Trading European Sovereign Bonds
The Microstructure of the MTS trading platforms *

Yiu Chung Cheung, Frank de Jong and Barbara Rindi

University of Amsterdam and Bocconi University

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Keywords: Bonds markets, Microstructure, Order flow

JEL codes: F31, C32

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1 Introduction

In recent years, the microstructure of financial markets has received considerable attention in the academic literature. Most of the substantial empirical work in this area pertains to stock markets. Given the emphasis on stock markets in the theory and the availability of data, this is understandable. On the other hand, in terms of both capitalization and trading volume, fixed income (bond) and foreign exchange markets are bigger than stock markets. Research on bond and foreign exchange markets is also interesting because of their special structure. Both markets are centered around a large number of professional dealers. Outside customers trade with the dealer of their choice. Volume is high and interdealer trading is frequently being observed. The interdealer trading is even bigger than the trading with outsiders. Lyons (2001) estimates that about 2/3 of the FX trading is interdealer. Due to its obvious importance, empirical research on the microstructure of bond markets has increased in recent years.[1]

In this paper we study the microstructure of the MTS Global Market system, which is the most important European interdealer government bond trading system. This system is composed of a number of trading platforms on which designated bonds can be traded. The trading system is fully automated and effectively works as an electronic limit order market. The structure of the MTS trading platforms is very similar to the EBS and D2002 electronic trading system for the foreign exchange market, but different from the quote screen-based US Treasury bond trading system. A study of this market is particularly interesting. There are two striking features which are worth investigating when looking at the microstructure of the MTS system.

The first interesting feature of the MTS trading platform is its organizational setup. The MTS trading mechanism consist of two types of trading platforms: a set of country specific ("domestic") platforms and a pan-European platform (EuroMTS). The range of securities traded on the domestic platforms is much larger than on the EuroMTS trading platform. For example, 55 BTP bonds are traded on the Italian market while just 11 of these bonds are traded on the EuroMTS system as of January

[1] For example, Umlauf (1993), Fleming and Remolona (1997, 1999), Scalia (1998), Fleming (2001) Cohen and Shin (2003) and Goldreich, Hanke and Nath (2003) for the US Treasury market. Proudman (1995) for the UK bond markets, Albanesi and Rindi (2000) and Massa and Simonov (2001a,b) for the Italian market.

2003. A bond trader on the domestic trading platform can therefore offer a much wider range of bonds to its clients. At first sight, EuroMTS therefore seems redundant as all bonds being traded on this market are also traded on the domestic trading system. In this, we provide a comparison of the trading costs and price dynamics on the domestic MTS markets and EuroMTS by calculating comparative measures of liquidity, such as the quoted and effective spread. If there are any differences in trading costs between both markets, this may justify the, at first sight redundant, existence of the EuroMTS trading platform. Hence, the first objective of this paper is to test for differences in trading costs between the local and the EuroMTS platforms.

We now discuss the second interesting feature. The MTS Global Market system is a pure interdealer platform with competitive market making. This allows us to study the price and order flow dynamics under such a market structure, which is quite different from equity markets. In particular, we study trading intensity and its relation to price and order flow dynamics. The usual theories of trade intensity do not explicitly take the role of interdealer trading into consideration. Single dealer models like Kyle (1985) and Easley and O'Hara (1992) argue that there exist a positive relation between information and trading intensity as more informed traders are active during large market activity. This means that any unexpected trade during active trading has a higher impact on prices. Empirical results by Dufour and Engle (2000) and Spierdijk (2002) indeed suggests that a higher trading intensity is related to a stronger price impact of trades. On the other hand, Diamond and Verrechia (1987) argue that short sale constraints will lead to a delay of bad news as informed traders are constrained from short selling. The expected price impact of trades arriving after a longer period of inactivity is therefore higher.

The literature on interdealer trading may shed a different light on these results. Manaster and Mann (1996), Hansch, Naik and Viswanathan (1998) and Reiss and Werner (1998) show that dealers use interdealer trading to control their inventory position. Ho and Stoll (1983) show that interdealer trading is more costly compared to outside customer trading because dealers have to pay a fee (to the other dealer) rather than receiving a fee (from an outside customer). In addition, Garman (1976) shows that there is less need to adjust the spread as traders enter the market on a frequent basis, which by definition occur during high market activity. Next to these searching costs, interdealer trading can also result in a repeated passing of inventory among dealers as they have the moral obligation to quote prices. Lyons

(1997) calls this repeated passing of inventory "hot-potato" trading and he shows that this creates noise in the pricing process when dealers are risk averse and speculative. In other words, a dealer's decision to conduct an interdealer trade depends on his ability to offset his inventory using customer order flow. Not only is direct trading with customers less costly for the market maker compared to interdealer trading, it also avoids the "hot-potato" process. This means that the price impact of a trade is much larger during periods where trading intensity is low because customer flows are scarce. Our data provides an opportunity to test this.

It is important to notice that our rationale in predicting price movements through order flow is built on inventory control and the costs associated with interdealer trading. However, market circumstances may create urgency to trade and if this urgency becomes the dominant factor, our arguments become invalid. Fleming and Remolona (1999), Balduzzi, Elton and Green (2001) and Cohen and Shin (2003) show that the largest price movements in government bond markets arises after the announcement of macroeconomic news. We therefore take this announcement effect into account. Green (2004) and Fleming (2001) documented a higher adverse selection component in government bond markets after the announcement of macroeconomic news due to stronger trading activity. This resulted in an increased information asymmetry. The same was found by Cao and Lyons (1999) and Lyons (2001) for foreign exchange markets. Because trading intensity is typically high during these periods, one can argue that prices become more sensitive to trading intensity as the urgency to trade is more important than the interdealer costs. However, even during announcement days, we can distinguish between periods with active and less active trading. For example, we find strong trading intensive periods when markets open in the morning or when the US market opens. On the other hands, lunch periods are typically less busy. These patterns can also be found during annoucement days where, in addition, the markets are less busy during periods before the actual announcement is made. Moreover, trading picks up rapidly right after the announcement. Green (2004) for example states that after the announcement "market participants actively watch trading to help determine the effect of economic news". Hence, the more trading activity, the better signal the dealer receives with respect to the true impact of economic news. In our empirical study, we also find that the impact of order flows is larger during days with macroeconomic news announcements.

Our results can be summarized as follows. Despite the apparent fragmentation of trading on domestic platforms and EuroMTS, the markets are very similar in terms of liquidity. As for the price and order flow dynamics, we find that order flows are strongly autocorrelated but the correlation gradually decreases with the time since the previous transaction. The price impact of a trade in periods with low trading intensity is larger than in a period with a relative high trading intensity and therefore contrasts the findings of Dufour and Engle (2000) and Spierdijk (2002) for stock markets. It instead supports the findings of Cohen and Shin (2003) and Green (2004) for the US fixed income market.

The setup of this paper is as follows. Section 2 briefly reviews the literature. Section 3 describes the MTS trading platform and the dataset. Section 4 focuses on liquidity, measured by quoted and effective bid-ask spreads. Section 5 analyzes the impact of order flows and trading intensity on price discovery in the domestic and EuroMTS platforms for the Italian 10-year benchmark bond. Section 6 concludes the paper.

2 Literature review

We first briefly review the literature on fragmentation of markets. This literature is extensive, but a few papers seem particularly relevant for the MTS system case with its distinction between local platforms and EuroMTS. Biais (1993) studies fragmentation of markets a setting in which there are competing markets (or market makers). Traders can shop around and find the lowest cost trader. The key assumption for fragmentation is that the market makers do not observe each other's quotes. In a centralized market, the quotes (or limit orders) are visible. Surprisingly, Biais concludes that the bid-ask spreads in fragmented and centralized markets will be the same. De Frutos and Manzano (2002) reach similar conclusions, where liquidity traders actually prefer to trade in fragmented markets. However, these results are debated by Yin (2004), who shows that in the presence of search costs, spreads in fragmented markets will be higher and liquidity traders prefer a centralized market. For the MTS setting, search costs are very low (the price and quantity information for EuroMTS and the local platform is shown on the same screen) and therefore MTS effectively looks like a centralized market.

