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TRADING EUROPEAN SOVEREIGN BONDS

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Frank de Jong [3]
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In 2005 all ECB publications will feature a motif taken from the €50 banknote.

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ECB-CFS Research Network on
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Abstract

We study the microstructure of the MTS Global Market bond trading system, which is the largest interdealer trading system for Eurozone government bonds. Using a unique new dataset we find that quoted and effective spreads are related to maturity and trading intensity. Securities can be traded on a domestic and EuroMTS platform. We show that despite the apparent fragmentation of trading, both platforms are closely connected in terms of liquidity. We also study the intraday price-order flow relation in the Euro bond market. We estimate the price impact of order flow and control for the intraday trading intensity and the announcement of macroeconomic news. The regression results show a larger impact of order flows during announcement days and a higher price impact of trading after a longer period of inactivity. We relate these findings to interdealer trading and to the structure of European bond markets.

Keywords: Bonds markets, Microstructure, Order flow

JEL classification: F31, C32

Non-technical summary

In this paper we study the microstructure of the MTS Global Market bond trading system using a new and unique dataset consisting of detailed transaction data provided by the MTS group. This interdealer trading system is fully automated and effectively works as an electronic limit order market. The structure of the MTS trading platforms are 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. The European bond market has also a much richer menu of bonds than the US market. Although the European capital market has integrated considerably in the last 5 years, mainly through the introduction of a single currency, European bonds can still differ in their credit rating. This varies from "AA2" for Italy to "AAA" for Austrian, Dutch, French and German bonds.

An interesting feature of the MTS trading platform is its organizational setup. Fixed income securities can be traded on a domestic platform (like MTS France, MTS Germany and MTS Italy) but also on a general platform called the EuroMTS. Local system provides trading opportunities for trading "off-the-run" and "on-the run" securities as long as some liquidity restrictions are fulfilled. On the other hand, the EuroMTS platform offers trading in only "on-the-run" securities. In other words, the range of securities being traded on the domestic platform is much larger compared to EuroMTS. A bond trader on the domestic trading platform can therefore offer a much wider range of bonds to its clients making the EuroMTS platform redundant. We therefore ask ourselves:

Are there any differences in trading costs between the EuroMTS and the domestic MTS trading platforms?

Throughout the paper, we provide a comparison of the trading costs and price dynamics on these platforms. We calculate comparative measures of trading costs like the quoted and effective spread. We show that despite the apparent fragmentation of trading on domestic platforms and EuroMTS, the markets are closely connected in terms of liquidity.

Another interesting feature of the MTS Global Market system is its pure interdealer characteristic. This allows us to study the price and order flow dynamics under competitive market making. The data also provides a detailed time stamp, which allows us to take trading intensity into account. In particular, we ask ourselves:

Are interdealer trades better absorbed by dealers under high or low trading intensity?

From the informational point of view, one can argue that a higher trading intensity will lure informed traders. These market conditions provides an opportunity for the informed traders to trade as much and as fast as possible without being detected. Hence, an unexpected trade in a period of high trading intensity will have a larger impact on the

price. On the other hand, one can argue that a low trading intensity makes it more difficult for dealers to control their inventory. Hence, dealers are more reluctant to trade when trading intensity is low and an unexpected trade during quiet periods have a larger impact on prices. To answer this question, a careful analysis of the price process is needed. Moreover, literature suggests that the impact of order flow on the price process during announcement days is much higher compared to days without news announcements. We apply a simultaneous modelling of price and order flow dynamics by taking trading intensity and news announcements into account.

Our empirical analysis is conducted for the running 10-year government bonds of Germany, France, Italy and Belgium. We estimate the model using the full dataset and by separating the dataset into days with and without macroeconomic news announcements. We find that order flows are strongly correlated but the correlation gradually decreases over time. We also find that the impact of order flows is larger during announcement days. This supports the findings of the US bond market. However, when we take intraday trading intensity into account, we find that the impact of a trade in a relative low trading intensive environment has a larger impact on price than in a relative high trading intensive environment. These findings contrast the findings for stock markets and we try to relate these findings to interdealer trading and the special structure of fixed income markets.

1 Introduction and Motivation

In recent years, the empirical work on 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, foreign exchange and bond markets are bigger than stock markets. Research on foreign exchange and bond 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 there is a lot of interdealer trading. The interdealer trading is even bigger than the trading with outsiders. Lyons (2002) 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 fixed income 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 are 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. The European bond market has also a much richer menu of bonds than the US market. Although the European capital market has integrated considerably in the last 10 years, mainly through the introduction of a single currency, European bonds can still differ in their credit rating. This varies from AA2 for Italy to AAA for Austrian, Dutch, French and German bonds[2]. There are a few interesting features of this trading platform.

