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Abstract

Many equity markets combine continuous trading and call auctions. Oftentimes designated market makers (DMMs) supply additional liquidity. Whereas prior research has focused on their role in continuous trading, we provide a detailed analysis of their activity in call auctions. Using data from Germany's Xetra system, we find that DMMs are most active when they can provide the greatest benefits to the market, i.e., in relatively illiquid stocks and at times of elevated volatility. Their trades stabilize prices and they trade profitably.

Keywords: Designated market makers, Call auctions

JEL classification: G10

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1 Introduction

Many equity markets operate a hybrid market structure that combines continuous trading in the electronic open limit order book during most of the trading day with call auctions at the open and close. While liquidity voluntarily provided by market participants is usually sufficient for large cap stocks, several exchanges rely on designated market makers (DMMs) for mid and small cap stocks. We study the activity of DMMs in call auctions in the context of an electronic hybrid market structure, a trading environment that is distinctly different from the settings analyzed in previous papers (to be briefly summarized below). Using data from 2011 and 2013, we find beneficial effects of DMM participation in the German electronic Xetra trading system. They are more active in less liquid stocks, and their activity increases at times of higher volatility and uncertainty. The latter finding implies that DMMs, while having a low overall market share, stand ready to trade at times when additional liquidity is needed most. We further find that DMMs, by leaning against the market, limit transitory price movements, thus stabilizing prices. Their trades are predictive of future returns and, hence, are profitable. This suggests that they are implicitly compensated for their services. Thus, the binding obligations imposed on DMMs, such as maximum spread requirements, do not render their trading activity unprofitable. In addition to the results immediately related to DMM activity, we show that the closing auction generally accounts for a much higher fraction of the total trading volume than the opening auction, and that the relative importance of the closing auction is increasing in firm size while the relative importance of the opening auction is decreasing in size.

Previous empirical evidence on designated market making is almost exclusively based on data from continuous trading sessions. Little is known about whether and how DMMs contribute to the liquidity of the call auctions. Call auctions form an important part of today's hybrid trading systems for at least three reasons: they attract a signficiant share of the daily trading volume, they serve to impound important information into prices at the open, and they define the closing price, which is increasingly relevant (e.g., for mutual funds' daily determination of their net asset values). The continuous trading sessions nowadays are dominated by high-frequency traders, many of which engage in voluntary market making. High-frequency traders are much less active in call auctions (e.g., Bellia et al., 2017; Anagnostidis et al., 2018). Consequently, DMMs may be facing less competition in call auctions and, thus, may be able to earn higher trading profits. Against the backdrop of the differences between call auctions and continuous trading, an understanding of whether and how DMMs can improve call auction outcomes is warranted.

We use data from the Xetra system operated by Deutsche Börse. Trading in Xetra opens and closes with a call auction. Further, there is a regular intraday call auction. Finally, trading is restarted with a call auction after volatility-induced trading halts. We can identify the trades of DMMs in our data. We are therefore able to analyze to what extent designated market makers participate in the auction, to analyze the cross-sectional and time series determinants of their trading activity, and to estimate their trading profits.

The relevance of our results extends beyond the German equity markets. Other trading venues operate DMM programs similar to the one in Xetra. For example, the spot equity market of Euronext features regular call auctions and auctions after volatility interruptions, operates a liquidity provider program, and requires the market makers participating in that program to regularly participate in the call auctions.[1] Similarly, the New York Stock Exchange requires DMMs to contribute capital in the opening and closing auctions.[2] Other markets do use call auctions and do operate DMM programs but currently do not formally require DMMs to participate in the call auctions.[3] Our results provide insight into the implications of such a requirement for market quality.

[1] See https://www.euronext.com/sites/www.euronext.com/files/liquidity_provider_programme_on_euronext_cash_equity_markets_0.pdf, accessed June 25, 2019.

[2] See https://www.nyse.com/publicdocs/nyse/markets/nyse/designated_market_makers.pdf, accessed June 25, 2019.

[3] An example is NASDAQ OMX, see https://business.nasdaq.com/media/MiFID-II-Market-Maker-Agreement-Nasdaq-TEMPLATE-%28Cash-Equities%29-updates-June-1_tcm5044-58198.pdf (accessed June 25, 2019).

Our paper contributes to the literature on DMMs and on call market trading. The former has mostly focused on DMMs in continuous limit order books. The theoretical models of Sabourin (2006) and Bessembinder et al. (2015) predict that the presence of a DMM increases liquidity. These theoretical predictions are supported by a growing body of empirical evidence that suggests that DMMs indeed improve liquidity (e.g., Declerck and Hazart, 2002; Nimalendran and Petrella, 2003; Eldor et al., 2006; Hengelbrock, 2008; Anand et al., 2009; Menkveld and Wang, 2013; Skjeltorp and Ødegaard, 2015; Anand and Venkataraman, 2016; Clark-Joseph et al., 2017; Bessembinder et al., 2017). The relative advantages of electronic call auctions have been discussed theoretically by Cohen and Schwartz (1989), Economides and Schwartz (1995), and Schwartz (2000). Several papers (e.g., Pagano and Schwartz, 2003; Chang et al., 2008; Chelley-Steeley, 2008, 2009; Kandel et al., 2012; Pagano et al., 2013) provide evidence that the introduction of an opening and/or a closing call auction improves market quality, particularly for small cap stocks.[4] Abad and Pascual (2010) and Zimmermann (2014) analyze call auctions subsequent to volatility-induced trading halts, an institutional feature that also plays a role in our study.

While trading in call auctions is analyzed in all the papers above, none of them considers the role of DMMs in these auctions. The only papers we are aware of that explicitly consider DMMs in call auctions are Madhavan and Panchapagesan (2000), Kehr et al. (2001), and Venkataraman and Waisburd (2007). Madhavan and Panchapagesan (2000) and Kehr et al. (2001) analyze floor-based trading systems in which the DMMs (the NYSE specialist and the "amtlicher Kursmakler" on the Frankfurt Stock Exchange, respectively) operate in a non-anonymous floor-based environment and enjoy important privileges. These DMMs have exclusive access to the limit order book and could decide on their participation in a trade after seeing the order book and the imbalance. Thus, they know in advance on which side and at what price they would trade. The ability to act last also gives them discretionary power in

[4]Interest in this issue has been reignited recently when the London Stock Exchange introduced a midday call auction. Note that our setting does not allow analyzing the effect of introducing a midday call auction because such an auction was conducted for all our sample stocks for the entire sample period.

setting the auction price. Both papers conclude that market makers facilitate price discovery and stabilize prices. The setting we analyze differs in several important ways from the setting analyzed by Madhavan and Panchapagesan (2000) and Kehr et al. (2001). First, the DMMs operate within a fully anonymous electronic market, as opposed to a non-anonymous trading floor. Second, the DMMs in Xetra do not have privileged access to information and have to submit their quotes in advance. Consequently, they do not have price setting discretion. Because of these fundamental differences between the NYSE specialist and the "amtlicher Kursmakler" on the one hand and the DMMs in Xetra on the other, it is unclear whether the results of Madhavan and Panchapagesan (2000) and Kehr et al. (2001) carry over to the setting we analyze.

Venkataraman and Waisburd (2007) use data from the French equity market, which operates an electronic call auction. They find that firms with DMMs have better market quality, and that share prices increase upon the announcement that a DMM maker will be introduced. Our paper differs from theirs in two important ways. First, the French stocks analyzed in Venkataraman and Waisburd (2007) are traded *only* in call auctions, while the stocks we analyze are traded in a hybrid market where call auctions and continuous trading are combined. Second, in the data analyzed by Venkataraman and Waisburd (2007) the trades made by DMMs are not identified. Therefore, they can test whether the existence of a DMM affects market quality, but they cannot analyze the trading activity of DMMs, nor can they estimate their trading profits. In a sense, then, our results complement theirs because we show in detail *how* DMMs improve the market quality in the call auctions, and we analyze the profitability of their trades.