Chowdhry and Nanda (1991) study a setting with two competing trading platforms. Some small liquidity traders are restricted to trade on one platform only, but other (large, institutional) liquidity traders and informed traders can trade in both market places. This resembles the setting for MTS, where some smaller traders are restricted to the local platform, but large traders and market makers operate on both platforms. An interesting conclusion of the Chowdhry and Nanda paper is that there is a concentration of trading in the location with the largest number of small liquidity traders who cannot split their orders. They call this a "winner takes most" feature; liquidity on the "winner" market is also higher. For the MTS system, this would imply a concentration of trading on the local platform, which would also exhibit lower transaction costs. However, the Chowdhry and Nanda result depends on the assumption of no cross-market information flow. For the MTS platforms, the information flow is virtually perfect and this concentration of trading and the differences in liquidity need not result.

We now turn to the literature on dealership markets. Although the importance of competition between market makers has been known for a long time, some influential papers like Stoll (1978), Copeland and Galai (1983) and Kyle (1985) focus on the behavior of a single market maker. There is however a small but important collection of theoretical papers on the behavior of market makers in a competitive setting. In these papers a crucial role is played by inventory. Ho and Stoll (1983) analyze the impact of inventory on trading behavior and argue that market makers having the largest long (short) position are first sellers (buyers). Biais (1993) analyzed the equilibrium number of traders in a competitive market setup and shows that the number of interdealer trades depends on the volatility of the security and the trading activity in the market. He also finds that the quoted spread around his reservation price is a decreasing function of the inventory. This supports the findings of Ho and Stoll. Lyons (1997) focuses specifically on order flow among dealers rather than inventory control. He finds that the repeated passing of inventory among dealers (the 'hot potato' effect) creates additional noise in the order flow as dealers influence the pricing directly. This creates noise which in turn makes it harder for dealers to infer the true price of a security.

There is also empirical documentation on interdealer trading. Manaster and Mann (1996) use CME Futures transactions and find evidence that futures floor traders manage their inventory on a daily basis. They find that active sellers have most likely the largest long position supporting the competitive dealer model of Ho-Stoll

(1983). In contrast to what inventory models predict, they find that an increase in the market makers position is done at less favorable prices. This suggests that market makers not only provide a service to their clients for providing liquidity, but also are active investors willing to increase their position to speculate. Reiss and Werner (1998) provide a detailed study of inventory control among market makers on the London Stock Exchange. Using trading data, they test several hypotheses with respect to interdealer trading and find that 65% of all interdealer trades are used to reverse positions. This suggests that market makers use interdealer trades to reduce inventory risk. Hansch, Naik and Viswanathan (1998) also use trading data from the London Stock Exchange and find that the mean reverting component in interdealer trades varies over time. There are periods in which inventory moves stronger back to its long run average. Overall, they find that this mean reversion component is stronger compared to the traditional specialist markets as found by e.g. Madhavan and Schmidt (1993). This suggests that it is easier to manage inventory using interdealer trading.

Both the Reiss-Werner and Hansch, Naik and Viswanathan papers analyze the motives and characteristics of interdealer trades. They do not however analyze the impact of these trades on price dynamics. We think that trading activity and order flow are important in the price process. Specifically, we expect trades in an interdealer system during busy periods to have a smaller impact on prices than during quiet periods for several reasons. The first reason is the search costs involved in inventory control. Hansch, Naik and Viswanathan's argument of changing mean reversion in inventory depends on the search cost for a counterpart. To unwind a position, a market maker can choose to wait until a trader enters the market or conduct an interdealer trade. Hence, the market maker may choose to trade immediately through the interdealer channel (paying the other market makers bid-ask price) or to wait (receiving his own bid-ask price). Hence, the potential costs of market making is lower during busy periods as it is more likely that another trader enters the market in a reasonable time avoiding the more costly interdealer trading. Closely related to this point is the argument of Reiss and Werner who argue that the direction of trade depends on the anticipation of a trade, which emphasizes the importance of order flows in the price process. If a market maker anticipates incorrectly, he can correct his mistake more easily when trades arrive frequently.

The second reason for time varying price impact lies in the information value of order flow. The type of private information in government bond market is fairly different from the information in stock markets, but comparable with the client based order flow information found by Lyons (1997) and Evans and Lyons (2002) for the foreign exchange market. These papers show that client based order flows also has a persistent impact on prices and market makers may therefore narrow their spreads to attract customer flows. The information acquired by market makers in these markets is long lived (compared to stock markets) and a market maker who observes a great deal of order flows can hold such information over time as there is no need to exploit this unique information as soon as possible. Therefore, a trade after a long time is more likely to be conducted by an informed trader. Moreover, Kaniel and Liu (2003) show that informed traders tend to use more limit than market orders when information is long lived resulting in a larger net supply of liquidity, smaller bid/ask spread and a smaller price impact of trades.

In analyzing the price impact of order flow, it is also important to control for macro-economic announcements. Fleming and Remolona (1999), Balduzzi, Elton and Green (2001) showed that macro-economic news produces an important impact on bond prices as the largest price movements arises in days with economic announcements. These papers find that before the announcement, trading intensity and price volatility is low while bid-ask spreads are high. Green (2004) documented a higher adverse selection component after the announcement of news and argues that this is due to an increase in trading activity. Dealers absorbing a large portion of order flow may have superior information about short term price directions. This informational advantage will result in a dispersion of information among dealers and an increase in information asymmetry in the market. This rationale is fully consistent with the order flow information models by Lyons and Cao (1999), Fleming (2001) and Lyons (2001). Green (2004) also finds that prices are more sensitive to order flow in a period of increased liquidity after a scheduled announcement. The same pattern is also documented by Cohen and Shin (2003), who conducted a comparable analysis for the US bond market. By dividing their dataset into days with and without announcements, they find that the effect of trades on return is higher on busy (announcement) days compared to days with relative low trading intensity.

Summarizing, order flow and trading intensity play an important role in interdealer trading. Moreover, inventory costs associated with market making are negatively correlated with trading intensity, for two reasons: Not only does it become easier to control inventory as the number of people entering the market is large, and the market maker can avoid the more costly interdealer trading. At the same time, the informational content of order flow can be extracted and analyzed. It is therefore important to take the role of these factors into account when analyzing the price process in a multiple dealer market.

3 Market Description and Data

The European bond market has a much richer menu of bonds than the US market because there are many more issuing countries. Although the European capital market has integrated considerably in the last number of years, mainly through the introduction of a single currency, European bonds still differ in their credit rating, which varies from AA2 for Italy to AAA for Austrian, Dutch, French and German bonds (based on Moody's credit rating).

There are two ways in which bonds can be traded in the secondary market. The traditional way is through an organized exchange but trading volume is fairly low. The second way is through the OTC market in which the main players are banks, most of them also participating in the primary auctions. Of particular interest in the OTC market is the MTS (*Mercato dei Titoli de Stato*) system. This system turned out to be successful by gaining a considerable market share since its creation in 1988 by the Bank of Italy and the Italian Treasury. Nowadays MTS is managed by a private company. The MTS system is an interdealer platform and therefore not accessible to individuals. A recent quarterly bulletin by the Italian treasury reports that some 6.4 billion euro of BTPs were traded per day in 2002 by the MTS trading platform. According to an older paper by the Italian debt office, this accounts for some 65% of all secondary market activities.[2]

The MTS market was introduced in Italy in 1988 in order to enhance trading in the secondary market for Italian government bonds, which already existed as an over-the-counter market. In order to improve market depth and activity, MTS was reformed in 1994 which created the basis of the current MTS trading system. Privatization

[2] This information can be found in Quarterly bulletin-3rd quarter 2002 and "The Italian Treasury and Securities Markets: Overview and Recent Developments", Public Debt Management Office, March 2000.

of the MTS system into MTS Spa took place in 1997 and later in 1999 EuroMTS was created. In 2001, EuroMTS and MTS Spa merged into MTS Global Market, becoming the largest interdealer market for Euro-denominated government bonds. Since the end of the nineties, the MTS system expanded to other Euro-denominated markets and is now successfully operational in a number of other Eurozone countries.[3] On these platforms only Government bonds and bills are traded. In April 1999 the EuroMTS system was launched. This electronic trading platform provides trading in European government benchmark bonds as well as high quality non-government bonds covered by either mortgages or public state loans.

