table 1 provides descriptive statistics regarding the trades in our data set and firm characteristics based on data of the calendar year 2006.

4 Market Makers' Activity

4.1 Overview

This section gives a first overview of the activity of market makers. Table 2 show to which extent the different types of market participants use the different order types in their executed trades, separately for trades they initiated and for those in which they were liquidity providers.[8] Market makers predominantly use limit orders when they take liquidity, while liquidity provision is mostly conducted by quote orders. Furthermore, the table shows that limit orders are the predominant order type for agency and principal traders, while the former, presumably less sophisticated, use market orders to a much larger extent than the others.

[8] Any differences in market shares reported in this paper are statistically significant at conventional levels because of the large number of observations.

Table 2: Order types by account type

		number of trades			volume in euros	
Trading vol.	Agency	Mkt Maker	Principal	Agency	Mkt Maker	Principal
Liquidity taking						
Iceberg	2.75	1.23	2.71	4.65	1.38	4.09
Limit	75.69	78.54	91.82	82.03	78.52	92.21
Market	21.48	1.59	5.47	13.27	1.30	3.69
Quote	0.00	18.64	0.00	0.00	18.80	0.00
Mkt-to-lmt	0.07	0.00	0.00	0.05	0.00	0.00
Liquidity provision						
Iceberg	15.38	8.00	14.65	19.27	10.10	17.70
Limit	84.59	19.57	85.35	80.71	18.75	82.30
Market	0.01	0.00	0.00	0.00	0.00	0.00
Quote	0.00	72.43	0.00	0.00	71.16	0.00
Mkt-to-lmt	0.02	0.00	0.00	0.03	0.00	0.00

This table shows the fractions of different order types used by the three types of market participants, agency traders, market makers, and principal traders, separately for liquidity taking and liquidity providing trades.

Table 3 shows how the market shares of the different types of traders differs by trading volume, separated into liquidity taking and providing trades, and in total. The firms are sorted into quintiles based on their trading volume in 2006, measured either by the number of trades or by the euro volume traded. The table shows that the market share of market makers generally decreases in trading volume. This is what one would expect because stocks with a lower trading volume tend to be more illiquid so that market makers have a more important role. However, the most actively traded shares form an exception as market makers are about as active in these stocks as they are in the least traded ones. It is likely that this higher activity is not because of their obligation to trade, but that they decide to trade more actively in the larger stocks because they deem it profitable. While we sort by predetermined trading volume, one concern that this table cannot address is still that the liquidity-enhancing activities of the designated market makers may lead to a higher trading volume than in the hypothetical case of less active market makers. This may partially explain the findings for firms with high trading volume.

The total market shares in the liquidity provision versus the liquidity taking show that market makers, while the majority of their trades are liquidity providing, do take liquidity to an extent that is non-negligible in comparison to their liquidity provision; about 38% of their activity is liquidity taking. It appears most likely that this results from market makers attempting to keep their inventory close to their target level, which is not always possible to achieve through mere liquidity provision.

Table 3: Participation rates by volume quintile

Trading vol.	number of trades			volume in euros		
	Agency	Market Maker	Principal	Agency	Market Maker	Principal
			Liquidity taking			
Low	39.39	0.76	59.85	40.64	0.72	58.64
2	40.88	0.43	58.68	40.54	0.35	59.11
3	44.51	0.57	54.92	41.60	0.27	58.13
4	48.17	0.29	51.55	44.89	0.14	54.97
High	52.14	0.69	47.18	46.95	1.12	51.93
Total	46.40	0.53	53.06	43.90	0.55	55.55
			Liquidity provision			
Low	36.68	1.18	62.15	39.66	1.51	58.83
2	34.29	0.95	64.75	36.15	0.97	62.88
3	37.23	0.56	62.21	36.91	0.40	62.69
4	39.12	0.40	60.48	40.68	0.29	59.03
High	40.27	1.40	58.33	39.59	1.56	58.85
Total	37.97	0.88	61.14	38.82	0.90	60.28
			All trades			
Low	38.03	0.97	61.00	40.15	1.12	58.73
2	37.59	0.69	61.72	38.35	0.66	60.99
3	40.87	0.56	58.57	39.26	0.34	60.41
4	43.64	0.34	56.01	42.79	0.22	57.00
High	46.20	1.04	52.75	43.27	1.34	55.39
Total	42.19	0.71	57.10	41.36	0.72	57.92

This table shows the fraction of trading, measured by the number of executed trades and their volume in euros, conducted by market participants classified as agents, designated market makers, and principals, respectively, sorted by trading volume, measured in euros, in 2006. The three panels separate the data with respect to trade initiation.

Table 4 is similar to Table 3, except that the quintile-sort is conducted by market value of equity at the end of 2006. The results are similar to those of Table 3 as the market makers' share decreases with firm size for the smaller four quintiles. It increases for the highest quintile but not to the same extent as it does in the case of sorting by trading volume. Since firm size and trading volume are positively correlated, the interpretation of the results is similar though the possibility of market makers causing trading volume is not a concern in this case.

Table 4: Participation rates by market capitalization quintile

Market cap.	number of trades Agency	Market Maker	Principal	volume in euros Agency	Market Maker	Principal
			Liquidity taking			
Small	51.69	1.29	47.02	47.12	0.93	51.95
2	47.25	0.94	51.81	44.26	1.61	54.13
3	41.58	0.45	57.97	41.31	0.45	58.25
4	47.51	0.20	52.30	45.56	0.23	54.21
Big	45.49	0.40	54.10	42.62	0.48	56.90
Total	46.40	0.53	53.06	43.90	0.55	55.55
			Liquidity provision			
Small	43.58	1.43	54.99	46.80	2.13	51.07
2	40.55	1.36	58.08	42.84	2.07	55.10
3	36.11	0.85	63.04	37.81	1.08	61.11
4	37.31	0.43	62.26	38.34	0.44	61.22
Big	35.68	0.94	63.38	36.84	0.64	62.52
Total	37.97	0.88	61.14	38.82	0.90	60.28
			All trades			
Small	47.63	1.36	51.01	46.96	1.53	51.51
2	43.90	1.15	54.95	43.55	1.84	54.61
3	38.84	0.65	60.50	39.56	0.76	59.68
4	42.41	0.31	57.28	41.95	0.33	57.72
Big	40.59	0.67	58.74	39.73	0.56	59.71
Total	42.19	0.71	57.10	41.36	0.72	57.92

This table shows the fraction of trading, measured by the number of executed trades and their volume in euros, conducted by market participants classified as agents, designated market makers, and principals, respectively, sorted by market value of equity at the end of 2006. The three panels separate the data with respect to trade initiation.