The remainder of this paper is organized as follows. In Section 2, we describe the institutional setting. In Section 3, we describe our data set and present descriptive statistics. Section 4 contains the empirical results. We conclude in Section 5.

2 The institutional setting

Xetra, operated by Deutsche Börse, is the dominant market for German stocks. Stocks can be traded either continuously or in a call auction-only mode. Which trading protocol applies for a particular stock is determined as follows. The exchange sorts stocks into two liquidity categories, liquid and illiquid, according to the turnover and transaction costs measured over a four-month period.[5] Stocks categorized as liquid are traded continuously. The issuer may voluntarily contract with a DMM.[6] Stocks categorized as illiquid, on the other hand, are traded in a call auction-only mode unless they have a DMM. As explained in more detail below, employing a DMM is costly. Firms may be willing to incur these costs because a switch to continuous trading has been shown to improve market quality and to result in an increase in share prices (Amihud et al., 1997; Kalay et al., 2002).

From this it follows that there are four groups of stocks: (1) illiquid stocks that do not have a DMM and are traded in a call auction-only mode; (2) illiquid stocks that do have a DMM and are traded continuously; (3) liquid stocks that have a DMM (on a voluntary basis); and (4) liquid stocks that do not have a DMM. Since the focus of our study is the participation of DMMs in call auctions, we only include stocks from groups 2 and 3 in our sample.[7] Consequently, all our sample stocks are traded continuously, and all sample stocks have at least one DMM.

The trading day in Xetra 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 in the middle of the trading

[5]Transaction costs are measured by the roundtrip cost of a trade of €25,000. This transaction cost measure is not publicly available and cannot be calculated from publicly available data. Therefore, a regression discontinuity design cannot be applied in the present context.

[6]The official name of designated market makers in Xetra is "designated sponsors." We use the term designated market maker (DMM) instead, which is more common in the academic literature.

[7]At first sight it is tempting to compare stocks in groups 1 and 2. Stocks in group 1 are traded in call auctions without market maker participation, while those in group 2 are traded in call auctions with market maker participation. However, stocks in group 1 are traded in a single daily call auctions *only* while there are three daily auctions plus a continuous trading session for the stocks in group 2. A comparison between the two groups would thus not be meaningful.

day (between 1 p.m. and 1:17 p.m.[8]). The continuous trading session, which comprises the remainder of the trading day, is organized as an electronic open limit order book. Trade execution is governed by price and time priority. Continuous 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. There are thus four types of call auctions: opening auctions, closing auctions, regular intraday auctions, and auctions after volatility interruptions.

Orders submitted to Xetra belong to one of three account types: agency, principal or market maker. Agency orders are submitted by Xetra members on behalf of other traders (i.e., 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 DMMs.

The designated market making arrangement is specified in a contract between the issuer and the market maker. The issuer pays the market making firm a fee. The market making firm, in turn, commits to register as a DMM for the issuer's stock. The minimum standards for DMMs are defined in the Designated Sponsor Guide published by Deutsche Börse. They are required to submit buy and sell limit orders (referred to as "quotes" hereafter) to the call auctions and to quote bid and ask prices during the continuous trading session. They have to meet a minimum participation rate in the call auctions and a minimum quotation time in the continuous trading session.[9] For a quote to count towards the minimum participation rate and minimum quotation time requirements, it must satisfy maximum spread and minimum depth requirements. The standards refer exclusively to the quotation activity of the market

[8]The intraday call auction is held between 1:00 p.m. and 1:02 p.m. for DAX and TecDAX stocks, between 1:05 p.m. and 1:07 p.m. for MDAX and SDAX stocks, and between 1:15 p.m. and 1:17 p.m. for the other stocks. The MDAX, SDAX, and TecDAX are indices calculated by Deutsche Börse AG. They comprise stocks that are listed in the prime standard segment of the Frankfurt Stock Exchange and which are (as measured by free float and trading volume) smaller than the 30 stocks included in the blue-chip index DAX. The MDAX and SDAX each comprise 50 stocks from non-technology sectors. The 50 stocks in the MDAX are the next 50 stocks outside the technology sector after the DAX stocks while the 50 stocks in the SDAX are those that follow after the MDAX stocks. The TecDAX comprises the 30 largest technology stocks outside of the DAX.

[9]Deutsche Börse monitors the performance of the DMMs and publishes a quarterly rating.

makers. They do not mandate a minimum number of trades or a minimum trading volume. DMMs do not have an informational advantage (such as exclusive access to the limit order book, as the NYSE specialists had), and their quotes are subject to the same price and time priority rules as orders submitted by agency and principal traders.

Provided DMMs fulfill their obligations, they benefit from a negative effective execution fee for illiquid stocks (group 2).[10] The negative fee is implemented as follows. First, market makers receive a full refund of the execution fee. In addition, they receive a fee credit that reduces the execution fee on other trades that they execute in Xetra.

Many firms have more than one market maker. There are two reasons why a firm can have several market makers. First, the issuer can voluntarily contract with more than one market maker. Second, market making firms can register as market makers in a particular security without entering into a contract with the issuer. In this case, they have to comply with the full set of requirements for DMMs but do not receive a fee from the issuer. We cannot differentiate between these two cases because the existence (and the terms) of a contract between the issuer and the market maker are not disclosed.

3 Data and descriptive statistics

Our data set contains all transactions executed in stocks that are traded continuously in Xetra during the months of July and August 2011 (44 trading days) and July and August 2013 (45 trading days). We exclude all stocks that do not have a DMM. Note that the most liquid stocks (in particular the component stocks of the DAX index) did not have a DMM during our sample period. Therefore, our dataset is tilted towards small and mid cap stocks. We further exclude foreign stocks (defined as stocks with an ISIN country code different from DE) and stocks that do not have at least one call auction with non-zero volume on at

[10] The fee rebates are conditional on certain requirements with respect to the order types used.

least 50% of the trading days in our sample period.[11] We match the transactions data with intraday data on best bid and ask prices provided by Deutsche Börse.[12] We obtain data on firm characteristics from Thomson Reuters Datastream. After the exclusion of five stocks because of missing data, the final sample contains 250 stocks in 2011 and 209 stocks in 2013.

Table 1 provides summary statistics for the stocks in our sample. Columns (1)-(5) ((6)-(10)) show data for the first (second) sample period. The average sample stock has a market capitalization of €689.8 (€993.1) million in the 2011 (2013) sample, and an average daily trading volume of €2.80 (€2.15) million. There is considerable cross-sectional variation in the sample. While the firm at the 5th percentile has a market capitalization of €25.4 (€30.3) million and an average daily volume of €11,719 (€17,166), the corresponding values for the firm at the 95th percentile are €3,050.2 (€4,715.8) million for the market capitalization and €14.7 (€9.6) million for the average daily volume. The average share price is €21.68 (€25.77) in the 2011 (2013) sample. The average quoted bid-ask spread is 1.10% (0.74%) while the average 5-minute price impact (a proxy for losses to informed traders) is 0.54% (0.40%). The large differences in the bid-ask spreads and price impacts for the two sample periods are a reflection of the fact that 2011 was a much more volatile period than 2013. This is evidenced by the average volatility (as measured by the standard deviation of daily returns), which amounts to 3.5% in the 2011 sample and 2.5% in the 2013 sample. The cross-sectional differences in volatility are substantial. The return standard deviation of the stock at the 95th percentile is more than three (more than five) times as large as the corresponding value for the stock at the 5th percentile in 2011 (2013).