Although there are different requirements for participants depending on the market of operation, we can categorize all participants either as market makers or as market takers. Market makers have market making obligations as they have to quote all assigned bonds in a two-way proposal for at least five hours a day. Table 1 gives us an overview of participants on the MTS trading system. As we can see in this table, the largest parts of the participants are market makers creating a very competitive trading platform. The only exception can be found for the Italian market where more than 60% of all participants are market takers. Most of the market makers are also active on both platforms. With respect to the identity of the market makers, large market makers have access to both markets while smaller traders tend to participate only in the local platform. The large numbers of market makers active on both trading platforms suggest no competitive advantages in terms of quoting rights. In the early years, the system knew full transparency, but in 1997 anonymity was introduced in order to avoid free-riding.[4]

Proposals must be formulated for a minimum quantity equal to 10, 5 or 2.5 million euro depending on the country of issue and maturity of the bond. Every market maker can post the entire quantity that he is willing to trade (block quantity) or a smaller amount (drip quantity) while taking into account the minimum quantity required. In the latter case, the remaining quantity will remain hidden to the market.

[3] MTS is operational in Finland, Ireland, Belgium, Amsterdam, Germany, France, MTS Portugal and Spain. The MTS system is also operational in Japan. Because we focus on Euro-denominated markets, we leave MTS Japan out of our analysis.

[4] Massa and Simonov (2001b) showed, by analyzing MTS data before and after anonimity was introduced, that free-riding existed as the reputation of a market maker had impact on the price process.

A maximum spread of these proposals exists and is prespecified depending on the liquidity and maturity of the security.[5] No obligations apply to market takers (they can only buy or sell at given prices). The quoted proposals are firm, i.e. every trader can hit a quoted proposal and trading is guaranteed against that quote. Effectively, the MTS system works as a limit order book, as orders in round lots are executed automatically according to price and time priority. Odd lots are subject to the market makers' acceptance. Finally, the super best page shows the best price for bonds listed on both the local MTS and the EuroMTS. This will allow market makers with access to both markets to see the best price. A market maker who has access to both markets can choose parallel quotation, i.e. simultaneous posting of proposals on the domestic and the EuroMTS platform. All trades are anonymous and the identity of the counterpart is only revealed after a trade is executed for clearing and settlement purposes.

Our dataset covers every transaction of Italian, French, German and Belgian government bonds traded on the MTS platforms from January 2001 until May 2002. The data records include the direction of the trade (buy or sell) and a very accurate time stamp. These data allow us to study a number of market microstructure issues in detail. Table 2 shows us the volume in the various markets including the number of transactions. A total of 867.901 trades took place reflecting more than 4.9 trillion euro of market value. The Italian bond market is by any means the largest market in our dataset. Some 83% of all transactions stems from trading activities in Italian securities. We also have trading data on the two largest AAA-rated bond markets in our dataset, France and Germany. These countries have a trading volume of 460 billion and 233 billion respectively. Although the German market is accepted as the benchmark for euro denominated government bonds due to the large liquidity and its triple 'A' status, the trading volume in German bonds on MTS is fairly low. There are a few reasons for this. First, the EUREX Bond trading platform is comparable to MTS system and offers (among other products) trading in all fixed income instruments of the federal republic of Germany. Second, the existence of successful futures contracts on the EUREX and LIFFE has provided investors a low cost margin based trading mechanism for all German bonds. The last bond market

[5] The longer the maturity the higher the maximum spread. A market maker is allowed to propose a quotation larger than this maximum spread. However, activities based on these trades are not added to his performance record.

that we study is Belgium with a trading volume of 316 billion euro.

Table 2 also shows the percentage of trading activity taken place on the local and EuroMTS platforms. German securities are mostly traded on EuroMTS together with the French medium term notes. Italian and Belgian securities are rarely traded on EuroMTS as most transactions take place on the local platform. The average trading size in Belgian, French and German long-term securities are quite comparable with more than 7 million euro per trade while the average trading size in Italian securities stands at 5.3 million euro. Because of the requirements with respect to the minimum lots being traded we counted the number of 2.5, 5 and 10 million euro trades. More than 95 percent of all trades have 2.5, 5 or 10 million of market value with the exception of the Italian securities, where there is a relative large fraction of odd-lot trades. The reason for this difference is the relative small size of the participants on the domestic Italian platform.

4 Liquidity on the MTS Market

In this section we study the transaction costs on the MTS system. Our first measure of trading costs is the volume weighted quoted spread (VWQS). This is a measure of the depth of the limit order book associated to a specific transaction size, and will reflect the implicit cost for an immediate transaction of a given size. We adapted the indicator of liquidity that Benston et al. (2000) suggested for gauging the ex-ante committed liquidity of a stock market organized like a limit order book. Let B_0 denote the inside bid price and A_0 the inside ask price with $B_h > B_{h+1}$ and $A_h < A_{h+1}$ respectively. Let the euro amount of bonds offered or requested at these prices be Q_h^z with $z = ask, bid$ and let the trade size be $L = 5, 10, 25$ million euro, respectively.[6] Define the indicator I_h^z as:

$$I_h^z = \begin{cases} 1 & \text{if} \quad L > \sum_{i=1}^{h} Q_i^z \\ Q_h^{-z} \left[L - \sum_{i=1}^{h} Q_i^z \right] & \text{if} \quad \sum_{i=1}^{h-1} Q_i^z < L < \sum_{i=1}^{h} Q_i^z \\ 0 & \text{if} \quad \text{otherwise} \end{cases} \tag{1}$$

Expressions (1) tell us that a market is least liquid if the trading size L is larger than aggregated demand or supply up to price h in the limit order book. As a result, an

[6]These transaction sizes are the most frequently traded in MTS Global Market.

order cannot be filled at price h and the liquidity indicator is therefore $I_h^z = 1$. In the most liquid market however, a trading size L will be filled at the inside spread and therefore $I_0^z = 0$. The volume weighted quoted spread associated to a trade size equal to L is

$$VWQS(L) = \frac{2\left[\sum_{i=0}^{\infty} I_h^{ask} A_h Q_h^{ask} - \sum_{i=0}^{\infty} I_h^{bid} B_h Q_h^{bid}\right]}{L\,(A_0 + B_0)} \tag{2}$$

Table 3 reports the Volume Weighted Quoted Spread measure for benchmark bonds of Belgium, France, Germany and Italy, on the domestic and EuroMTS platforms. The estimates are based on data from 4-8 and 11-15 February 2002.

Our findings are that the quoted spread is similar across countries and for class A (1-3.5 years time to maturity) and B (3.5-6.5 years) bonds, around 2 or 3 cents from the best prevailing midquote. For class C (6.5-13.5 years) bonds, the quoted spreads are slightly larger than for the A and B class. The Italian market is more liquid than the others for class C bonds, probably because it includes the heavily traded 10 year BTP bonds. The quoted spread is substantially larger for the longest maturity bucket D (13.5 to 30 years), ranging from 11 to 18 cents, depending on maturity and country. This pattern is consistent with the findings in Amihud and Mendelsohn (1991), who show that the bid-ask spread is higher in US treasury notes compared to more liquid US T-bills.

An interesting finding is that the market is very deep, i.e. the quoted spread for large orders is only marginally larger than the quoted spread for standard size orders. For example, for the Italian 10 year benchmark bond the quoted spread for a standard 5 million trade is 3 cents, for a large trade of 25 million the quoted spread is still below 4 cents. This pattern is similar for the other bond classes and countries. In practice, trades larger than 10 million euro are rare. Observe that the quoted spreads on the EuroMTS platform are always slightly larger than on the domestic MTS platforms, but the pattern across bond classes and countries is exactly the same as on the domestic MTS systems.