Table 5 shows the shares of bilateral matches of liquidity providers (rows) and liquidity takers (columns) by type of traders. Measured by the number of trades, agency and principal traders demand similar liquidity from agency traders while the former take a disproportionately high euro volume from market makers. By contrast, market makers take slightly less liquidity, measures in euro volume, from principal traders, when compared with the different groups' overall shares in liquidity provision.

Table 5: Bilateral distribution of trades

Liquidity taker	number of trades				volume in euros			
provider	Agency	Market Maker	Principal	Total	Agency	Market Maker	Principal	Total
Agency	17.87	0.20	19.91	37.97	17.05	0.20	21.57	38.82
Market Maker	0.43	0.03	0.43	0.88	0.35	0.08	0.48	0.90
Principal	28.11	0.30	32.73	61.14	26.50	0.27	33.51	60.28
Total	46.40	0.53	53.06	100.00	43.90	0.55	55.55	100.00

This table shows the fraction of trading, measured by the number of executed trades and their volume in euros, conducted by market participants classified as agents, designated market makers, and principals, respectively, with each other. The data are separated with respect to trade initiation, the columns indicating the liquidity taker, the row the liquidity maker.

4.2 Firm Specific Determinants

Table 6 shows how firms' corporate and trading characteristics can predict market makers' share in trading activity, separated into, on the left, liquidity taking, and, on the right, liquidity provision. The independent variables are as defined in section 3.2, except for the rebate dummy which takes the value 1 when a stock is not in the highest Xetra liquidity class and, hence, market makers receive a rebate on their exchange fees for liquidity provision. We run three regressions each for both liquidity taking and liquidity provision. The table shows regressions separated by trade initiator status and by the measures of trading activity, the number of trades and the euro volume traded, respectively. One apparent finding is that firm and stock characteristics predict liquidity taking and liquidity provision in a very similar way. This suggests that market makers do not make a conscious decision to focus on active or passive trading, but that the need for liquidity taking trades coincides with the willingness to provide liquidity, probably for purposes of inventory management. We find that the size of the relative bid-ask spread is positively associated with the market makers' trading share. There are two possible explanations for this: market makers may decide to trade in these shares because large spreads make liquidity provision profitable, or the large spreads cause the best bids and asks to be more often those of the markets makers. There is a marginally significant negative relation of market maker share to the average price impact of a stock's trades which may also be interpreted in two ways. On the one hand, market makers will prefer to trade in stocks with little information asymmetry and thereby a small price impact. On the other hand, their activity may dampen price impact when their quotes become the best quotes. The only other significant variable is trading volume, which is positively associated with market makers' market share. As usual, this can be interpreted in two ways: market makers seek trading in stocks with high trading volume because this may be more profitable, or the presence of market makers enhances liquidity and therefore increases trading volume. The liquidity rebate dummy proves to be insignificant, implying that, everything else being equal, market makers do

not significantly increase their activity in stocks for which they receive fee rebates. Market value, Tobin's q as a measure of firms' growth opportunities, and stock price volatility, all measures presumably related to information asymmetry and uncertainty, prove to be statistically insignificant.

The insignificance of several variables could result from actual economic insignificance or from a multicollinearity problem rendering estimates imprecise. Considering this possibility, we compute variance inflation factors (VIFs) of the explanatory variables. The highest VIF, at 8.3 and therefore below the usually, heuristically used boundary 10, is that of the bid-ask spread, a variable whose coefficients are consistently significant in our regressions. The VIF of the price impact, whose coefficients are marginally significant, is 6.62, while the other VIFs reach a maximum of only 3.33. Thus, we conclude that the explanatory variables' statistical insignificance is not caused by multicollinearity.

Table 6: Cross-sectional regression of participation rates of designated market makers

	Number of Trades			Volume in Euros		
	Liquidity taking	Liquidity provision	All trades	Liquidity taking	Liquidity provision	All trades
Price	0.012	0.011	0.011	0.017	0.012	0.015
	(1.45)	(1.30)	(1.38)	(1.65)	(1.29)	(1.50)
Bid-ask spread	0.093***	0.093***	0.093***	0.116***	0.106***	0.111***
	(3.23)	(3.26)	(3.29)	(3.15)	(3.21)	(3.22)
Price impact'	-0.071*	-0.066*	-0.068*	-0.089*	-0.072*	-0.080*
	(-1.94)	(-1.83)	(-1.91)	(-1.91)	(-1.73)	(-1.85)
Market value	0.008	0.012	0.010	0.011	0.010	0.010
	(0.79)	(1.22)	(1.02)	(0.90)	(0.91)	(0.92)
Trading volume	0.011**	0.016***	0.014***	0.016**	0.017***	0.016***
	(2.19)	(3.23)	(2.75)	(2.43)	(2.85)	(2.67)
Volatility	-0.034	-0.031	-0.033	-0.044	-0.039	-0.041
	(-1.23)	(-1.14)	(-1.19)	(-1.22)	(-1.23)	(-1.24)
Q	-0.012	-0.018	-0.015	-0.016	-0.019	-0.018
	(-0.97)	(-1.48)	(-1.24)	(-1.07)	(-1.41)	(-1.25)
Rebate	0.008	0.020	0.014	0.017	0.034*	0.025
	(0.45)	(1.21)	(0.84)	(0.80)	(1.74)	(1.26)
Constant	-0.034	-0.052	-0.044	-0.080	-0.000	-0.040
	(-0.20)	(-0.32)	(-0.27)	(-0.37)	(-0.00)	(-0.20)
Observations	69	69	69	69	69	69
Adjusted R^2	0.300	0.412	0.363	0.337	0.421	0.383