The trading volume reported above relates to the total volume in the continuous trading

[11] Of course, the activity of DMMs may affect the probability of observing positive auction volume. The frequency of observing positive volume could therefore serve as a measure of market quality. However, in our setting stocks without a market maker are traded in a single daily call auctions *only* while there are three daily auctions plus a continuous trading session for stocks with a DMM. A comparison of the fraction of auctions with positive volume would thus not be meaningful.

[12] The data on bid and ask prices does not include information on whether the corresponding order was submitted by a DMM. Thus, while we do observe their trades, we do not directly observe their quotation behavior.

session and the call auctions. On average, the call auctions account for 12.2% (11.9%) of the total volume in the 2011 (2013) sample. The closing auction is by far the most important auction in terms of volume. It accounts for 50.9% (58.7%) of the auction volume in the 2011 (2013) sample.[13] The high volume share of the closing auction is consistent with the stylized fact that many institutional traders prefer to trade at or near the close (e.g., Cushing and Madhavan, 2000). The opening auction accounts for 25.5% (25.7%) of the auction volume, the intraday auction for 3.0% (3.9%), and auctions after volatility interruptions for the remaining 20.8% (11.7%). When interpreting the last figure, one needs to take into account that there are, on average, 0.51 (0.17) volatility interruptions per stock and day. Thus, conditional on a volatility interruption occurring, the call auction conducted to restart trading accounts for a considerable fraction of the volume.

Table 1 also provides the percentage of auctions with positive volume. Averaged over all stocks, 79.5% (82.1%) of the closing auctions, 71.3% (72.5%) of the opening auctions, and 35.6% (55.1%) of the intraday auctions have non-zero volume in the 2011 (2013) sample. There is considerable cross-sectional variation. The stock at the 95th percentile always has a positive volume in the opening and closing auction. In contrast, the stock at the 5th percentile has a positive volume in the opening and closing auctions on less than one-third of the trading days. The fraction of intraday auctions with positive volume is even lower. These figures indicate that some of our sample stocks are very illiquid indeed.

While the number of opening, intraday, and closing auctions is fixed at one per stock and day, the same does not hold for auctions after volatility interruptions. As noted above, these auctions are triggered by large price changes. Their number is thus endogenous. Therefore, the figures provided for this auction type have to be interpreted differently. They indicate

[13] Note that these figures were obtained by first calculating the volume share for each stock and then averaging over all sample stocks. If we first aggregate the volume in the different auctions and then calculate the volume shares based on the aggregate volume, we obtain much higher volume shares for the closing auction. This is because the share of the closing auction is higher for stocks with higher total auction volume.

that, on average, there were 0.51 (0.17) such auctions per stock and day in 2011 (2013).[14] The higher number of volatility interruptions in the 2011 sample is a reflection of the higher volatility in 2011 documented above. Again, there is considerable cross-sectional variation. The stock at the 5th percentile has 0.07 (0) auctions after volatility interruptions per day while the stock at the 95th percentile has 1.20 (0.64) such auctions per day in 2011 (2013). These numbers reflect the large differences in return volatility across the sample stocks documented above.

Table 1 about here

Table 2 provides more insight into the relative importance of the four different types of auctions. It shows the fraction of the total trading volume accounted for by the call auctions for five groups of stocks. The groups are created as follows. Those stocks that are categorized as liquid by the exchange are sorted into one group denoted "liquid". As noted in Section 2, these stocks do not require a market maker to be traded continuously. The remaining stocks are sorted into size quartiles.

The volume share of the closing auction increases almost monotonically as we move from small to larger stocks. In 2011 (2013), the closing auction accounts for 3.16% (2.05%) of the total volume in stocks of the smallest size quartile. This fraction increases to 7.40% (9.46%) for the stocks in the largest volume quartile and to 10.30% (15.40%) in the liquid group. A potential explanation for this finding is that (as discussed in the next section) principal traders have a much higher market share in large and high volume stocks and, at the same time, display a preference for trading in the closing auction (possibly because they use the closing price as benchmark and/or want to avoid holding inventory overnight). Consequently, the closing auctions account for a higher fraction of the total volume in larger stocks. We find the opposite pattern for the opening and intraday auctions. Here, the auction accounts

[14] Note that our dataset only contains information on auctions after volatility interruptions with positive volume. It is conceivable that there are additional volatility interruptions in which the auction conducted to restart trading yielded zero volume. We do not observe these cases.

for a higher share of the total volume for smaller stocks than it does for larger ones. The same is true for auctions after volatility interruptions. For these auctions, the pattern is partially explained by the fact that smaller stocks tend to have more volatile returns and therefore experience more frequent volatility interruptions.[15]

Table 2 about here

4 Results

4.1 Market shares and trading patterns

We start our empirical analysis by considering the participation of the three groups of traders (agency traders, principal traders, and DMMs) in the call auctions.[16] The results are shown in Table 3. Panel A shows results for groups of stocks sorted by market capitalization (using the procedure described above) while Panel B presents results for the four different types of call auctions. In each panel, columns (1)-(6) show the results for the 2011 sample while columns (7)-(12) show those for the 2013 sample. Columns (1)-(3) and (7)-(9) (denoted "any participation") show how often traders of the respective group participate in an auction. Take as an example the figure 89.54 in the upper left cell of Panel A. It indicates that agency traders participated in 89.54% of the auctions for the group of stocks of the smallest firms. Columns (4)-(6) and (10)-(12) show market shares as a percentage of the euro trading volume. The figure 69.84 in column (4) of the first row in Panel A indicates that transactions by agency traders account for 69.84% of the volume in the auctions for the stocks of the smallest firms.

[15] In fact, the number of auctions after volatility interruptions decreases almost monotonically across the size groups.

[16] We use the term *participation rate* to measure how frequently the traders in a group participate in an auction. We use the term *participation share* to measure the fraction of the auction volume the traders in a group account for.

Table 3 about here

Agency traders are the most active auction participants. They participate in more than 89% of the auctions even in the stocks of the smallest size group. Principal traders participate less in auctions for small cap stocks. Their participation rates increase monotonically as we move towards more liquid stocks. The pattern for DMMs is the exact opposite. They have the highest participation rates (37.0% in the 2011 sample and 25.0% in the 2013 sample) in the smallest firms, whereas their participation rates are only 13.6% and 9.0% in the 2011 and 2013 sample, respectively, for the group of liquid stocks. DMM thus appear to provide relatively more liquidity to stocks that are inherently less liquid.

When considering market shares in terms of the euro trading volume, we find that trading is dominated by agency and principal traders. Together they account for 90.2% to 99.7% of the trading volume. Market shares vary systematically with firm size. Agency traders have the largest market shares in the least liquid market capitalization group. Their market share then decreases monotonically as we move to the more liquid sample stocks. We observe the reverse pattern for principal traders. As for the agency and principal traders, the market shares of the DMMs vary systematically across size groups. They account for 9.8% (2011) and 4.4% (2013), respectively, of the volume in the smallest size group. Their market shares decrease almost monotonically across the size groups and amount to only 0.3% (0.1%) in the 2011 (2013) sample in the most liquid group.

The market shares for the different auction types displayed in Panel B of Table 3 show a distinct pattern. Agency traders dominate the opening auctions and the call auctions after volatility interruptions. Principal traders, by contrast, dominate the closing auctions. DMMs have a low market share in the closing auction. It amounts to 0.35% of the euro volume in the 2011 sample and to 0.21% in the 2013 sample. Their share in the opening auction is much larger, at 2.1% (1.6%) in the 2011 (2013) sample. Their market shares are highest in the intraday auctions (7.1% and 1.8%) and in auctions after volatility interruptions (4.5%

and 4.0%). It is interesting to compare the results on market maker participation to those on the market shares of the four auction types shown in Table 1. Market maker participation appears to be inversely related to the total volume transacted in the auction. In particular, the closing auction is by far the most important auction in terms of volume, but it has the lowest market maker participation share. The intraday auction, in contrast, is the least important auction in terms of volume and has the highest market maker participation share in the 2011 sample and the second highest share in the 2013 sample. It also appears that market makers have a comparably high participation share in those auctions where price uncertainty is likely to be higher, namely, opening auctions and auctions after volatility interruptions.