Of course, the quoted spread may include periods where there is little trading and may give an inaccurate indication of actually incurred trading costs. Therefore, we also calculate measures of the effective spread, defined as twice the difference between the transaction price and the midpoint of bid and ask quotes

$$\hat{S}_{eff} = \frac{1}{T}\sum_{t=1}^{T} 2I_t(p_t - m_t) \tag{3}$$

where p_t is the transaction price, m_t the prevailing midquote at the time of the trade, and I_t the buy/sell indicator ($I_t = +1$ if the trade is initiated by the buyer, $I_t = -1$ if it is initiated by the seller). In our dataset we do not always observe p_t and m_t exactly at the same time, but we select the midquote that was posted closest before the time of the transaction. The realized spread compares the transaction price p_t and the subsequent midquote, m_{t+1}. Here we use a similar definition,

$$\hat{S}_{realized} = \frac{1}{T}\sum_{t=1}^{T} 2I_t(p_t - m_{t+1}) \tag{4}$$

It is obviously not always the case that the trade price is above/below the subsequent midprice for buyer/seller initiated trades, as the market may have moved. Therefore, the realized spread measure may be negative.

Table 4 shows the estimates of effective and realized spread. The table shows that the realized spread is always smaller than the effective spread. The numbers, however, are sometimes quite large and the estimates of the effective spread are probably not very accurate due to the mismatch in time between trades and midquote. Table 4 also provides the outcome of testing whether the effective (realized) spread on the EuroMTS is significantly different from the effective (realized) spread on the domestic platforms. As we can see, there can be a difference in realized spreads but this only occurs for a small number of bonds.

We now turn to a final measure of the spread. We use a measure that is based on transaction prices only: the spread based on absolute price changes between two transactions

$$S_{APC} = \frac{1}{n}\sum_{t=1, j\neq z}^{n} \left| p_{t+1}^{j} - p_t^{z} \right| \tag{5}$$

where $j = ask, bid$ and $z = bid, ask$. Table 5 reports estimates of the spread based on absolute price changes for the same menu of bonds as before. The results confirm the pattern that we found for the quoted spreads. Estimated spreads are increasing with maturity, and on average are slightly higher on EuroMTS. Moreover, the estimated spread of the long bonds is somewhat smaller in the Italian securities compared to the estimated spread in Germany and France. Figure 1 shows the same information graphically. Table 5 also includes a test to see whether there exist significant differences between EuroMTS and the local trading platform. Some differences exist but the overall conclusion is that spreads across the different platforms are the same.

Finally, we take a quick look at intraday spread patterns. Figure 2 shows the intraday pattern of quoted spreads for the most actively traded issue, the Italian 10-year bond. The quoted spreads shows a typical U-shaped pattern. The trading day starts with a relatively large spread around 3 cents in the early morning, falling to 2 cents in the late morning and gradually increasing to 4 cents in the late afternoon. Scalia (1998) also studied intraday volume and spread patterns on MTS, but his dataset is from 1992-1993 when the MTS market structure was not anonymous and the day trading day contained a lunch break. He found a U shaped spread pattern in the pre-lunch trading hours. Figure 3 shows the intraday pattern of effective and realized spread for the 10 year Italian bond. Again, a U-shaped pattern is observed.

Summarizing these results, this section provides insight into the pricing behavior of market makers on both the local and EuroMTS trading platforms. The results show that the spreads in the bond market are very small, between 1 and 3 basis points for the issues with maturities up to 10 years. The 30 year issues have somewhat higher spreads. The spreads are smallest for the most actively traded issues such as the Italian 10 year bonds. The MTS order book for the benchmark bonds is also very deep as the quoted spreads are only marginally different for larger trade sizes. By analyzing intraday patterns of the spread, we find a U-shaped pattern for the quoted spread. For some securities, there are small differences between the spreads of the domestic trading platforms and EuroMTS. The differences however are small and economically insignificant. Hence, we find only very weak evidence for the fragmentation effects predicted by the Chrowdhy and Nanda (1991) model. A likely explanation for this result is that the MTS trading platforms are very closely linked in their provision of price and trade information and the two platforms effectively operate as one integrated market. Moreover, liquidity differences cannot justify the existence of the EuroMTS system and this makes EuroMTS an unnecessary superstructure. Stated differently, the existence of the EuroMTS platform cannot be justified by differences in pure trading costs and liquidity issues.

5 The Price Impact of Trading

The analysis in the previous section provides us some useful insights in the trading costs on the MTS trading platforms. The measures of liquidity used sofar are however static and a dynamic structure will give us additional information for a number of reasons. First, dealers on the MTS are able to extract information from the live market pages of the system. Therefore, the actions taken by dealers not only depend on the concurrent price and trade but also on the previous changes in price and order flow. Manaster and Mann (1996) showed also the importance of lagged effects of order flows on futures prices on the CME. They argue that this is consistent with active position building. Second, previous observations of price and order flow are also important because the MTS trading system allows the splitting of orders. It is likely that the observed volume is the drip quantity instead of the total (block) quantity.

Trading intensity plays an important role in the study of price and order flow dynamics. From the information based approach, one can argue that informed market participants want to trade as much and as fast as possible without being detected. Hence, informed traders will trade when noise traders are active (Kyle, 1985 and Easley and O'Hara, 1992) and this implies a positive relation between information and trading intensity.[7] This means that any unexpected trade during strong trading activity has a higher impact on prices. On the other side, Diamond and Verrechia (1987) argue that informed traders always trade as they can take long or short positions. If short sale constraints exist, bad news takes more time to reveal resulting in lower market activity or trading intensity. Hence, a longer period of trade absence increases the probability of facing an informed trader with bad news who is constrained from selling short. Therefore, they expect a negative relation between information and trading intensity (more informed traders will trade during low trading intensity) and hence a negative correlation between price discovery and trading intensity (higher impact of trades arriving after a longer period of inactivity). Empirical results so far suggest that a higher trading intensity is related to stronger price impacts. Dufour

[7] Kyle's (1985) model itself does explicitly make a statement about time as orders are aggregated. He does however argue that informed traders prefer to trade simultaneously with noise traders in order to minimize the chance of being detected. Easly and O'Hara (1992) argue that absence of trades reflects no-news creating a safer environment for a market maker to lower its spread.

and Engle (2000) show that trading during busy periods is likely to be an informational event as the market maker increase its bid-ask spread in response to trades. Spierdijk (2002) also reports the same results. She shows using NYSE stock trading data that, during trading intensive sessions, a new trade has a larger impact on prices. Interestingly, the issue of price impact and varying trading intensity does not take the role of interdealer trading into consideration. We think that this is important for a number of reasons and we provide some arguments in the next subsection.

In summary, we argue that in interdealer markets an inverse relationship may exist between price impact and trading intensity. To test this hypothesis empirically, we model price impact by taking order flow dynamics and trading intensity into account. We apply the VAR model proposed by Dufour and Engle (2000). This model is a system of two dynamic equations, one for price changes (returns) and one for signed quantities, with lagged values of both variables as explanatory variables. This model allows us to analyze the interaction between order flow and returns in the form of impulse responses of a shock (an unexpected trade) to the trading process. The main advantage of this model is the dynamic setup between order flow and price return. The process of market making not only depends on the concurrent price and trade but also on the previous changes in price and order flow. Lagged traded quantity is also important as the MTS trading system allows the splitting of orders and it is likely that the observed order book is the drip quantity instead of the total (block) quantity. Following Dufour and Engle (2000), we make the coefficients a function of trading intensity, measured by the calendar time elapsed between two subsequent trades. We also make the coefficients depend on the location of the trade, i.e. whether the trade occurred on a domestic platform or on EuroMTS.