This table shows the result of cross-sectional regressions of the percentage of trades during the whole sample period on firm characteristics measured at the end of the year 2006. *Price* denotes the stock price, $Bid-ask\ spread$ the bid-ask spread as a percentage of the stock price at the time of trades, *Price impact* the change in midprice within 5 minutes after the trade, $Marketvalue$ the market value of equity, $Trading\ volume$ the trading volume measured in euros, $Volatility$ the standard deviation of daily stock returns, Q Tobin's q, proxied for by the ratio of the sum of market value of equity and book value of debt, and total assets. *Rebate* is a dummy variable indicating that designated market makers received rebates on the exchange's fees when trading in this stock at the beginning of the year 2007. The first three regressions explain percentages of liquidity taking, the next three those of liquidity provision. Regressions (1) and (4) include all firms designated market makers conducted any trades in during our sample period, regressions (2) and (5) include only those firms' stocks without rebated granted to the market makers, regressions (3) to (6) those with rebates. All variables are included as logs. ***, ** and * denote statistical significance at the 1%, 5% or 10% level.

4.3 Time-Variation during the Trading Day

Table 7 displays the distribution of market makers' market share over the course of the trading day. It is apparent that their trading peaks at the beginning of the day, i.e., when uncertainty with respect to stock prices is considered to be highest because of any events, such as market-wide developments, economic or firm-specific news that became public information after the previous day's close. The table also shows that the ratio of liquidity taking and liquidity provision by designated market makers increases during the day. One possible explanation, which merits further investigation, is that market makers seek to balance their inventory towards the end of the trading day and may thus be relatively more often willing to take liquidity in order to achieve that.

Table 7: Participation rates of market makers by 30 minute interval of continuous trading

	number of trades			volume in euros		
Trading vol.	Liquidity taking	Liquidity provision	All trades	Liquidity taking	Liquidity provision	All trades
9.00 - 9.30	0.90	1.84	1.37	0.76	1.54	1.15
9.30 - 10.00	0.63	1.16	0.90	0.55	1.08	0.81
10.00 - 10.30	0.56	0.99	0.78	0.54	0.96	0.75
10.30 - 11.00	0.59	0.98	0.79	0.60	1.00	0.80
11.00 - 11.30	0.55	0.90	0.73	0.57	0.90	0.74
11.30 - 12.00	0.53	0.95	0.74	0.56	1.01	0.78
12.00 - 12.30	0.52	0.83	0.67	0.52	0.90	0.71
12.30 - 13.00	0.51	0.80	0.66	0.53	0.83	0.68
13.00 - 13.30	0.55	0.83	0.69	0.63	0.94	0.79
13.30 - 14.00	0.46	0.84	0.65	0.61	0.89	0.75
14.00 - 14.30	0.53	0.89	0.71	0.62	0.99	0.80
14.30 - 15.00	0.47	0.78	0.63	0.57	0.87	0.72
15.00 - 15.30	0.53	0.75	0.64	0.59	0.84	0.72
15.30 - 16.00	0.45	0.70	0.57	0.51	0.73	0.62
16.00 - 16.30	0.44	0.68	0.56	0.50	0.73	0.61
16.30 - 17.00	0.43	0.63	0.53	0.49	0.72	0.60
17.00 - 17.30	0.49	0.65	0.57	0.39	0.60	0.50
Total	0.54	0.88	0.71	0.55	0.90	0.72

This table shows the fraction of trading, measured by the number of executed trades and their volume in euros, conducted by market participants classified as agents, designated market makers, and principals, respectively, during 30 minute intervals comprising the trading day. The three panels separate the data with respect to trade initiation.

5 Short-term Determinants of Market Maker Activity

This section looks at which trading characteristics predict market makers' activity in the short term, i.e., on a daily basis [9].

Table 5 shows the results of a panel estimation of determinants of daily market shares of market makers, separated into liquidity provision, liquidity taking, and total trading, and into trading volume measures by the number of trades and by the euro volume. We estimate a linear panel regression with firm fixed effects to control for unobserved heterogeneity[10]. Because of autocorrelation within the stock's time series of market maker involvement, we control for four lags of the respective dependent variable. The coefficients of the lagged dependent variable (not reported) are generally positive, and more importantly so for liquidity provision than for liquidity taking. The results in table 5 show that, when controlling for firm fixed effects and past market maker activity, daily volatility, bid-ask spreads, trading activity, and stock price level are generally insignificant predictors of market maker activity. The only consistently significant variable is price impact, a direct measure of the cost of liquidity provision. Accordingly, its coefficient is larger for market makers' liquidity provision than for their liquidity taking activity. The results suggest that the services provided by market makers are used on days when there is an elevated level of informed trading.

[9] An intra-day trade-by-trade analysis will be contained in a subsequent version of the paper

[10] System or difference GMM estimations do not prove useful because our data does not contain a sufficiently large cross-section of stocks relative to the number of trading days. Because of the relatively large number of time periods, the problem of endogeneity affecting our estimates should be limited

Table 8: Panel estimation of determinants of daily participation rates of designated market makers