In addition to the descriptive analysis described above we estimate cross-sectional regressions. Table 4 reports the results of a fractional logit model. The dependent variable is the average participation share of the DMMs. The independent variables include the log of the average market value of equity during the sample period, the share turnover (defined as the ratio of share trading volume and market capitalization[17]), the 5-min price impact (averaged over the sample period) as a measure of adverse selection risk, and three dummy variables that indicate whether the stock is a constituent stock of the mid cap index MDAX, the technology stock index TecDAX, or the small cap index SDAX. Table 4 shows the marginal effects in percentage points, measured per standard deviation for the continuous independent variables. The Table reports results for the opening, the closing, and the intraday auctions, and for auctions after volatility interruptions. Columns (1)-(4) ((5)-(8)) show the results for the 2011 (2013) sample.

Market maker participation shares are decreasing in the market capitalization and in the turnover ratios. A coefficient of -1.5 for market capitalization implies that a one standard deviation increase in the log of market capitalization decreases market maker participation by 1.5 percentage points. Relative to the participation shares shown in Table 3 (all well below

[17]The correlation between market capitalization and turnover is 0.26 (-0.11) in the 2011 (2013) sample.

10%), this is an economically significant decrease. One leading intention of integrating DMMs into (continuous and/or call) auction markets has been to increase liquidity for stocks that are inherently illiquid (e.g., Nimalendran and Petrella, 2003; Menkveld and Wang, 2013). Our findings that the relative importance of DMMs is inversely related to firm size and turnover, and that DMMs are relatively more active in auctions with lower volume, is supportive of this intention.

In the 2013 sample, there is some evidence that market maker participation rates are higher for stocks with higher adverse selection risk as measured by the 5-min price impacts. The respective coefficients in the 2011 sample are insignificant. The results further imply that market maker participation tends to be lower in the component stocks of the MDAX and TECDAX indices (which are the largest and most liquid stocks in our sample).

Table 4 about here

The analysis so far has focused on market maker participation across the four different auction types and across stocks. We now turn to the time series dimension of market maker participation. We ask whether, within one type of auction, market maker participation varies systematically with the trading volume in the auction. To address this issue, we estimate pooled fractional logit models in which we regress the market maker participation share on the logarithm of the auction volume. We estimate separate regressions for each auction type. For all auctions except the opening auction, we include the absolute change in the quote midpoint in the 5-minute interval of the continuous trading session immediately preceding the call auction as an additional explanatory variable.[18] We repeat the analysis using 30-minute intervals instead of 5-minute intervals. Including the pre-auction change in the quote midpoint allows us to test whether market maker participation is related to

[18]The opening auction follows the overnight trading halt. Therefore, there is no prior return from the continuous trading session. If we include the absolute close-to-open return as an explanatory variable, it does not significantly explain market maker participation and leaves the coefficient on auction volume qualitatively unchanged.

volatility. Because of the market makers' affirmative obligation to quote, we expect a positive relation between the volatility proxy and market maker participation.

The results (marginal effects) of the fractional logit regressions are presented in Table 5.[19] Standard errors are clustered by stock and date. For all four auction types, the coefficient on the log auction volume is significantly negative. Thus, DMMs participate relatively more when the trading volume in the auction is lower. This finding of a time series relation between auction volume and market maker participation complements the results presented above of an inverse relation between the average volume of an auction type and market maker participation.

The coefficients on the absolute change in the quote midpoint in the 5-minute and 30-minute intervals prior to the auctions are always positive and are significant in three out of six cases. This indicates that, as expected, the DMMs trade a higher fraction of the total volume in auctions that take place at times of elevated volatility. The magnitude of the marginal effects implies that a one standard deviation change in the absolute midquote return increases the market maker participation share by 0.13–1.05 percentage points. These numbers should be related to the average market maker participation shares (shown in Table 3), which range between 0.21% (for the closing auctions in the 2013 sample) and 7.08% (for intraday auctions in the 2011 sample). Thus, in relative terms an increase in volatility is associated with a substantial increase in market maker participation. This is most likely due to their affirmative obligation to submit buy and sell orders which are subject to a maximum spread requirement that is more likely to be a binding restriction in times of high volatility. Principal and agency traders, on the other hand, can withdraw from the market at those times.

Table 5 about here

[19] Note that the number of observations differs between the three auction types. This is because, as documented in Table 1, the fraction of auctions with non-zero volume differs across auction types. For auctions after volatility interruptions, the number of observations is lower when we include the price change in a 30-minute interval as an explanatory variable because some volatility interruptions occur during the first 30 minutes of the trading day.

4.2 Price stabilization

The NYSE specialists had the explicit affirmative obligation to preserve price continuity (e.g., Hasbrouck and Sofianos, 1993; Panayides, 2007). If market makers preserve price continuity, they "trade against the trend" and thus reduce the magnitude of price changes. We will refer to this behavior as "price stabilization." While the DMMs in Xetra do not have an explicit obligation to stabilize prices they may still do so. This is because, in the presence of order imbalances, a liquidity supplier will usually trade on the short side of the market and will thus be trading against the trend.

The implications of stabilization for market quality depend on whether price changes are caused by new information or whether they are triggered by factors unrelated to information, such as illiquidity. In the latter case, stabilization by market makers reduces volatility and prevents prices from moving away from fundamental values, thus enhancing the informational efficiency of prices. If, however, price changes are triggered by new information, stabilization will slow down the adjustment of prices to the new information. The stabilizing trades of the market maker will be unprofitable (because she sells in a rising market and buys in a falling market), and they will induce positive serial return correlation.

Our empirical analysis proceeds as follows. We first analyze whether DMMs stabilize prices, i.e., whether their trades exacerbate or dampen price changes. We then turn to the question of whether price stabilization by market makers predominantly reduces non-information related (or transitory) price changes or slows down the adjustment of prices to new information (i.e., permanent price changes).

To analyze whether DMMs stabilize prices we calculate the signed price change from the last quote midpoint prior to the auction to the auction price. We then regress this variable on the signed market maker participation share, defined as the market maker's trade in the auction divided by the total volume of the auction. In an alternative model specification, we also include the quote midpoint return in the 5 (30) minutes prior to the auctions.[20] We estimate separate regressions for the intraday auctions, closing auctions, and for auctions after volatility interruptions. We cannot report results for the opening auction because the dependent variable (the price change from the previous quote midpoint to the auction price) is not defined for the opening auction.

The results are shown in Table 6. The coefficient on the signed market share of DMMs is always negative and is significant at the 1% level in every case. This implies that DMMs sell shares when prices go up and buy shares when prices go down. For example, in the hypothetical case that they are the buyers of half of the trading volume in an auction after a volatility interruption, the regression results suggest that the immediate return will be about 30 basis points (bps) lower than in an otherwise similar auction without market maker participation. Thus, DMMs appear to "lean against the wind" and stabilize prices. We note that this leaning against the wind does not necessarily imply a conscious trading decision by the market maker. Rather, the market maker routinely submits buy and sell orders to the auction. When the auction price is higher than the preceding prices in the continuous trading session, the market maker's sell orders are likely to be executed, resulting in the negative relation between price change and signed market maker participation share that we document.