Intraday data typically contain very strong diurnal patterns. Engle and Russel (1998) documented higher volatility at the beginning and end of the day with similar patterns for volume and spreads. In order to capture some of these patterns, we correct duration for intraday seasonality. The exact procedure is as follows: we divide our dataset in 17 intervals running from [8.30-9.00) to [17.00-17.30). We omit the durations between market close and the next day's opening. Our indicator for trading duration in interval τ is given by $T_{t,\tau}$ which is the time in minutes between trade t and trade $t-1$[8], $t \in \tau$. The trading duration is now corrected for diurnal

[8]We add one second to the observed duration, because some trades have exactly the same time stamp but a different transaction price.

patterns by dividing by the average trading duration in interval τ as given by $\bar{T}_\tau$.

Define the following variables: let $r_t = 10000 \ln(P_t/P_{t-1})$ be the trade-to-trade returns, and Q_t the signed quantity in millions of Euro of the notional amount. Hence, Q_t is negative when a 'sell' occurred and positive in case of a 'buy'. The coefficients are a function of the duration since the previous trade (T_t) and a market dummy (D_t) which takes the value 1 if trade t occurred on the EuroMTS, and zero otherwise. With these ingredients, the full model becomes

$$\begin{aligned} r_t &= \alpha^r + \sum_{i=1}^{P} \left(\beta_i^r + z_i^r \ln \frac{T_{t-i,\tau}}{T_\tau} \right) r_{t-i} \\ &\quad + \delta_0^r D_t + \tau_0^r \ln \frac{T_{t,\tau}}{T_\tau} + \sum_{i=1}^{P} \left(\gamma_i^r + \delta_i^r D_{t-i} + \tau_i^r \ln \frac{T_{t-i,\tau}}{T_\tau} \right) Q_{t-i} + \varepsilon_{1,t} \qquad (6) \\ Q_t &= \alpha^Q + \sum_{i=1}^{P} \left(\beta_i^Q + z_i^Q \ln \frac{T_{t-i,\tau}}{T_\tau} \right) r_{t-i} \\ &\quad + \sum_{i=1}^{P} \left(\gamma_i^Q + \delta_i^Q D_{t-i} + \tau_i^Q \ln \frac{T_{t-i,\tau}}{T_\tau} \right) Q_{t-i} + \varepsilon_{2,t} \qquad (7) \end{aligned}$$

Notice that in this representation, the equation for the returns does not contain the contemporaneous effect of the signed trade quantity. Instead, we back γ_0^r out from the estimated covariance between $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$.

5.1 Empirical Results

In the estimation, we truncate the lagged variable at $p = 3$. We report White heteroskedasticity consistent standard errors for statistical inference. In order to preserve space, we focus our discussion on the Italian 2011 bond as this is the most actively traded series in our dataset. The estimation results can be found in Table 6.

The effects of trades on the quote revision r_t are considered first. The most important set of parameters for our investigation are γ_i^r, δ_i^r and τ_i^r, which are the coefficients of the signed quantity indicator, the market indicator and the interaction between signed quantity and duration. The impact of signed quantity on return is reflected in the γ_i^r parameters. First, note that the instantaneous impact is positive, $\gamma_0^r = 0.105$. This indicates an instantaneous upward (downward) price movement when a buy (sell) order occurs. This number can be compared to the earlier estimates of the quoted and effective bid-ask spread: twice the price impact for a 5 million euro trade is around 1 basis point, which is smaller that the 2 to 3 basis point estimated spreads. Interesting are the results for the lagged variables $\gamma_2 = 0.004$ and $\gamma_3 = 0.003$ which are both positive and significant at a 10% confidence interval. Significant lagged effects of trading volume of price returns were also found by Manaster and Mann (1996) for futures on the CME. They argue that this result is consistent with active position building.

We also test for the difference between the domestic and EuroMTS platform, using a market indicator dummy. We find that $\delta_0 = -0.025$ is significant and negative while all other lagged market indicators are not significant. This means that (ceteris paribus) a buy trade at time $t = 0$, i.e. $Q_t = +1$, has a lower instantaneous impact on price relative to the same trade on the local MTS market. Recall that the dependent variable is $10000 \ln(P_t/P_{t-1})$ and the total impact of a one million 'buy' trade on the EuroMTS platform is therefore $\gamma_0 + \delta_0 = 0.105 - 0.025 = 0.08$ or 0.4 basis points for a 5 million euro trade. On the other hand, the same trade has an impact of 0.53 basis points on the local platform resulting in a difference of approximately 0.13 basis points return per 5 million euro. Like the differences in the bid-ask spreads found in the previous section, this difference is economically small.

The z_i^r parameter relates the change in r_t on its own lagged values. Table 6 shows that this effect is important and significant at a 10% confidence interval. The most important parameter for our analysis is τ_i^r, which indicates the effect of the interaction of duration and signed quantity on return. Our estimates shows that $\tau_0^r = 0.046$ is positive and strongly significant.[9] In other words, the longer the time since the previous transaction, the stronger is the instantaneous price reaction. This is in contrast to the findings of Dufour and Engle (2000) or Spierdijk (2002) who, for stock markets, document a stronger price impact after a *short* time interval since the previous trade.

Let us now focus on the effect of trades on the quantity equation. First, signed trade volume exhibits strong autocorrelation. The constant in our regression model is positive and significant differently from zero. The γ_i^Q parameters are all positive and significant. Hence, a buy (sell) order is likely to be followed by some additional

[9]The expected instantaneous price reaction on a local market given a duration $\ln(\tau^*)$ is given by $(\gamma_0 + \tau_0 \ln(\tau^*)) = 0.105 + 0.046 \ln(\tau^*)$.

buy (sell) orders. This is also confirmed by the results of Hasbrouck (1991a) and Dufour and Engle (2000). This effect is even stronger on the EuroMTS platform as $\delta_i > 0$ and significant for all lagged flows. Interesting are the estimates of the duration coefficients τ_i^Q which are negative and significant. The conclusion that $\gamma_i^Q > 0$ is that "buy" is likely accompanied by a another "buy" but the fact that $\tau_i^Q < 0$ reflects the fact that this likelihood will decrease when the time between the trades increases. In other words, buy orders are likely to be accompanied by further buy orders but this pattern decreases when duration is longer and activity is lower. This implies a weaker positive autocorrelation of signed trades when trading activity is low.

Cohen and Shin (2003) also analyze the impact of trades on return for the US treasury market. Their VAR estimations are based on subsamples of high and low trading intensity. They find that the impact on return on busy days is larger compared to days with low trading intensity. We follow the approach of Cohen and Shin and divide our dataset into a sample with no news and a sample with macro-economic news announcements and estimate the VAR model for both subsamples. However, in contrast to Cohen and Shin, we still take time-varying trading intensity into account in the VAR model. Fleming and Remolona (1999) identify the news items with the highest trade impact; we take the European equivalents of their list of major news items. Specifically, we use the European employment numbers, ECB meetings, Producer Price index, Consumer Price Index, IFO survey, retail sales, gross domestic product, industrial production and consumer confidence. We also include the US jobless claims, Producer Price Index, NAPM, consumer confidence and Fed fund target rates as these events are also awaited anxiously by European bond traders and therefore may have an impact on trading. We then divide our sample into days with news announcements (105 days, 20781 observations) and days without news announcements (40043 observations) and re-estimate the Dufour-Engle model for both subsamples.[10]

Let us discuss the findings for γ_i^r (effect of signed quantity on return), δ_i^r (effect of trading platform on return) and τ_i^r (effect of duration on return). The effect of order flow on return is reflected by the γ_i parameters. First, the instantaneous impact of an incoming order is the largest for days with news announcements and the smallest for days without announcements ($\gamma_0^{r,news} = 0.109$ versus $\gamma_0^{r,nonews} = 0.104$). The

[10]The tables with estimation results are omitted in here but available upon request.

lagged variables γ^r_{t-i} are all positive but generally insignificant. The impact of a trade on return for the domestic and EuroMTS platform can be analyzed through the δ^r_i parameters. We find that δ^r_0 is significant and smallest during days without news announcements ($\delta_0^{r,nonews} = -0.0253$ versus $\delta_0^{r,news} = -0.0223$). All other lagged market indicators appears not to be significant. Because this parameter is negative, it means that the impact is smaller on the EuroMTS trading platform but the difference becomes smaller during announcement days. Overall, the estimated magnitudes show that the instantaneous impact of a trade on EuroMTS during an announcement day is larger compared to a non-announcement day and the difference per 5 million trade is $5 \times 0.008 = 0.04$ basis point. Interesting are also the τ^r_i parameters which reflect the impact of duration on return. Our estimates are positive, significant and larger for days without news announcements ($\tau_0^{r,nonews)} = 0.049$ versus $\tau_0^{r,news} = 0.043$). It shows that the instantaneous price impact of order flow is stronger in periods with low trading intensity but this effect is even stronger in days without announcements.