	Liquidity provision		Liquidity taking		All trades	
	trades	euro volume	trades	euro volume	trades	euro volume
Volatility	-0.557	-2.130*	-0.281	-0.659	-0.260	-1.324
	(-0.47)	(-1.80)	(-0.51)	(-1.59)	(-0.28)	(-1.59)
Bid-ask spread	-1.123	-1.212	-1.676	-0.739	-1.539	-1.158
	(-0.27)	(-0.20)	(-0.64)	(-0.42)	(-0.45)	(-0.28)
Number of trades	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(-1.50)	(-1.57)	(-1.65)	(-1.43)	(-1.63)	(-1.62)
Price impact	6.988***	13.465***	2.867**	2.721**	4.763***	8.042***
	(5.35)	(3.76)	(2.41)	(2.27)	(4.63)	(3.89)
Price	-0.000	-0.000	0.000	0.000	-0.000	-0.000
	(-0.60)	(-0.54)	(0.02)	(0.67)	(-0.49)	(-0.34)
Constant	0.007	0.011	0.012***	0.011***	0.010*	0.014*
	(1.12)	(1.33)	(2.97)	(5.41)	(1.89)	(1.94)
Observations	5447	5447	5447	5447	5447	5447

This table shows the result of firm fixed effect regressions explaining the determinants of daily fractions, measured by the number of trades and the euro trading volume, of trading by market makers, separately for liquidity providing and liquidity taking trades, and their sum. We control for four lagged observations of the dependent variable because of serial dependence in the panels. Coefficients for these lagged variables are omitted for brevity. *Volatility* denotes the day's intra-day volatility measured as the standard deviation of 5-minute midpoint returns, *Bid − ask spread* the mean bid-ask spread at times trading takes place as a percentage of the stock price, *Number of trades* the number of executed transactions in a stock on the respective day, *Price impact* the daily mean change in midprice from immediately prior to a trade to five minutes thereafter, and *Price* the closing stock price. ***, ** and * denote statistical significance at the 1%, 5% or 10% level.

6 Profitability of Market Making and time-varying market characteristics

In this section, we look at a variety of measures of the profitability of market making, in comparison to the trading of the other types of traders.

Table 9 shows the mean and median price impacts that the different types of traders earn and suffer, respectively, when they take or provide liquidity. We use the 5 minute price impact, the abnormal 5 minute price impact controlling for the respective stock's trades' average price impact, the ratio of the 5 minute price impact and the average over all trades in the respective stock, and the corresponding three variables using the price impact over one hour. The top panel shows the average price impacts from the perspective of the liquidity taker, the bottom from the perspective of the liquidity provider. We see that the liquidity taking trades of market makers appear uninformative. The 5 minute price impacts are lower than those of the other market participants and the price impact is largely reversed after one hour, which is also different from other traders. The bottom panel shows that the price impacts that liquidity providing market makers suffer are almost twice as large as comparable trades by the other types of traders and that these price impacts persist. Principal traders suffer smaller price impacts than agency traders do, but this difference is relatively small in comparison to the outsize price impacts that market makers incur. These results suggest that market makers provide liquidity in circumstances in which liquidity provided by other traders in lacking, while their liquidity taking is not information driven.

Table 10 shows the average bid-ask spreads and the average volatility during the 30 minutes before trades conducted by the different kinds of traders. The data show that both market makers' liquidity making and taking takes place when bid-ask spreads are elevated, though this finding is more pronounced for liquidity provision. The findings for the 30 minute volatility prior to a trade is similar. Thus, market makers trade at times when stocks are volatile and illiquid.

When comparing the price impacts and bid-ask (half-)spreads, we can make conclusions about the realized spreads traders earn. It becomes apparent that the realized spread creates a loss for market makers both when they make and when they take liquidity. Agency traders make a smaller loss than market makers when liquidity providing and roughly break even when liquidity taking. Principal traders are the only group that breaks even when providing liquidity and they generate a profit when taking liquidity.

Table 9: Price impacts of trades by different participants

	Agency			Market Maker			Principal			All		
	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median
Liquidity taking												
Price imp.	0.083	0.385	0.042	0.083	0.384	0.059	0.080	0.313	0.046	0.081	0.348	0.044
Price imp.(Δ)	0.000	0.383	-0.034	-0.011	0.385	-0.024	0.000	0.312	-0.028	-0.000	0.347	-0.031
Price imp.(rel)	0.990	4.626	0.546	0.986	4.034	0.685	1.009	4.098	0.604	1.000	4.350	0.576
Price imp.1h	0.073	0.941	0.044	0.010	1.016	0.042	0.074	0.794	0.046	0.073	0.866	0.045
Price imp.1h(Δ)	-0.003	0.940	-0.024	-0.088	1.019	-0.049	0.004	0.793	-0.020	0.000	0.865	-0.022
Price imp.1h(rel)	0.929	12.892	0.633	0.287	11.259	0.507	1.069	12.482	0.692	1.000	12.668	0.663
Observations	2596065			29837			2980013			5605915		
Liquidity provision												
Price imp.	0.092	0.390	0.047	0.182	0.507	0.084	0.073	0.317	0.042	0.081	0.348	0.044
Price imp.(Δ)	0.008	0.388	-0.029	0.092	0.501	0.002	-0.006	0.316	-0.032	-0.000	0.347	-0.031
Price imp.(rel)	1.083	4.637	0.603	1.877	5.474	1.033	0.936	4.140	0.558	1.000	4.350	0.576
Price imp.1h	0.080	0.950	0.046	0.180	1.124	0.103	0.068	0.805	0.043	0.073	0.866	0.045
Price imp.1h(Δ)	0.003	0.949	-0.023	0.090	1.119	0.025	-0.003	0.805	-0.022	0.000	0.865	-0.022
Price imp.1h(rel)	1.030	12.957	0.666	1.874	12.838	1.290	0.969	12.483	0.654	1.000	12.668	0.663
Observations	2126362			49102			3430451			5605915		

This table gives information on the price impacts encountered by traders of the different categories, i.e. agency, principal and designated market maker, in their trading. Separated by liquidity taking and liquidity providing executed orders, means, standard deviations and medians of the following measures of liquidity are provided. *Price imp.* gives information on price impact, i.e. the change in midprice from immediately prior to a trade to five minutes thereafter. *Price imp.*(Δ) denotes the difference between the actual price impact and its firm-specific average. *Price imp.*(rel) denotes the ratio of actual and firm-specific mean price impacts. *Price imp.* $1h$ denotes the price impact over a period of one hour, *Price imp.*$1h(\Delta)$ and *Price imp.*$1h(rel)$ are defined equivalently to the measures of the five minute price impact.