Table 6 about here

The analysis documented in Table 6 considers short-term price stabilization. In order to broaden the perspective, we also consider close-to-open (overnight) returns and open-to-close returns. We regress the close-to-open returns on the market makers' signed buying volume in the closing auction of day $(t-1)$ and the opening auction on day t. Consider the case of a negative close-to-open return. Such a return will obtain when there is upward pressure

[20] Below we report results for pooled OLS estimation. We also estimate panel regressions with (a) firm fixed effects and (b) firm and year fixed effects. The results are very similar to those reported below and are thus omitted.

on the closing price or downward pressure on the opening prices. A price-stabilizing market maker would sell in the closing auction and/or buy in the opening auction. Consequently, we expect a positive coefficient on the market makers' net buying volume in the closing auction of day $(t-1)$ and a negative coefficient on the net buying volume on the opening auction on day t. A similar argument (resulting in the same expected coefficient signs) applies in the case of positive overnight returns.

We perform an analogous analysis for open-to-close returns. To this end, we regress the open-to-close return on the market makers' signed net buying volume in the opening and closing auctions of day t. By a similar argument as above, price stabilization implies a positive coefficient on the market makers' net buying volume in the opening auction and a negative coefficient on the signed net buying volume in the closing auction.

The results are shown in Table 7. They are fully consistent with price stabilization. Market makers, on average, trade against the trend. When the overnight return is positive, they have been buying in the closing auction, and they sell in the opening auction (and vice versa for negative overnight returns). Thus, their trading activity in both auctions contributes to a reduction of the magnitude of the overnight return. We find similar results for open-to-close returns. When the return is positive, market makers have been buying in the opening auction and selling in the closing auction. The results in Table 7 thus corroborate those documented in Table 6. DMMs trade in call auctions in a way that contributes to price continuity.

Table 7 about here

Our analysis so far has not attempted to differentiate between information-related (permanent) and non-information related (transitory) price changes. To address this issue, we consider all auctions that take place during the trading day (i.e., auctions after volatility interruptions and regular intraday auctions).[21] We regress, in separate regressions, the pre-

[21] Our approach is based on an analysis of price changes before and after the auction. Therefore, we can neither include the opening nor the closing auction.

auction price change (measured as the price change from the quote midpoint 5, 10 or 15 minutes prior to the auction to the auction price) and the post-auction price change (defined as the change from the auction price until the quote midpoint 5, 10 or 15 minutes after the auction) on the market makers net buying volume. A negative coefficient in the pre-auction price change regression implies that the market makers stabilize prices – they buy when prices decrease and sell when prices increase. A negative coefficient in the post-auction price change regression would imply that the price trend continues after the auction and would thus be evidence that the price change is permanent.

The results for auctions after volatility interruptions are shown in Panel A and those for regular intraday auctions in Panel B of Table 8. In both cases, all coefficients for the pre-auction price changes are negative, confirming our earlier findings that market makers stabilize prices. The coefficients for the post-auction price changes are close to zero and insignificant for the auctions after volatility interruptions. This result implies that the pre-auction price trend does not continue after the auction, meaning that the market maker trading activity prevents the auction price from overshooting.

For the regular intraday auctions, we find positive coefficients in the post-auction price change regressions, a finding that implies that the pre-auction price trend partly reverses after the auction. Our interpretation of this result is that the market makers' trades do not prevent transitory price changes from occurring, but dampen their magnitude.

To summarize, the results in this section demonstrate that market makers stabilize prices by trading against the price trend. The evidence further suggests that their trading activity reduces transitory price changes. We find no evidence of market maker trades slowing down the adjustment of prices to new information.

Table 8 about here

4.3 Profitability

An obvious question is whether DMMs earn trading profits. Market makers need to earn revenues, which compensate them for the inventory risk that they take. This argument should hold for market making in call auctions in the same way as it holds for continuous trading.[22] Grossman and Miller (1988) argue that the price discreteness caused by the existence of a minimum tick size allows market makers to earn positive trading profits because the actual bid-ask spread will be larger than the unconstrained equilibrium bid-ask spread. Prices in call auctions are constrained in the same way as those in continuous trading sessions and the Grossman and Miller (1988) argument should therefore also apply to call auctions. We note, though, that our sample stocks are rather illiquid. The mean quoted spread (in the continuous trading session) is 1.098% (0.735%) in the 2011 (2013) sample (see Table 1). It is large relative to the minimum tick size, which was €0.01 for stocks with prices between €50 and €100 and €0.005 for stocks with prices between €10 and €50, resulting in a relative tick size of 3.98 (3.23) bps for the median stock in our 2011 (2013) sample. Therefore, while the Grossmann and Miller argument is still relevant, we believe that it only provides a partial explanation for the profitability of market making in the sample we analyze.

We address the question of market maker profitability in three steps. First, we calculate price impacts, measured by the return from the auction price to a post-auction benchmark price. The price impacts measure the profitability in percentage terms of participating as a buyer or seller in an auction (where total buyer and total seller profit obviously add up to zero). We can make statements on the profitability of the trades of each of the three groups of traders by taking into account the groups' net buying or net selling. Second, to put the magnitude of the trading gains into perspective, we calculate annualized Sharpe ratios. The Sharpe ratios are a risk-adjusted measure of relative performance but do not allow conclusions on the euro profits earned by DMMs. Therefore we investigate absolute

[22] Consistent with this view, Madhavan and Panchapagesan (2000) find that the trades of NYSE specialists in the opening auction are profitable.

profits per auction in the third step of our analysis.

We calculate price impacts as the return from the auction price to a post-auction benchmark price in the case of net buying, and the negative of that value in the case of net selling. For all but the closing auctions, we use three different benchmark prices. The first is the quote midpoint 5 min after the auction, the second is the quote midpoint 1 h after the auction, and the third is the closing price of the trading day. Obviously, none of these benchmark prices is defined for the closing auction. Therefore, we assess the profitability of trades in the closing auction by relating the closing price to the opening price on the next trading day.

We note that the price impacts we consider are hypothetical in nature and are not equal to the actual returns realized by the traders. Rather, they are based on the assumption that the position opened by the initial trade is closed at the benchmark price. We cannot calculate actual realized profits because positions can also be closed in the continuous trading session in Xetra or in other trading venues.

In Table 9, we report the value-weighted mean price impacts for trades conducted by agency traders, DMMs, and principal traders in the auctions.[23] The t-statistics are based on WLS regressions on a constant with standard errors clustered by stock and date.

Results for the opening auctions are reported in Panel A of Table 9. Agency traders suffer substantial losses when they trade in the opening auction. The magnitude of the coefficients increases as we increase the length of the interval over which we calculate the price impact. The statistical significance decreases, however, because of the higher volatility of returns measured over longer intervals. Principal traders trade profitably. The profit increases as we extend the interval over which the profit is calculated, reaching 31 bps by the end of the trading day. DMMs' average returns are negligible at horizons of 5 minutes and 1 hour. They turn positive and similarly large to those of principal traders by the close of trading, even though the results do not reach statistical significance. We thus conclude that there is

[23]In Table 9, we do not differentiate between liquid stocks (i.e., those that do not require a DMM to be traded continuously) and other stocks. We repeat the analysis for both groups of stocks separately and obtain results consistent with those reported in Table 9.

weak evidence that DMMs trade profitably in the opening auctions.

Table 9 about here

The results for auctions after volatility interruptions are shown in Panel B. We find that agency traders lose up to 10 bps, a result that is stable through the end of the trading day. Principal traders gain about 17 bps in the near term, though the profit decreases by the end of the day. The group that trades the most profitably in auctions after volatility interruptions are the DMMs. They make a 5-min profit of about 21 bps. This profit increases to 65 bps by the close of trading. In untabulated results, we find that the majority of volatility interruptions are caused by price declines and that DMMs tend to be buyers in auctions following the interruptions, subsequently profiting from the recovery of prices.