We can conclude the following: The impact of trades is larger during days where macro-economic news is announced. This confirms the findings of Cohen and Shin (2003) and Green (2004) who conducted a comparable analysis using treasury bonds. However, in contrast to their model, we also make a distinction between intraday trading intensity under news versus no news announcements. We find that the impact during days with news announcements is larger compared to days without any news, the impact is even larger when intraday trading intensity is lower.

5.2 Impulse Response Functions

In this section we focus on the impulse response functions using the estimated coefficients for the local trading platform. Specifically, we are interested in an unexpected shock in the signed quantities innovation and its impact on return and signed quantity when an unexpected buy trade of 5 million euro occurs in the market. Here, we use the average trading intensity for analyzing the systems dynamics and the model changes into

$$r_t = \bar{\alpha}^r + \sum_{i=1}^{P} \bar{\beta}_i^r r_{t-i} + \sum_{i=0}^{P} \bar{\gamma}_i^r Q_{t-i} + \varepsilon_{1,t} \tag{8}$$

$$Q_t = \bar{\alpha}^Q + \sum_{i=1}^{P} \bar{\beta}_i^Q r_{t-i} + \sum_{i=1}^{P} \bar{\gamma}_i^Q Q_{t-i} + \varepsilon_{2,t} \tag{9}$$

which is the VAR model that Hasbrouck (1991) used. Again, we focus our discussion on the impulse response functions of the Italian securities which are given in figure 4. The figures also shows the impulse response function when a trade occur in a period with high trading intensity (straight line) and in a period with low trading intensity (dotted line). In the high trading intensity case, we pick a trade with $T_{t-i,\tau}$ on the 10^{th} quantile and, in case of low trading intensity, we pick a trade with $T_{t-i,\tau}$ on the 90^{th} quantile. As we can see, the initial response at time $t = 1$ is much larger during a period of low trading activity. The appendix gives us some details of impulse response functions in these cases.

An unexpected buy trade results in a positive response as a buy will always be traded on the ask side. Note that the initial impact of a buy trade is much larger when the market is quiet, i.e. the time between trades is large. The lowest impact on the price process occurs when trading intensity is high. As we can see in the figures, an unexpected positive shock results in a instantaneous upward price movement between 0.4 to 0.6 basis points. The bid-ask bound arises in the second trade and this will cause the impulse response function to move downwards. However, the estimations suggested a positive correlation between order flows and a buy order is likely to be followed by additional buy orders. The system therefore does not instantaneous move back to its equilibrium but it will take approximately 9 trades. The permanent effect of a initial buy on the price process is positive as shown by the accumulated response function. As we can see, the permanent impact runs from 0.45 to 0.9 basis points with the highest impact for periods in which trading intensity is low followed by average and high trading intensive periods.

We also computed the impulse response functions taking news announcements into account. The accumulated impact of a 5 million euro buy trade has resulted in an 0.57 basis point increase in return in case when no news arrives and 0.64 basis points when news arrives. However, the impact is larger during periods with a lower trading intensity as the accumulated response stands at 0.65 basis points for no-announcement days and 0.7 basis points for announcement days. This difference is illustrated in figure 5.

6 Conclusions

This paper focuses on the costs of trading European sovereign bonds. We test several hypotheses regarding the microstructure of the MTS trading system for European government bonds. We first measured trading costs using static measures such as the quoted spread, the effective spread and the realized spread. The results show that the spreads in the bond market are very small, between 1 and 3 basis points for the issues with maturities up to 10 years. The 30 year issues have somewhat higher spreads. The spreads are smallest for the most actively traded issues such as the Italian 10 year bonds. We find that liquidity on the domestic and EuroMTS platforms is almost the same, and there are no significant differences in trading costs. Hence, liquidity differences cannot justify the existence of the EuroMTS system and this makes the EuroMTS an unnecessary superstructure. In other words, the existence of the EuroMTS platform cannot be justified by differences in pure trading costs and liquidity issues. Other explanations may be that some participants only trade the benchmark securities, i.e. the EuroMTS platform is a trading vehicle that groups the most important benchmark securities of all Eurozone bonds. Another explanation for the existence of the EuroMTS system is to avoid the dominance of a particular country-specific platform in order to export the technology worldwide.

We then turn our attention to the price impact of trades and trading duration. The interdealer literature suggests that a key role is played by inventory control which depends on trading activity. Specifically, we argue that it is more difficult to control inventory when trading activity is low, increasing the search cost. Moreover, the information content of order flow and the repeated passing of inventory create additional noise in the price process. We analyze price discovery by adding parameters of trading intensity and lagged order flows, using the Dufour-Engle model. The results show that order flow is an important determinant of price fluctuations on the bond market. Also, trading intensity plays a key role. In contrast to findings for stock markets, we find a higher price impact of trades after long durations, and lower price impacts when trading activity is high. We also find that the order flow becomes less correlated after long durations. Finally, we divided our dataset into days with and without important news announcements and re-estimate the model. We find that the price impact of order flow is bigger on announcement days.

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Table 1: Number of MTS Participants

The first column shows the total number of participants on the domestic trading platforms. The second column shows the number of domestic market makers. The number in brackets are the number of market makers who are also active on the EuroMTS system. Also, the total number of participants on the EuroMTS is 95 (of which 79 are market makers).

Market	Participants	Market Makers (EuroMTS)
MTS Amsterdam	31	22 (21)
MTS Belgium	28	19 (19)
MTS Finland	20	18 (16)
MTS France	31	31 (30)
MTS Germany	60	39 (39)
MTS Ireland	10	10 (10)
MTS Italy	140	38 (33)
MTS Portugal	23	19 (17)
MTS Spain	24	22 (22)
EuroMTS	95	79

Table 2: Overview cash traded bonds

Trading characteristics of dataset. This table shows the percentage of trades on the EuroMTS and the local platform respectively. ATS stands for average trading size (both platforms). The Italian platform also offers trading facilities for German securities. The right part of the table shows the percentage of total trades in the 2.5, 5.0 and 10 million Euro buckets. OLO, OAT, DBR and BTP bonds are long-term bonds and the central focus of our analysis. All other bonds have either medium or short time to maturity.

Market	Transactions	Volume	% EuroMTS (% local)	ATS	% Round lot trades 2.5	5	10
Germany							
DBR	14683	90033	56 (37)	6.1	3	75	19
OBL	9703	81184	67 (26)	8.4	0	46	49
BKO	7128	62385	72 (28)	8.8	0	36	57
Total	31514	233602					
Italy							
BTP	518432	2851689	17 (83)	5.5	22	64	10
CTZ	43698	230281	0 (100)	5.3	69	11	8
CCT	139615	692323.5	0 (100)	5	66	10	9
BOT	27875	126218	0 (100)	4.5	69	17	5
total	729620	3900512					
France							
OAT	33864	207018	41 (59)	6.1	8	66	24
BTNS	29472	252045	55 (45)	8.6	0	31	67
total	63336	459063					
Belgium							
OLO	43431	316857	22 (78)	7.3	4	50	44

Table 3: Volume weighted quoted spread (VWQS) in cents for different classes of maturity (class A bonds have the lowest maturity while class D bonds have the highest maturity) from benchmark bonds of Belgium, France, Germany and Italy. Values in parenthesis are the volume weighted quoted spreads for the same bonds on the EuroMTS platform.