Table 10: Bid-ask spreads and price volatility prior to trades by different participants

	Agency			Market Maker			Principal			All		
	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median
Liquidity taking												
Bid-ask spread	0.156	0.192	0.106	0.244	0.274	0.182	0.132	0.136	0.089	0.144	0.166	0.096
Bid-ask(Δ)	0.008	0.178	-0.028	0.038	0.263	-0.028	-0.008	0.126	-0.038	-0.000	0.153	-0.033
Bid-ask(rel)	1.049	1.226	0.779	1.218	1.568	0.838	0.955	0.905	0.691	1.000	1.071	0.730
Vola 30m	0.068	0.098	0.041	0.086	0.120	0.049	0.065	0.093	0.039	0.066	0.095	0.040
Vola 30m(Δ)	-0.001	0.096	-0.024	0.017	0.115	-0.013	0.000	0.091	-0.023	0.000	0.093	-0.023
Vola 30m(rel)	0.988	1.375	0.621	1.235	1.593	0.779	1.008	1.406	0.626	1.000	1.393	0.624
Observations	2596065			29837			2980013			5605915		
Liquidity provision												
Bid-ask spread	0.147	0.184	0.098	0.236	0.242	0.169	0.141	0.151	0.095	0.144	0.166	0.096
Bid-ask(Δ)	-0.003	0.171	-0.036	0.052	0.225	0.002	0.001	0.140	-0.032	-0.000	0.153	-0.033
Bid-ask(rel)	0.979	1.129	0.716	1.296	1.205	1.011	1.009	1.030	0.736	1.000	1.071	0.730
Vola 30m	0.070	0.102	0.041	0.091	0.139	0.053	0.064	0.090	0.039	0.066	0.095	0.040
Vola 30m(Δ)	0.001	0.099	-0.023	0.026	0.136	-0.009	-0.001	0.089	-0.023	0.000	0.093	-0.023
Vola 30m(rel)	1.011	1.426	0.634	1.370	1.932	0.857	0.988	1.362	0.616	1.000	1.393	0.624
Observations	2126362			49102			3430451			5605915		

This table gives information on the bid-ask spreads and volatility encountered by traders of the different categories, i.e. agency, principal and designated market maker, in their trading. Separated by liquidity taking and liquidity providing executed orders, means, standard deviations and medians of the following measures of liquidity are provided. $Bid-ask\ spread$ denotes the bid-ask, as a percentage of the midprice, immediately prior to the trade. $Bid-ask(\Delta)$ denotes the difference between the actual bid-ask spread and its firm-specific average. $Bid-ask(rel)$ denotes the ratio of actual and firm-specific mean bid-ask spreads. $Vola\ 30m$ denotes the standard deviation of five minute midprice returns over the half hour before a trade. $Vola\ 30m(\Delta)$ and $Vola\ 30m(rel)$ are defined equivalently to the similar bid-ask spread measures.

7 Market Maker Trading around News Events

In this section, we look more closely at the trading activity of market makers at times when asymmetric information is likely to be extreme, and then changes abruptly, namely around the publication of corporate news. We define a day without a news announcement by a particular company as one with no published news from the previous trading days' close until the following day's opening.[11] Table 11 shows market makers' participation separately for days with no news published, for points in time with news published later during the day (during trading hours or afterward before the next day's opening) but not within the next hour, with news published within the next hour but not the next 15 minutes, with news published within the next 15 minutes, and the corresponding periods after the publication of news.

It becomes apparent that designated market makers reduce both their active and passive trading before a news announcement, and that the liquidity taking is more starkly reduced than the liquidity provision. This suggests that market makers may try and avoid trading against insiders with knowledge of the impending news. Market maker's trading remains reduced until an hour after the publication of the news before approaching a similar level to that on days without news.

Table 12 displays the abnormal price impacts over periods of 5 minutes and one hour, defined as the difference from a stock's mean price impact around news events and at times without news. It is apparent that trading around news events is costly to market makers. Price impacts of trades initiated by them are even lower than in periods without news, while those they provide liquidity create larger price impacts. The comparison to the other types of market participants suggests that the above observations do not hold for the whole market. Price impacts are generally elevated both before and after the publication of news and the table suggests that principal traders are able to take advantage while agency traders do more poorly, though not as bad as market makers. Thus, it appears that the market making services are used to better informed traders' benefit at times of high information asymmetry

[11] We exclude trading days of stocks with a news event lacking a time stamp from our analysis in this section.

and the fact that market makers reduce their involvement is a sensible one from their point of view.

Table 11: Participation rates by news environment

	number of trades			volume in euros		
	Agency	Market Maker	Principal	Agency	Market Maker	Principal
			Liquidity taking			
No News	46.12	0.54	53.34	43.76	0.58	55.66
Before News	49.03	0.43	50.54	46.05	0.30	53.65
1h Before News	46.59	0.45	52.96	43.44	0.25	56.31
15 min Before News	46.50	0.42	53.07	42.61	0.29	57.10
15 min After News	44.65	0.20	55.15	39.94	0.10	59.96
1h After News	44.43	0.61	54.96	40.84	0.47	58.68
After News	48.56	0.59	50.84	44.36	0.43	55.22
			Liquidity provision			
No News	37.78	0.90	61.33	38.65	0.93	60.42
Before News	39.90	0.68	59.43	40.84	0.57	58.58
1h Before News	40.06	0.89	59.04	40.02	0.57	59.41
15 min Before News	38.90	0.68	60.42	39.42	0.58	60.01
15 min After News	36.62	0.57	62.81	35.63	0.62	63.74
1h After News	38.20	0.75	61.05	38.04	0.65	61.31
After News	39.77	0.96	59.28	39.98	0.88	59.14
			All trades			
No News	41.96	0.72	57.32	41.22	0.75	58.03
Before News	44.46	0.55	54.98	43.45	0.44	56.12
1h before News	43.33	0.67	56.00	41.73	0.41	57.86
15 min Before News	42.70	0.55	56.75	41.01	0.44	58.55
15 min After News	40.63	0.38	58.98	37.78	0.36	61.85
1h After News	41.31	0.68	58.01	39.44	0.56	60.00
After News	44.17	0.78	55.06	42.17	0.65	57.18

This table shows the fraction of trading, measured by the number of executed trades and their volume in euros, conducted by market participants classified as agents, designated market makers, and principals, respectively, around news events and at times of no news. The three panels separate the data with respect to trade initiation.