Panel C of Table 9 reports the results for the closing auctions. As noted above, we use the opening price on the next trading day as the reference price to calculate the price impact. Average overnight profits and losses are smaller in magnitude than those for the other auctions and only weakly significant for agency and principal traders. Agency traders earn 3.8 bps on average. Conversely, principal traders make a loss of 2.5 bps. A potential reason why principal traders lose money in the closing auctions (while they trade profitably in the other auctions) may be that some principal traders (e.g., high-frequency traders) do not want to carry overnight inventory and are therefore less price-sensitive towards the end of the trading day. Market makers earn an insignificant overnight return of 11 bps.

Panel D Table of 9 shows the results for the regular intraday auctions. Agency traders lose 2.6 bps in the short term, with losses increasing to 7 bps by the end of the day. Principal traders make zero near-term profits, though they earn, albeit statistically insignificant, 4 bps by the close of trading. DMMs are highly profitable: they earn a highly significant 21 bps at the 5-minute horizon, a result that barely changes for the remainder of the day.

The analysis of price impacts thus reveals that DMMs trade profitably. However, the price impacts ignore the risk inherent in market making activities. Therefore, we calculate annualized Sharpe ratios. The numerator is the average price impact after DMM trades, taking trade direction into account, i.e., we use the price impact after buys (sales) when the DMM are buying (selling) in an auction. The denominator is the standard deviation of the price impacts. We ignore the risk-free rate.[24] We annualize the Sharpe ratio by multiplying the ratio by the square root of the number of trading days. The Sharpe ratio depends on the reference price used to calculate the price impacts. For all auctions except the closing auction, we use the midquote 5 minutes and 1 hour after the auction, the closing price of the trading day, and the opening price of the next trading day. For the closing auction, we only use the opening price of the next trading day.

The results are shown in Table 10. For the opening auctions, the Sharpe ratios are negative when based on short-term returns but turn positive when we consider longer-term horizons (i.e., those relating the auction price to the closing price of the day or to the opening price of the next day). The Sharpe ratio for the closing auctions is positive and of a magnitude similar to that of large stock market indices. Sharpe ratios for the regular intraday auctions and for auctions after volatility interruptions are unanimously positive and are considerably larger than those for the opening and closing auctions.

In conclusion, the risk-adjusted returns of DMMs are modest in those auctions where volume is relatively high (i.e., in the opening and closing auctions). They are much larger in the regular intraday auctions and in auctions after volatility interruptions. These are the auctions with the lowest overall volume and the highest DMM market share. Market makers may thus be facing less competition in liquidity provision, allowing them to earn higher risk-adjusted returns. When interpreting the Sharpe ratios, it is important to note that they are measures of relative risk-adjusted profitability. A higher Sharpe ratio in an auction type does not imply that market makers can earn large absolute profits in auctions of this type. This is because the market makers' trading strategies are not scalable.

Table 10 about here

[24]The overnight rate was about 1% in July and August 2011 and about 0.1% in July and August 2013.

In order to analyze the absolute amounts of market maker trading profits, we next estimate the average euro trading profit per auction. The calculation is based on the assumption that a position opened during the day (in the closing auction) is closed at the day's closing price (the next day's opening price). We adjust the profits for trading fees using the following procedure. As noted in Section 2, market makers get a full refund plus an additional fee credit on the execution fee on trades in illiquid stocks (i.e., stocks in group 2 as defined in Section 2). These rebates are conditional on certain requirements with respect to the order types the market makers use. While we cannot observe individual DMMs' activity, those requirements appear to be generally fulfilled. Therefore, we assume that market makers obtain the rebate and pay a zero execution fee on trades in illiquid stocks. We further add the fee credits because they reduce the fees that market makers pay on other trades and thus constitute monetary benefits that are caused by the trades in the illiquid stocks. For their trades in liquid stocks (group 3), market makers pay the same fees as other market participants. These fees decrease with an exchange member's total trading volume on Xetra. Based on correspondence with the exchange, we assume that market makers in liquid stocks are generally highly active market participants. We assume their monthly trading volume to be €15 billion. Our estimates of after-fee profits are not sensitive to this assumption because the volume-based discounts on trading fees are in the order of magnitude of only about 0.1 bps of trading volume.

The profit estimates shown in Table 11 indicate that market makers, conditional on participating in a closing auction, earn €11.58 on average. The corresponding figures for the intraday auctions, opening auctions, and auctions after volatility interruptions are €25.02, €22.08, and €31.52, respectively. Multiplying these figures by the total number of auctions of the respective type in which market makers participate results in estimated trading profits per stock and year of €2,652.12. Note that the trading profit is the estimated gross revenue of the market makers' trading activities. Unfortunately, we are unable to deduct the cost of doing business because information on these costs is unavailable. However, we believe that the marginal cost of adding a stock to the portfolio of market making activities is low, particularly when the market making firm uses computer algorithms to perform its market making activities.

Our profit estimates appear low at first sight. It is important to note that our estimates exclude the (undisclosed) fee paid by the issuer and any benefits the market making firm may obtain from cross-selling other services to the issuer. In fact, the market making activities for a specific issuer may be a component of a broader customer relationship that also includes investment banking (e.g., underwriting) and other services. While the entire customer relationship should be profitable, the same need not be true for each component. Therefore, DMMs may be willing to accept market making mandates even when these do not generate positive trading profits.

Table 11 about here

5 Conclusion

In this paper, we analyze DMM activity in the Xetra call auctions. Xetra is a hybrid trading system that combines a continuous trading session and call auctions. While the liquidity of a pure order-driven market is usually sufficient for large and high-volume stocks, it often is not for small cap stocks. Therefore Xetra, like several other trading venues, employs DMMs to supply additional liquidity for small and mid cap stocks.

There are four different types of call auctions in Xetra: opening auctions, closing auctions, one regular intraday auction per stock and per day, and auctions after volatility-induced trading halts. Taken together, these call auctions account for approximately 12% of the total trading volume of the stocks in our sample. We find that trading in the call auctions is dominated by principal traders and agency traders while the share of DMMs is much lower. We further find that their share in the total auction volume is inversely related to firm size.

Thus, in the cross-section market makers tend to trade relatively more in less liquid stocks. A similar pattern holds across the four auction types. Market makers are relatively least active in the closing auction (which is by far the most liquid of the four auction types) and are relatively more active in the less liquid auctions. Taken together it appears that market makers trade relatively more actively precisely in those stocks and on those occasions where their contribution to liquidity is needed more.

Results of a time series analysis reveal that market makers tend to trade more in times of higher volatility. This finding is likely, at least in part, the result of their affirmative obligation to quote. DMMs are obliged to submit buy and sell orders to the auction, and they are subject to maximum spread requirements. Therefore, unlike principal and agency traders, market makers cannot withdraw from the market in times of high volatility or increased informational asymmetry.

When we relate returns to signed market maker trading activity, we find clear evidence that market makers stabilize prices, even though they do not have an explicit obligation to do so. They thus contribute to price continuity. Our results further suggest that the market maker trades serve to dampen transitory price changes, not to slow down the adjustment of prices to new information.

DMMs need to be compensated for the cost of doing business and for the inventory risk that they take. Our analysis reveals that they earn positive trading profits which, however, are small in magnitude (€2,652.12 per stock and year). The trading profits are augmented by the (undisclosed) fee that market makers receive from the issuer. Further, market making activities for a specific issuer may be only one component of a broader customer relationship that also includes investment banking (e.g., underwriting) services. Profits from those activities may be used to subsidize the market making activities.