The first interesting feature of the MTS trading platform is its organizational setup. Fixed income securities can be traded on a domestic and a European (or EuroMTS) platform. The range of securities being traded on the domestic platform is however much larger than on the EuroMTS trading platform[3]. A bond trader on the domestic trading platform can therefore offer a much wider range of bonds to its clients. Throughout the paper, we provide a comparison of the trading costs and price dynamics on the domestic MTS markets and the EuroMTS by calculating comparative measures of liquidity, such as quoted and effective spreads. We show that despite the apparent fragmentation of trading on domestic platforms and EuroMTS, the markets are closely connected in terms of liquidity.

The second interesting feature of the MTS Global Market system is its interdealer characteristic.

[1]For example, Umlauf (1993), Fleming and Remolona (1997, 1999), 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.

[2]Based on Moody's credit rating.

[3]As an example, MTS France offers trading in a large range of French debt securities including the benchmarks and highly liquid issues. On the other hand, EuroMTS only offers a smaller range of French debt issues.

This allows us to study the price and order flow dynamics under competitive market making. There is a small but important collection of papers studying interdealer trading behavior. Ho and Stoll (1983) were the first to discuss the role of competition between market makers. They argue that market makers with the most extreme inventory will execute all the trades by quoting the most competitive prices. Biais' (1993) theoretical model supports the findings of Ho and Stoll. In addition, he shows that the number of suppliers of liquidity depends on the volatility of the security and the trading activity in the market. Lyons (1997) analyzed the impact of a repeated passing of inventory among dealers. He calls this phenomenon hot potato trading and shows that the passing of inventory creates additional noise in the order flow. There is also empirical evidence documenting the passing of inventory among dealers. Manaster and Mann (1996) find that CME futures floor traders manage their inventory daily and that the most active sellers have the largest long position. Reiss and Werner (1998) and Hansch, Naik and Viswanathan (1998) studied the role of inventory among market makers on the London Stock Exchange. They find an important role for inventory control as most of these trades are used to reverse positions. In addition, the mean reversion component of inventory changes over time and is stronger compared to the traditional specialist markets as analyzed by e.g. Madhavan and Schmidt (1993).

Interestingly, these papers do not analyze the impact of these trades on price dynamics. In particular, they do not ask under *which circumstances (i.e. busy or quiet markets)* these interdealer trades are better absorbed by market makers. The literature suggests that the impact of order flow on the price process during announcement days is much higher compared to days without news announcements. To answer this question, a careful analysis of the price process is needed which in turn requires the simultaneous modelling of price and order flow dynamics by taking trading intensity and the announcement of news into account. This is the main objective of the paper. The investigation of trading surrounding economic announcements in fixed income markets has been analyzed by Fleming and Remolona (1999) and Balduzzi, Elton and Green (2001). These papers find that the largest price movements arises during announcement days. Green (2004) documented a lower adverse selection component before the announcement which is a consequence of no-information leakage. After the announcement however, the adverse selection component starts to increase because dealers absorbing a large portions 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. Cohen and Shin (2003) also conducted a comparable analysis for the US treasury 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. In contrast to Green (2004) and Cohen and Shin (2003), we include intraday trading intensity in our analysis. We find that order flows are strongly correlated but the correlation gradually decreases over time. We also find that the impact of order flows is larger during announcement days. This supports the findings of Cohen and Shin (2003) and Green (2004) for the US fixed income market. However, when taking intraday trading intensity into account, we find that the impact of a trade in a relative low trading intensive environment has a larger impact on price than in a relative high trading intensive environment. This finding contrast the findings of Dufour and Engle (2000) and Spierdijk (2002) for stock markets.

The setup of this paper is as follows. Section 2 starts with a description of the European Bond market, the MTS trading platform and our dataset. Section 3 focuses on the study of liquidity, measured by quoted and effective bid-ask spreads. Sections 4 analyzes the impact of order flows and trading intensity on the price discovery of the domestic and EuroMTS market in some important 10-year benchmark bonds. We estimate the model (i) using the full dataset and (ii) separating the dataset into days with and without macroeconomic news announcements. Section 5 concludes the paper.