Table 12: Price impacts of trades by different participants

	Price impact (Δ)				Price impact 1h (Δ)			
	Liquidity taking							
	Agency	Market Maker	Principal	All	Agency	Market Maker	Principal	All
No News	-0.002	-0.01	-0.001	-0.001	-0.007	-0.088	0.002	-0.002
Before News	0.031	-0.006	0.011	0.021	0.024	-0.057	0.012	0.018
1h Before News	0.084	-0.064	0.008	0.042	0.057	-0.095	0.024	0.038
15 min Before News	0.015	-0.199	0.013	0.014	-0.018	-0.32	0.02	0.002
15 min After News	0.035	-0.065	0.013	0.023	0.079	-0.132	0.026	0.05
1h After News	0.019	-0.045	0.012	0.015	0.037	-0.202	0.008	0.02
After News	0.005	-0.022	0.002	0.003	0.017	-0.125	0.014	0.015
	Liquidity provision							
No News	0.005	0.083	-0.007	-0.001	-0.001	0.081	-0.004	-0.002
Before News	0.04	0.173	0.006	0.021	0.026	0.18	0.01	0.018
1h Before News	0.097	0.205	0.006	0.042	0.07	0.143	0.017	0.038
15 min Before News	0.023	0.137	0.007	0.014	-0.01	0.041	0.009	0.002
15 min After News	0.04	0.187	0.011	0.023	0.109	0.454	0.007	0.05
1h After News	0.026	0.173	0.005	0.015	0.071	0.29	-0.016	0.02
After News	0.017	0.161	-0.007	0.003	0.032	0.163	0.003	0.015

This table gives information on the price impacts encountered by traders of the different categories, i.e. agency, principal and designated market maker, in their trading in periods with and without news events. *Price imp.*(Δ) denotes the difference between the actual 5 minute price impact and its firm-specific average, *Price imp.*(Δ)$1h$ is defined analogously for a period of one hour. The rows refer to periods before the publication of news occurring before the next trading day's opening, for the period of one hour and 15 minutes before the news release, for the time after a news release that occurred after the previous day's close, for the periods of one hour and 15 minutes after a news release, and periods without any news.

8 Trading in call auctions

While we have so far focused on market makers' activities during continuous trading, they also play an important role in call auctions. Table 13 shows their market shares in all auctions by trading volume and market capitalization quintiles, as well as by type of call auction. The market shares of market makers are generally higher than during continuous trading and they are higher for firms with low trading volume and with low market capitalization than for those with high trading volume and size. The pattern is slightly different from that of the market shares of continuous trading but generally consistent with it. When separating the data by type of auction, the results show that market makers' share is higher for those auction types with higher prior price uncertainty, i.e., auctions after volatility interruptions and opening auctions, than they are for intra-day and closing auctions. This can be interpreted as the market makers being more important in calming the market by providing liquidity in auctions where price uncertainty is high. Additionally, market makers may be more inclined in these auctions as the share of, presumably uninformed, agency trades is particularly high.

Table 8 focuses on call auctions after volatility interruptions and shows average bid-spreads and 30 minute volatility before different types of traders got involved in the call auctions. The results show that market makers generally tend to be buyers, and more so when bid-ask spreads were very high, while there selling takes place when bid-ask spreads are less extremely elevated. The behavior of principals resembles that of the market makers, while agency traders are, on average, sellers, and bid-asks are higher before they sell than before they buy. Volatility is, self-evidently, extreme and while principal trades are conducted when volatility is on average even higher than overall, there is no general consistent pattern explaining the results. The price impact in the usual sense, i.e., signed by the trade direction of the trade initiator, for trades conducted in a call auction can obviously not be computed since there is no opposition of active and passive sides to a trade. We are nevertheless interested in how prices move after the call auction. We have decided to denote by "price impact" the signed price change, i.e., the

profit the buyer makes, the loss the seller incurs. The first obvious finding is that prices, on average, increase after an auction following a volatility interruption. Since most volatility interruptions occur after a quick fall in stock prices, this can be interpreted as a recovery taking place after the interruption. We find agency traders to be losers subsequent to the auctions, while both market makers and principal traders earn positive profits. While the price increase is smaller subsequent to purchases by market makers than on average, they avoid losses when selling because prices do not recover after market maker sales, differently from sales by principals and, to a much larger extent, sales by agency traders. To summarize, market makers' actions in call auctions subsequent to volatility interruptions, serving to calm the market, are profitable.

Table 15 provides a look at market maker activity in opening auctions. While investigating prior market conditions is impossible in this case, we define the price impact in the same way as we did for the volatility interruptions. We see that market makers are predominantly sellers and that they do not earn an economically meaningful profit or loss in the opening auctions. As usual, principal traders gain while agency traders lose.

The activity of market makers in closing auctions, considered in Table 16, is in line with expectations. Market makers are active when, on average, bid-ask spreads prior to the auction and the volatility during the 30 minutes before the auction have been high. Table 15 provides an overview of intra-day call auctions. These are unusual in that bid-ask spreads are only slightly higher before trades by market makers than before trades by other traders and volatility is lower before their trades. However, the sample is small as market makers are not very active in intra-day auctions.