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Table 1: Descriptive statistics

	2011					2013				
	Mean	Median	Std. dev.	5th pct	95th pct	Mean	Median	Std. dev.	5th pct	95th pct
A: Company and stock statistics										
Market cap. (€ million)	689.801	219.308	1062.131	25.417	3050.164	993.122	293.850	1565.321	30.328	4715.898
Price (€)	21.681	12.573	29.486	1.273	69.876	25.770	15.481	33.976	1.252	82.154
Volatility (daily std)	0.035	0.033	0.013	0.016	0.054	0.025	0.019	0.021	0.011	0.058
Price impact 5m	0.539	0.395	0.473	0.080	1.415	0.398	0.228	0.506	0.052	1.184
Bid-ask spread	1.098	0.616	1.088	0.127	3.164	0.735	0.401	0.810	0.070	2.488
ADV total (€)	2796464	372706	5972757	11719	14666964	2151163	315215	4280445	17166	9601774
B: Call auction trade statistics										
Volume share of auctions	12.23	10.68	5.81	6.06	24.83	11.93	10.62	5.22	5.27	22.16
ADV Open (€)	37181	9275	74923	443	172748	30523	6788	58957	455	135793
ADV Close (€)	271666	15356	625619	379	1788802	303031	16547	676227	504	1529346
ADV Intraday (€)	6950	1221	12363	24	36761	3976	1472	5697	21	16610
ADV Volatility (€)	8170	4500	13292	444	25838	4601	1723	10885	100	18225
Open share of auctions	25.45	23.80	15.07	5.31	52.59	25.74	22.70	17.07	4.50	58.50
Close share of auctions	50.95	49.40	26.24	11.85	92.13	58.74	60.31	27.01	14.66	94.26
Intraday share of auctions	3.01	2.29	2.71	0.41	9.46	3.88	2.56	4.13	0.50	10.91
Volatility share of auctions	20.85	14.02	20.11	0.20	61.87	11.69	4.15	15.97	0.00	47.58
Intraday > 0	35.62	27.27	31.90	0.00	93.18	55.07	62.22	36.19	2.22	100.00
Close > 0	79.54	97.73	27.75	27.27	100.00	82.13	100.00	26.06	28.89	100.00
Open > 0	71.26	79.55	28.14	22.73	100.00	72.45	82.22	28.45	22.22	100.00
Volatility > 0	51.22	40.91	46.29	6.82	120.46	17.08	6.67	27.34	0.00	64.44

This table shows descriptive statistics for the firms in our sample. The top panel provides information on the companies, their stocks, and their trading overall. The left part of the table summarizes data for our sample in 2011, the right part for 2013. *Market cap.* is the market value of equity, *Price* is the stock price, and *Volatility* is the standard deviation of daily returns. *Price impact 5m* is the average price impact during continuous trading, *Bid-ask spread* is the time-weighted average quoted spread in percent, and *ADV total* is the daily trading volume in euros aggregated over the continuous and call auction phases. The bottom panel of the table summarizes trading activity in call auctions. *ADV auction type* is the average daily euro trading volume in the different types of call auctions. *Volume share of auctions* is the percentage of call auction trades relative to total trading volume. *Auction type share of auction volume* is the relative share, in percent, of the respective auction type in total call auction trading. *Auction type* > 0 is the percentage of auction of the respective type with a non-zero trading volume. For volatility auctions it is the number of volatility auctions with non-zero trading volume expressed as a percentage of the number of trading days.

Table 2: Market shares of types of call auctions by market capitalization quartile and liquidity class

	Open	Close	Intraday	Vola	All Auctions
			2011		
Small	3.67	3.16	0.38	5.41	12.63
2	3.78	2.89	0.22	2.02	8.91
3	2.70	4.60	0.31	1.46	9.06
Big	1.80	7.40	0.30	0.75	10.26
Liquid	1.18	10.30	0.22	0.15	11.84
			2013		
Small	2.81	2.05	0.27	1.50	6.64
2	2.79	3.89	0.52	1.50	8.71
3	2.72	5.35	0.32	0.77	9.17
Big	1.59	9.46	0.29	0.35	11.69
Liquid	1.29	15.40	0.16	0.09	16.94

This table shows the fraction of trading, measured by the volume in euros, conducted in call auctions and relative to the total trading volume, for non-liquid stocks, sorted by market capitalization quartiles at the beginning of the two sample periods, and liquid ones.

Table 3: Market shares in call auctions

	2011						2013					
	any participation			volume in euros			any participation			volume in euros		
	Agency	DMM	Principal	A	DMM	P	A	DMM	P	A	DMM	P
A: Participation by market capitalization quartile and liquidity class												
Small	89.54	36.98	47.47	69.84	9.80	20.36	89.54	25.02	65.36	72.09	4.44	23.46
2	89.16	32.31	63.61	65.16	6.12	28.72	89.86	27.64	70.21	57.80	6.19	36.01
3	92.25	30.65	76.05	57.21	5.37	37.42	93.92	20.73	81.66	49.73	4.27	46.00
Big	94.13	27.74	85.07	44.91	3.03	52.06	94.81	15.30	91.34	43.61	1.69	54.71
Liquid	97.50	13.57	95.88	39.47	0.34	60.19	96.82	8.98	99.41	43.44	0.11	56.45
B: Participation by type of call auction												
Open	97.35	30.32	76.29	61.70	2.09	36.21	94.55	22.36	84.63	56.48	1.58	41.94
Close	91.03	22.13	95.19	37.10	0.35	62.54	93.58	15.26	96.74	42.14	0.21	57.65
Intraday	92.21	13.47	73.35	40.83	7.08	52.09	93.06	8.77	77.72	54.44	1.82	43.75
Volatility	92.02	36.07	56.78	67.14	4.49	28.37	94.50	37.61	60.05	64.90	4.04	31.06

This table shows the fractions of call auctions with non-zero participation and the share of trading, measured by the trading volume in euros, for agency traders, designated market makers (DMM), and principal traders. The left part of the tables shows data from 2011, the right part from 2013. Panel A reports results separately for non-liquid stocks, sorted by market capitalization quartiles at the beginning of the two sample periods, and liquid ones. Panel B reports results sorted by type of call auction.

Table 4: Cross-sectional fractional logit regression of participation shares of designated market makers

	2011				2013			
	Open	Close	Intraday	Volatility	Open	Close	Intraday	Volatility
Log Market cap.	-1.542**	-1.296**	-3.671**	-1.369	-1.559**	-1.836***	-1.296	1.074
	(-1.97)	(-2.11)	(-2.11)	(-1.45)	(-2.25)	(-4.41)	(-1.48)	(0.81)
Share turnover (relative)	-5.743***	-2.849***	-2.540**	-3.423***	-4.990***	-2.583***	-5.836***	-3.614***
	(-5.48)	(-3.60)	(-2.40)	(-3.19)	(-5.34)	(-4.51)	(-4.69)	(-2.67)
Price impact 5m	-0.839	-0.056	-1.947	-0.072	0.564***	0.157	0.606***	0.614
	(-1.04)	(-0.10)	(-0.97)	(-0.08)	(3.62)	(1.39)	(2.91)	(1.06)
MDAX	-3.396**	-3.514***	9.889***	-5.592***	-2.839**	-2.251**	-1.432	-7.810***
	(-2.57)	(-3.69)	(2.65)	(-3.80)	(-2.07)	(-2.39)	(-0.81)	(-3.13)
TecDAX	-0.826	-2.998***	-3.598***	-3.670*	0.203	-1.131	1.041	-4.575*
	(-0.49)	(-3.17)	(-3.01)	(-1.78)	(0.13)	(-1.20)	(0.49)	(-1.66)
SDAX	1.907	-0.393	3.191	-0.737	2.606**	0.419	0.189	-3.388
	(1.50)	(-0.38)	(1.49)	(-0.55)	(1.97)	(0.51)	(0.16)	(-1.38)
Observations	250	250	229	246	209	209	207	174

This table shows marginal effects obtained from fractional logit regressions explaining the share of designated market maker trading in each type of call auction. The left part of the table provides results for 2011, the right part for 2013. The explanatory variables comprise the natural logarithm of the market value of equity as of the beginning of the respective sample period, share turnover, the ratio of total trading volume and the market value of equity, the average 5 min price impact, and dummy variables indicating whether a stock is among the constituent stocks of the midcap index MDAX, the technology stock index TexDAX, or the smallcap index SDAX. The independent variables, except for the indicator variables, are standardized and the coefficients are expressed in percentage points. Standard errors are robust to heteroskedasticity. T-statistics are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% or 10% level, respectively.