	Class A	Class B	Class C	Class D
Mts Italy (EuroMTS Italy)				
Trade size	BTP 15/07/05	BTP 01/03/07	BTP 01/08/11	BTP 01/05/31
5	1.99 (2.25)	2.84 (2.90)	2.70 (2.80)	12.00 (11.78)
10	2.30 (2.45)	3.00 (3.07)	2.91 (3.00)	13.25 (13.03)
25	2.88 (2.92)	3.82 (3.69)	3.50 (3.63)	14.89 (14.86)
Mts France (EuroMTS France)				
Trade size	BTAN 12/07/05	BTAN 12/07/06	OAT 25/10/11	OAT 25/10/32
5.0	2.70 (2.48)	2.52 (2.48)	3.08 (2.90)	12.55 (12.49)
10.0	2.71 (2.49)	2.56 (2.54)	3.08 (2.98)	13.73 (13.80)
25.0	4.46 (2.89)	3.00 (3.10)	3.51 (3.35)	15.54 (15.76)
Mts Germany (EuroMTS Germany)				
Trade size	OBL 135 05/05	OBL 138 08/06	DBR 04/01/12	DBR 04/01/31
5	3.07 (3.99)	3.81 (3.80)	3.30 (3.17)	15.21 (15.23)
10	3.43 (3.43)	3.95 (4.00)	3.54 (3.39)	16.80 (16.26)
25	3.93 (6.13)	4.91 (4.95)	3.97 (3.74)	18.11 (17.84)
Mts Belgium (EuroMTS Belgium)				
Trade size	OLO 34 09/05	OLO 37 09/06	OLO 36 09/11	OLO 31 03/28
5	2.81 (2.81)	2.99 (2.99)	4.11 (4.14)	14.07 (13.86)
10	2.89 (2.87)	3.00 (2.99)	4.12 (4.16)	15.04 (14.82)
25	3.93 (3.46)	3.39 (3.44)	4.67 (4.68)	16.57 (16.48)

Table 4: Effective and realized spreads on the MTS system.

This table offers a comparison of the realized spread and the average effective spread in cents. The T-statistics reflects $Spread_{EuroMTS} = Spread_{domestic}$. BTP are Italian bonds, BTNS and OAT are French, OBL and DBR are German, OLO are Belgian bonds. At the moment of our analysis, the OLO 10/04 was not traded on the EuroMTS platform.

Maturity		Effective spread			Realized spread		
class	Bond	Domestic	EuroMTS	t-statistic	Domestic	EuroMTS	t-statistic
	BTP 07/05	1.80	1.80	0.128	0.00	0.50	3.544
A	OBL 05/05	35.8	44.40	0.208	31.9	41.30	0.243
	BTNS 07/05	3.20	1.90	0.753	1.20	0.20	1.601
	OLO 10/04	1.00			1.30		
	BTP 03/07	2.60	2.90	0.634	0.30	0.60	0.108
B	OBL 08/06	3.30	2.10	1.028	-0.20	2.60	2.207
	BTNS 07/06	3.20	2.20	1.088	1.60	0.00	1.674
	OLO 09/06	3.40	3.50	0.046	0.80	1.40	0.731
	BTPS 08/11	3.80	4.10	0.674	0.40	-0.20	0.378
C	DBR 01/12	4.40	4.40	0.023	-2.20	0.50	1.630
	AOT 10/11	4.60	4.90	1.025	0.60	1.00	0.296
	OLO 09/11	4.10	6.00	1.376	1.60	1.70	0.015
	BTP 05/31	11.00	11.4	0.272	2.80	2.30	0.300
D	DBR 01/31	14.30	13.80	0.104	2.10	-0.50	0.870
	OAT 10/32	11.10	6.00	1.376	0.70	7.2	1.324

Table 5: Spread for absolute price changes on the MTS system.

This table shows spread estimates in cents based on absolute price changes for class A, B, C and D benchmark bonds as a percentage ($times100$) of the price. We test $Spread_{EuroMTS} = Spread_{domestic}$ using a standard t-test.

Class	A	B	C	D
	BTP 15/07/05	BTP 01/03/07	BTP 01/08/11	BTP 01/05/31
Euromts	3.35	5.50	4.96	13.26
Mts Italy	2.02	3.38	3.20	8.39
T-stat	2.06	1.68	2.29	1.18
	BTNS 12/07/05	BTNS 12/07/06	OAT 25/10/11	OAT 25/10/32
Euromts	4.34	10.38	6.82	17.54
Mts France	4.92	5.48	7.58	35.64
T-stat	2.33	1.20	0.45	1.61
	OBL 135 05/05	OBL 138 08/06	DBR 04/01/12	DBR 04/01/31
Euromts	3.78	4.01	16.99	17.89
Mts Germany	3.09	3.76	9.16	16.18
T-stat	0.79	3.04	0.53	1.44
	OLO 34 09/05	OLO 37 09/06	OLO 36 09/11	OLO 31 03/28
Euromts	5.97	4.39	9.35	26.31
Mts Belgium	4.98	5.60	7.17	28.27
T-stat	1.26	0.78	0.76	0.05

Table 6: Dufour-Engle estimates for the BTP 2011 bond

Estimation of the Engle-Dufour model using Maximum likelihood. The t-statistics are based on White standard errors. The γ_0 coefficient is calculated using the correlation between the error terms. The left-hand side shows the estimation results for the return r_t equation and the right-hand side shows the estimation result for the quantity Q_t equation. For convenience, the coefficients are multiplied with 100.

Parameters	Coefficient **Return equation**	t-statistic	Coefficient **Order flow equation**	t-stat
β_1	-4.20	-2.47	0.17	0.11
β_2	1.04	0.97	-4.88	-3.19
β_3	-0.77	-0.93	-6.05	-3.99
γ_0	10.50			
γ_1	0.21	0.89	26.11	54.06
γ_2	0.45	2.07	6.28	12.51
γ_3	0.35	1.83	4.64	9.46
z_1	0.57	0.50	2.33	2.18
z_2	-1.63	-1.84	3.13	2.90
z_3	1.23	1.69	4.38	4.07
τ_0	4.62	15.40		
τ_1	-0.60	-2.31	-4.16	-8.55
τ_2	-0.29	-1.15	-4.26	-8.72
τ_3	-0.42	-1.87	-3.28	-6.89
δ_0	-2.45	-9.37		
δ_1	-0.37	-1.47	1.69	1.94
δ_2	0.18	0.63	2.83	3.25
δ_3	0.48	1.76	3.63	4.18
α	-0.47	-0.56	8.48	3.63

Figure 1: The estimated spread based on absolute price differences on domestic MTS platforms versus EuroMTS