Table 13: Market shares in call auctions

	number of trades			volume in euros		
Trading vol.	Agency	Market Maker	Principal	Agency	Market Maker	Principal
Participation rates by volume quintile						
Low	50.90	2.38	46.72	41.45	1.23	57.33
2	49.03	2.12	48.84	42.83	1.03	56.14
3	54.67	1.05	44.28	42.24	0.34	57.42
4	59.24	1.07	39.69	47.69	0.41	51.90
High	62.04	1.34	36.62	44.58	0.68	54.75
Participation rates by market capitalization quintile						
Small	67.77	2.52	29.71	56.16	2.52	41.32
2	61.40	1.68	36.92	49.15	1.21	49.64
3	50.97	1.82	47.21	40.67	0.96	58.38
4	55.88	0.80	43.31	43.27	0.30	56.43
Big	49.31	0.91	49.78	43.49	0.32	56.20
Participation rates by type of call auction						
Open	75.45	1.94	22.61	60.22	1.79	37.99
Intraday	45.89	1.15	52.96	22.39	0.68	76.93
Close	38.78	0.82	60.40	42.01	0.27	57.72
Vola	70.80	3.06	26.14	63.71	2.16	34.13
Total	56.82	1.44	41.74	44.32	0.63	55.05

This table shows the fractions of trading in call auctions, measured by the number of executed trades and their volume in euros, conducted by market participants classified as agents, designated market makers, and principals, respectively, sorted by trading volume and market capitalization, both measured in euros, in 2006, as well as by the type of call auctions.

Table 14: Price impacts, spreads, and volatility when different participants trade in call auctions after volatility interruptions

	Agency			Market Maker			Principal			All		
	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median
Buying												
Price impact	1.043	2.945	0.278	0.762	2.163	0.451	1.077	2.564	0.347	1.042	2.792	0.333
Bid-ask spread	0.944	1.571	0.400	1.230	1.452	0.671	1.320	2.237	0.388	1.084	1.837	0.400
Bid-ask (Δ)	0.542	1.499	0.028	0.752	1.425	0.253	0.935	2.137	0.050	0.685	1.756	0.040
Bid-ask (rel.)	2.196	3.051	1.067	2.645	2.733	1.643	2.914	4.080	1.189	2.460	3.453	1.129
Vola	0.232	0.505	0.098	0.139	0.223	0.042	0.231	0.424	0.111	0.229	0.473	0.105
Vola (Δ)	0.183	0.490	0.067	0.114	0.220	0.015	0.198	0.408	0.096	0.186	0.458	0.072
Vola (rel.)	9.112	18.730	3.576	9.186	17.374	1.713	14.285	29.320	5.762	10.840	22.908	3.725
Observations	6056			437			3256			9749		
Selling												
Price impact	1.267	3.011	0.375	0.008	1.281	-0.036	0.184	1.392	0.063	1.042	2.792	0.333
Bid-ask spread	1.216	2.012	0.424	0.651	0.996	0.350	0.627	0.872	0.351	1.084	1.837	0.400
Bid-ask (Δ)	0.809	1.919	0.072	0.250	1.003	-0.036	0.260	0.869	-0.007	0.685	1.756	0.040
Bid-ask (rel.)	2.637	3.660	1.233	1.818	2.663	0.862	1.853	2.510	0.972	2.460	3.453	1.129
Vola	0.228	0.472	0.090	0.231	0.462	0.078	0.232	0.476	0.125	0.229	0.473	0.105
Vola (Δ)	0.183	0.454	0.065	0.186	0.458	0.053	0.194	0.470	0.084	0.186	0.458	0.072
Vola (rel.)	8.981	18.264	3.576	13.436	28.229	3.096	16.730	32.928	5.049	10.840	22.908	3.725
Observations	7748			160			1841			9749		

This table gives, separately for purchases and sales, information on various variables reflecting liquidity and information asymmetry when traders of the different categories, i.e. agency, principal and designated market maker, trade in call auctions following volatility interruptions. Separated by liquidity taking and liquidity providing executed orders, means, standard deviations and medians of the following measures of liquidity are provided. *Price impact* denotes the percentage difference between the midprice five minutes after the auction and the price trades are executed in the auction. $Bid-ask\ spread$ denotes the bid-ask, as a percentage of the midprice, immediately prior to the trade. $Bid-ask$ (Δ) denotes the difference between the actual bid-ask spread and its firm-specific average. $Bid-ask$ ($rel.$) denotes the ratio of actual and firm-specific mean bid-ask spreads. $Vola$ denotes the standard deviation of five minute midprice returns over the half hour before a trade. $Vola$ (Δ) and $Vola$ ($rel.$) are defined equivalently to the similar bid-ask spread measures.

Table 15: Price impacts, spreads, and volatility when different participants trade in opening and closing auctions

	Agency			Market Maker			Principal			All		
	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median
Opening auctions - buying												
Price impact	-0.174	1.033	-0.105	-0.170	1.378	0.104	-0.104	1.076	-0.000	-0.159	1.049	-0.083
Observations	70134			1474			19212			90820		
Opening auctions - selling												
Price impact	-0.172	1.116	-0.073	-0.108	0.682	-0.145	-0.126	0.844	-0.100	-0.159	1.049	-0.083
Observations	66891			2032			21897			90820		
Closing auctions - buying												
Bid-ask spread	0.230	0.186	0.192	0.342	0.267	0.269	0.229	0.178	0.191	0.230	0.182	0.192
Bid-ask (Δ)	-0.051	0.220	-0.056	-0.039	0.293	-0.051	-0.047	0.204	-0.054	-0.048	0.212	-0.055
Bid-ask (rel.)	0.912	0.713	0.764	1.007	0.758	0.838	0.906	0.684	0.766	0.909	0.696	0.765
Vola	0.000	0.002	0.000	0.001	0.006	0.000	0.000	0.002	0.000	0.000	0.002	0.000
Vola (Δ)	-0.015	0.030	-0.005	-0.016	0.020	-0.010	-0.013	0.026	-0.005	-0.014	0.027	-0.005
Vola (rel.)	0.009	0.517	0.000	0.048	0.457	0.000	0.014	0.645	0.000	0.012	0.597	0.000
Observations	37142			664			56176			93982		
Closing auctions - selling												
Bid-ask spread	0.232	0.182	0.192	0.285	0.229	0.250	0.228	0.181	0.191	0.230	0.182	0.192
Bid-ask (Δ)	-0.053	0.217	-0.059	-0.046	0.242	-0.050	-0.046	0.208	-0.053	-0.048	0.212	-0.055
Bid-ask (rel.)	0.905	0.700	0.755	0.938	0.672	0.826	0.911	0.695	0.769	0.909	0.696	0.765
Vola	0.000	0.002	0.000	0.001	0.006	0.000	0.000	0.002	0.000	0.000	0.002	0.000
Vola (Δ)	-0.016	0.031	-0.005	-0.014	0.021	-0.009	-0.013	0.025	-0.005	-0.014	0.027	-0.005
Vola (rel.)	0.009	0.652	0.000	0.054	0.805	0.000	0.014	0.555	0.000	0.012	0.597	0.000
Observations	35748			884			57350			93982		