Table 5: Fractional logit regressions of participation share of designated market makers

	Open	Close	Close	Intraday	Intraday	Volatility	Volatility
Log Auction Volume	-2.600***	-2.155***	-2.157***	-0.911***	-0.922***	-3.936***	-4.019***
	(-10.40)	(-14.88)	(-14.91)	(-2.86)	(-2.86)	(-9.09)	(-8.85)
Absolute return previous 5m		0.127		0.199		1.050***	
		(1.64)		(0.86)		(2.67)	
Absolute return previous 30m			0.466***		0.307**		0.720
			(4.49)		(2.33)		(1.26)
Observations	15515	17035	17035	9464	9462	7217	6408

This table shows marginal effects obtained from fractional logit regressions explaining the participation share of designated market makers in opening auctions, closing auctions, regular intraday auctions, and auctions after volatility-induced trading halts. The independent variables are the standardized absolute value of the quote midpoint return in the 5 or 30 min interval immediately preceeding the auction and the natural logarithm of the auction euro volume. Standard errors are clustered by stock and date. T-statistics are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% or 10% level, respectively.

Table 6: Determinants of auction returns

	Close	Close	Close	Intraday	Intraday	Intraday	Volatility	Volatility	Volatility
DMM share (signed)	-0.332***	-0.337***	-0.335***	-0.245***	-0.247***	-0.247***	-0.585***	-0.603***	-0.614***
	(-4.36)	(-4.40)	(-4.38)	(-6.26)	(-6.29)	(-6.29)	(-3.35)	(-3.39)	(-3.40)
Return previous 5m		-0.180***			-0.093			-0.090***	
		(-3.70)			(-1.64)			(-3.67)	
Return previous 30m			-0.025			-0.037**			-0.050**
			(-1.45)			(-1.99)			(-2.10)
Constant	0.031*	0.034**	0.032*	0.010	0.011	0.012	-0.059	-0.059	-0.069
	(1.89)	(2.03)	(1.90)	(1.23)	(1.31)	(1.41)	(-0.90)	(-0.92)	(-1.14)
Observations	17035	17035	17035	9464	9464	9462	7456	7217	6408

This table shows results of OLS regressions explaining the signed return from the quote midpoint immediately prior to the auction to the auction price. Explanatory variables are the signed market maker participation, computed as the signed market maker trading volume divided by the total volume traded in the respective auction, and standardized quote midpoint returns in either the 5-min or the 30-min interval immediately preceeding the auction. Standard errors are clustered by stock and date. T-statistics are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% or 10% level, respectively.

Table 7: Market maker impact on close-open and open-close returns

	Close-Open	Open-Close
DMM Open Net-Buying	-0.724***	0.327***
	(-6.46)	(2.81)
DMM Close Net-Buying	0.315***	-0.506***
	(3.49)	(-3.65)
Constant	-0.007	0.007
	(-0.72)	(0.41)
Observations	12159	12766

This table shows results of OLS regressions of the returns from the previous close to the open and from the open to the close as explained by designated market makers' signed trading, as a share of total volume in the respective opening and closing auction. Returns are adjusted for the corresponding sample average on the day. Standard errors are clustered by stock and date. T-statistics are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% or 10% level, respectively.

Table 8: Returns Before and After Call Auctions

	5m to Auc.	10m to Auc.	15m to Auc.	5m from Auc.	10m to Auc.	15m from Auc.
A: Volatility Auctions						
DMM Net-Buying	-0.746***	-0.825***	-0.898***	-0.009	0.000	0.031
	(-3.49)	(-3.68)	(-4.14)	(-0.06)	(0.00)	(0.19)
Constant	-0.028	-0.118	-0.153	-0.142*	-0.143*	-0.133
	(-0.35)	(-1.24)	(-1.33)	(-1.95)	(-1.76)	(-1.60)
Observations	6516	6305	6172	6832	6804	6781
B: Intraday Auctions						
Market Maker Net-Buying	-0.271***	-0.288***	-0.301***	0.146***	0.148***	0.143***
	(-6.67)	(-6.84)	(-7.03)	(3.72)	(4.13)	(3.88)
Constant	0.022**	0.036***	0.042***	-0.017*	-0.012	0.002
	(2.20)	(2.66)	(2.64)	(-1.67)	(-0.92)	(0.10)
Observations	8562	8560	8560	8562	8562	8562

This table shows results of OLS regressions of the returns from the quote midpoints 5, 10, and 15 min before call auctions to the auction price, and from the auction price to 5, 10, and 15 min after call auctions, as explained by designated market makers' signed trading, as a share of total volume in the respective call auction. Panel A reports the results for volatility auctions, Panel B for intraday auctions. Standard errors are clustered by stock and date. *T*-statistics are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% or 10% level, respectively.

Table 9: Price impacts when different participants trade in call auctions

	Agency	DMM	Principal
A: Opening Auctions			
Price Impact 5m	-0.046***	-0.019	0.069***
	(-2.81)	(-0.41)	(2.81)
Price Impact 1h	-0.073***	-0.009	0.110***
	(-2.76)	(-0.10)	(2.75)
Price Impact Close	-0.213*	0.293	0.313*
	(-1.93)	(1.47)	(1.89)
B: Volatility Auctions			
Price Impact 5m	-0.092***	0.214***	0.174***
	(-3.62)	(2.61)	(3.21)
Price Impact 1h	-0.100**	0.341***	0.173
	(-2.19)	(4.01)	(1.62)
Price Impact Close	-0.085	0.649***	0.092
	(-1.12)	(3.56)	(0.55)
C: Closing Auctions			
Price Impact Next Open	0.038*	0.109	-0.025*
	(1.84)	(0.86)	(-1.89)
D: Intraday Auctions			
Price Impact 5m	-0.026*	0.213***	-0.000
	(-1.82)	(14.34)	(-0.01)
Price Impact 1h	-0.064***	0.186***	0.036
	(-3.46)	(3.21)	(1.53)
Price Impact Close	-0.070**	0.209**	0.040
	(-2.53)	(2.36)	(1.30)

This table provides information on returns (i.e., price impacts), value-weighted by trade size, earned by traders of the three different categories (agency traders, principal traders and designated market makers) when trading in the different types of call auctions. For closing auctions, returns are computed from the auction price to the next day's opening price. For the other auctions, returns are computed based on quote midpoints 5 min and 60 min after the auction, and for the return based on the same day's closing price. T-statistics, in parentheses, are computed based on WLS regressions of price impacts on a constant with standard errors clustered by stock and date.

Table 10: Market maker's Sharpe ratios by auction type

	Close	Intraday	Open	Volatility
5 min	NA	9.72	-0.26	1.92
1	NA	3.94	-0.08	1.88
Close	NA	2.32	1.52	2.36
Next Open	0.72	3.36	0.65	1.49

This table shows the annualized Sharpe ratios earned by designated market makers by auction type and considering different return horizons.

Table 11: Market maker profit per auction net of fees, including auctions with DMM trading but zero net position

	Close	Intraday	Open	Volatility
Profit (€)	11.581	25.020	22.075	31.523
Observations	2250	924	3428	1990

This table shows the profits per auction earned by designated market makers in call auctions. The profit is calculated by multiplying the signed trade size by the return from the call auction to the closing price, with the exception of closing auctions, for which the return is calculated to the next day's opening price, and adjusted for trading fees.

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