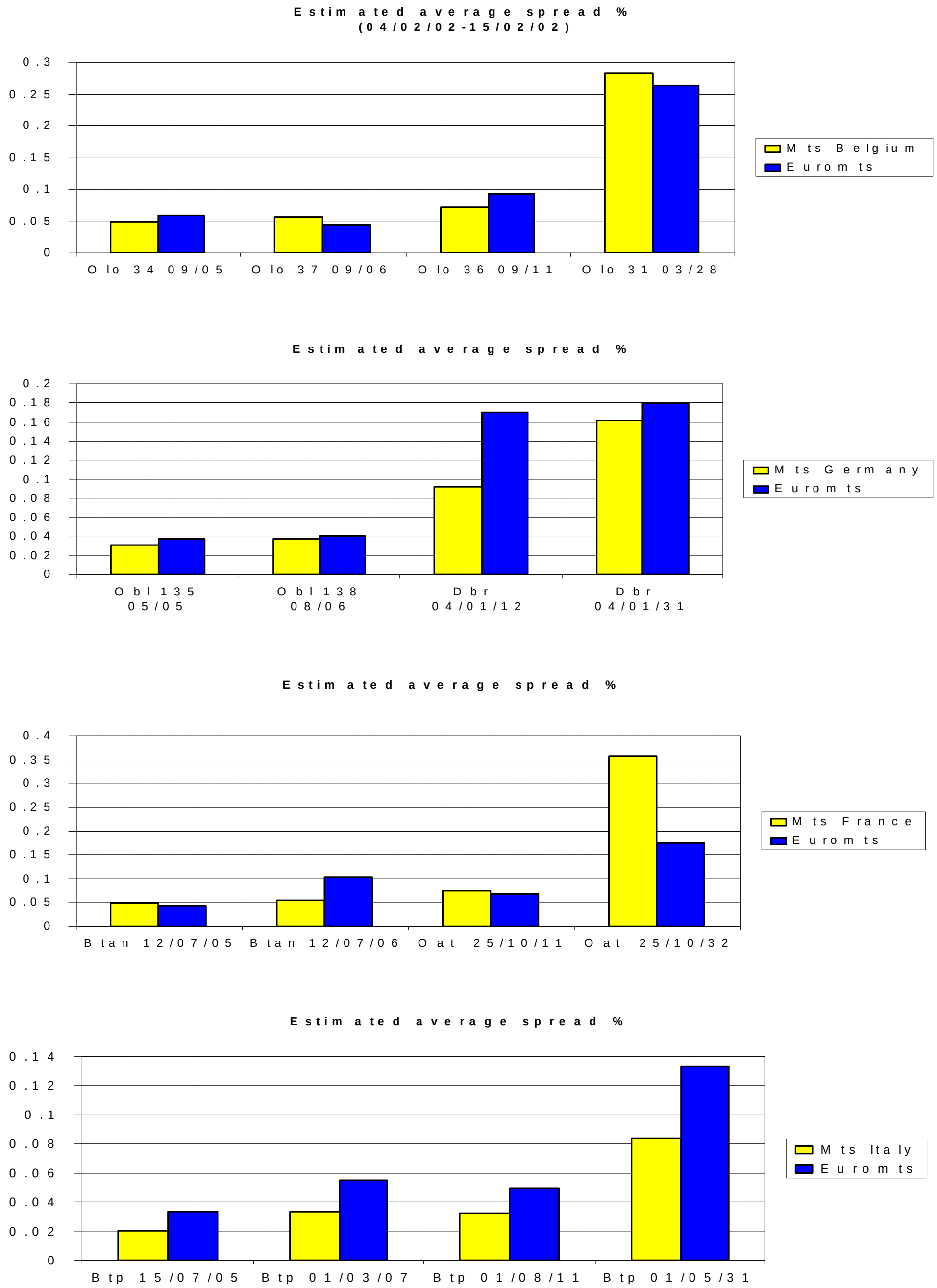

Figure 2: Intraday pattern of quoted spread

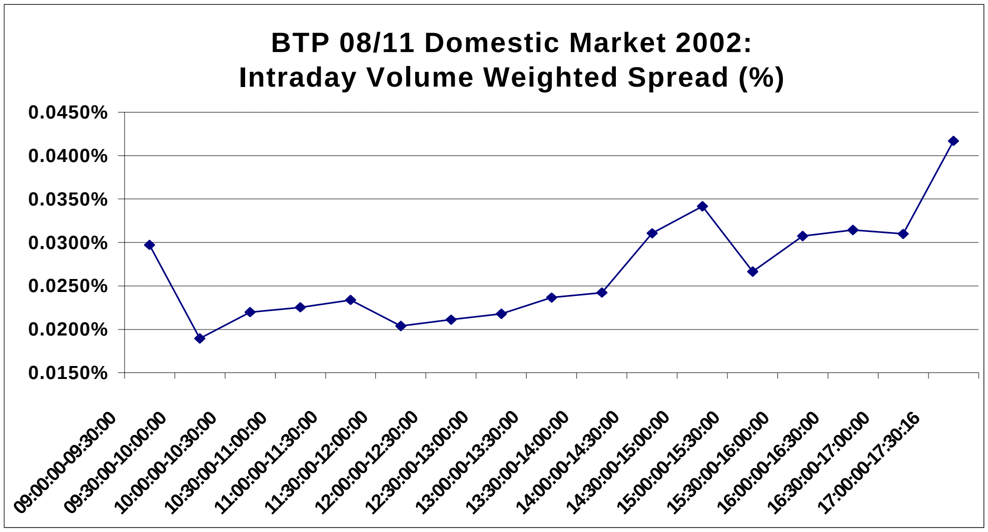

Figure 3: The average effective and realized spread.

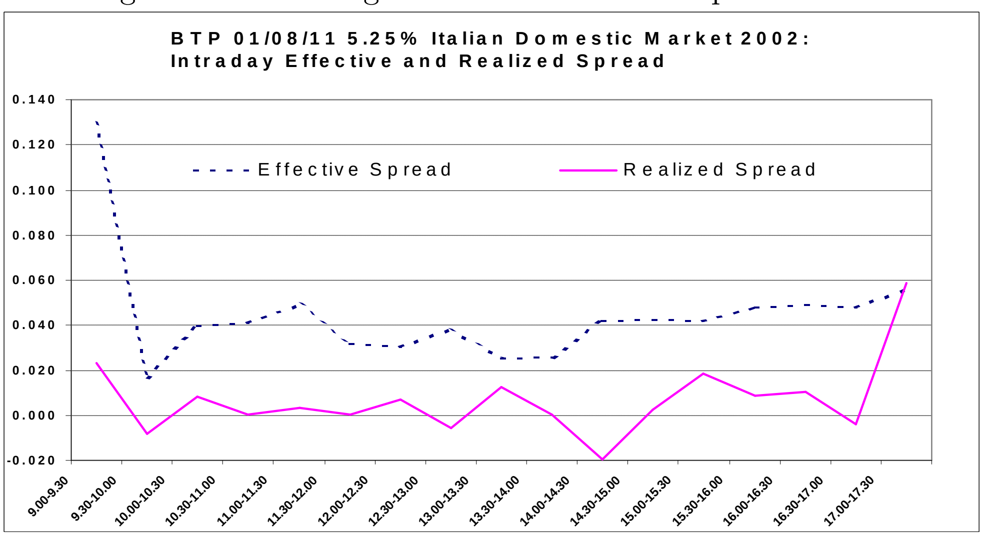

Figure 4: Impulse response function

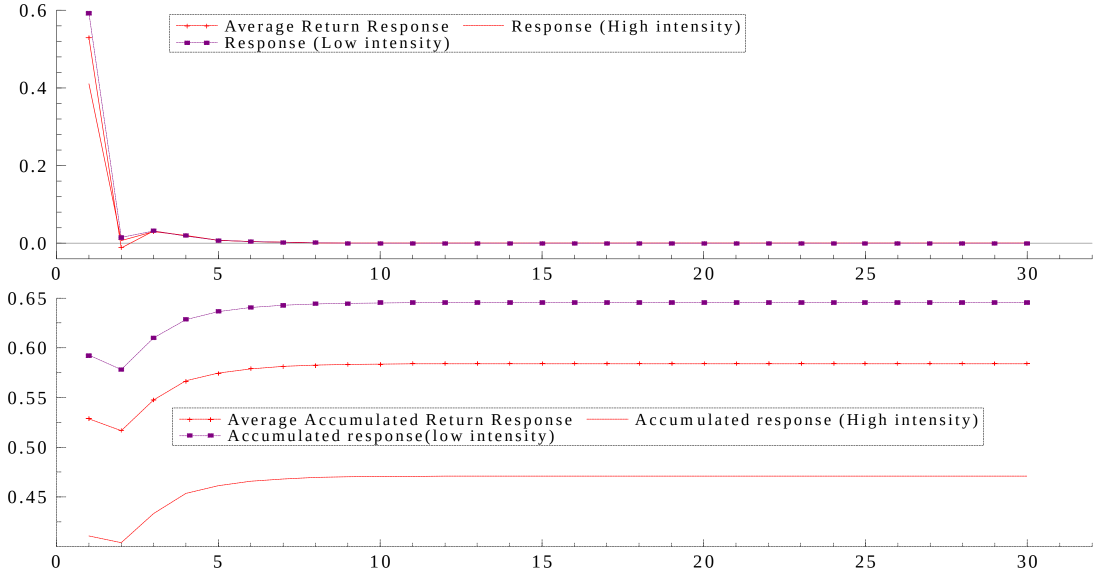

Figure 5: Impulse response function (days with news announcements)