This table gives, separately for purchases and sales, information on various variables reflecting liquidity and information asymmetry when traders of the different categories, i.e. agency, principal and designated market maker, trade in opening and closing call auctions. Separated by liquidity taking and liquidity providing executed orders, means, standard deviations and medians of the following measures of liquidity are provided. Variables are defined as in Table 8.

Table 16: Price impacts, spreads, and volatility when different participants trade in regular intraday call auctions

	Buying											
	Agency			Market Maker			Principal			All		
	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median	Mean	Std. dev.	Median
Price impact	-0.027	0.355	-0.023	0.104	0.273	0.063	0.018	0.293	0.025	-0.003	0.325	0.000
Bid-ask spread	0.193	0.163	0.147	0.229	0.173	0.183	0.169	0.145	0.125	0.181	0.155	0.137
Bid-ask (Δ)	-0.120	0.211	-0.120	-0.097	0.197	-0.109	-0.121	0.180	-0.120	-0.120	0.196	-0.120
Bid-ask (rel.)	0.680	0.581	0.517	0.745	0.550	0.618	0.620	0.510	0.500	0.650	0.547	0.512
Vola	0.015	0.032	0.000	0.015	0.027	0.000	0.011	0.025	0.000	0.013	0.028	0.000
Vola (Δ)	-0.011	0.050	-0.005	-0.013	0.034	-0.009	-0.005	0.036	-0.003	-0.008	0.043	-0.004
Vola (rel.)	2.552	8.131	0.000	1.740	5.471	0.000	2.460	7.262	0.000	2.497	7.680	0.000
Observations	6028			137			6219			12384		
Price impact	0.004	0.340	0.024	-0.153	0.419	-0.076	-0.006	0.309	-0.019	-0.003	0.325	0.000
Bid-ask spread	0.182	0.148	0.145	0.202	0.118	0.211	0.181	0.161	0.130	0.181	0.155	0.137
Bid-ask (Δ)	-0.133	0.198	-0.124	-0.128	0.149	-0.118	-0.110	0.195	-0.118	-0.120	0.196	-0.120
Bid-ask (rel.)	0.630	0.491	0.516	0.643	0.352	0.586	0.667	0.590	0.507	0.650	0.547	0.512
Vola	0.015	0.032	0.000	0.021	0.036	0.000	0.011	0.025	0.000	0.013	0.028	0.000
Vola (Δ)	-0.010	0.049	-0.005	-0.005	0.039	-0.006	-0.007	0.038	-0.004	-0.008	0.043	-0.004
Vola (rel.)	2.663	8.524	0.000	1.397	4.537	0.000	2.391	7.010	0.000	2.497	7.680	0.000
Observations	5338			149			6897			12384		

This table gives, separately for purchases and sales, information on various variables reflecting liquidity and information asymmetry when traders of the different categories, i.e. agency, principal and designated market maker, trade in regular intraday call auctions. Separated by liquidity taking and liquidity providing executed orders, means, standard deviations and medians of the following measures of liquidity are provided. *Price impact* denotes the percentage difference between the midprice five minutes after the auction and the price trades are executed in the auction. $Bid-ask\ spread$ denotes the bid-ask, as a percentage of the midprice, immediately prior to the trade. $Bid-ask$ (Δ) denotes the difference between the actual bid-ask spread and its firm-specific average. $Bid-ask$ ($rel.$) denotes the ratio of actual and firm-specific mean bid-ask spreads. $Vola$ denotes the standard deviation of five minute midprice returns over the half hour before a trade. $Vola$ (Δ) and $Vola$ ($rel.$) are defined equivalently to the similar bid-ask spread measures.

9 Conclusion

Many exchanges operating an electronic open limit order book employ designated market makers to improve liquidity, particularly for less liquid stocks. Prior empirical literature has demonstrated that these market makers increase stock liquidity and valuation. Little is known about what designated market makers exactly do. Using a proprietary data set from Deutsche Börse AG, we seek new insights into market makers' activities. Our empirical analyses provide the following results. First, market maker participation rates as a function of firm size (or, alternatively, trading volume) display a u-shaped pattern. It is highest for the smallest firms, then decreases in firm size but increases again for the largest size quintile. Second, we demonstrate that market makers not only provide liquidity but also take liquidity. Third, we find that other traders take liquidity supplied by designated market makers particularly in times of high volatility, high bid-ask spreads and high informational asymmetries. Fourth, we find that the activity of market makers decreases during the trading day and that their ratio of liquidity taking to liquidity providing trades increases at the same time. Fifth, we demonstrate that the designated sponsors do, on average, not earn profits on their trading activities.

A distinguishing feature of our study is that we also analyze market maker trading activity during the call auctions. We find that their participation rates are higher in those auctions that take place when uncertainty and informational asymmetries are likely to be higher (opening auctions and call auctions to restart trading after a trading halt). Trades of designated market maker in call auctions appear to be profitable on average.

Overall, it appears that designated market makers' services are sought at times of high uncertainty and information asymmetry so that, while their overall market share appears low, they provide liquidity at crucial times and thus protect traders in need of liquidity.

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