2 Description of the European Bond Market and the Dataset

This section gives a short description of the organization of the European market for sovereign bonds. The institutional environment of this market can broadly be divided into 2 sectors. The primary sector decides upon the finance policy based upon the funding requirement of each government. The operational activities for the implementation of these strategies is carried out by various treasury agents like the Bundesbank for German securities, the French Tresor for French securities and the Italian Treasury for Italian debt instruments. The secondary market decides upon the trading environment. In particular, it determines the structure of payments and settlements and the trading facilities offered by brokers and market makers. Both sectors influence the price dynamics through supply and demand, where the primary sector acts as the ultimate provider of liquidity. It is therefore useful to give a description of the Eurozone government bond market based on these two sectors.

2.1 Primary Market

In a broad sense, the government bond market can be seen as the market for debt instruments with a maturity running from 2 years up to 30 years. Although later we will focus on bonds with a 10-year maturity, there is also a very active market for debt instruments with a maturity smaller than 2 years. Here, the primary sector is special as it acts as the ultimate provider of liquidity in a given government security. In the Eurozone money market, the European Central Bank is the ultimate supplier of monetary liquidity in the Eurozone. In contrast, every member of the Eurozone can decide its own financing operations and its supply of debt instruments. Hence, the

Eurozone bond market is heterogeneous compared to the Eurozone money market.[4] Table 1 shows the size of outstanding medium and long term debt which differs considerably across countries. Despite the differences in issue size, governments choose to finance their needs using debt paper with almost similar maturities.

We now describe the bond market for German and Italian debt securities in more detail. We pick these two markets as both markets are highly liquid while having different credit ratings. The German securities are rated 'AAA' while the Italian securities are rated with the 'AA2' status .

Germany The German market is the second largest bond market in the Eurozone and the fourth largest market in the world, smaller only to the United States, Japan and Italy. The government bond market has been given a strong boost since the unification of the two German states as East Germany required large financing to modernize its infrastructure.

The issues of public authorities can be categorized in a few groups from which the highly liquid Federal government bullet bonds are the most important ones[5]. In turn, the federal bonds are categorized depending on their maturity. The most popular instruments are the long-term government bonds (*Bundesanleihen or Bunds*) which have a maturity between 8 and 30 years, with the 10 year bonds being the most popular. In addition to Bunds, the federal government issues medium term notes which gained popularity since the beginning of the 1990's when foreigners were allowed to purchase these notes. These medium term notes (*Bundesobligationen or BOBL*) have a maturity of 5 years. In order to differ between the well known 5 or 10-year bonds, the German authorities introduced short term notes (*Bundesschätzanweisungen or Schätze*) in 1991 with a maturity of 2 years.

Only the Bundesbank is authorized to issue federal bonds and it publishes a calendar with the date, type and planned issue size for the next quarter. Federal bonds are issued on Wednesday using tendering where some 80% of the whole issuance is sold. The remaining 20% is set aside for market management operations and intervention. Only members of the "Bund Issuance Auction Group" are entitled to participate directly during the auction. The participants have to quote in percentages of the par value in multiples of 1 million euro with a minimum of 1 million euro. The Bundesbank expects members to submit successful bids for at least 0.05% of the total issuance in one calendar year. There are two ways in which a bond is auctioned. The first is through an American auction, a competitive bidding schedule in which the participants announce the quantity and price that they are willing to pay for the security taking a minimum price into account. The participant with the highest price will be met first followed by the second highest price, and so forth. The second method is through a Dutch auction, a non-competitive bid in which the Bundesbank determines one price through the bidding schedule of the participants.

[4]Hartmann et al. (2001) provide an excellent overview of the EU money market.

[5]Other bonds are for example Länder bonds and unity bonds

Italy The Italian market remains one of the largest bond market in the world [6]. By now, the Italian market is by far the largest European Bond market due to its large deficit in the government budget. Since its approval of the Maastricht duty in 1991 however, the Italian government tightened its economic and monetary policy to pursue an economic environment of stable prices and solid public finances. This has its influence on the performance of Italian securities. We can see this in Figure 1 where the spread between the 10 year benchmark bonds of Italy is plotted against its German equivalent[7].

The most important medium and long term bond issued by the Italian treasury are BTPs (*Buoni del Tesoro Poliennali*). These are bullet bonds with a maturity of 3, 5, 7, 10 or 30 years with coupons paid on a semi-annual basis. The vast majority of bonds in the Eurozone market are bullet bonds with fixed coupons although some bonds are successful in the floating rate market. The Italian CCT bonds (*Certificati di Credito del Tesoro*) for example are relatively successful just like the French OATi bonds. Although both bonds pay a variable coupon rate, they are calculated differently. The coupon of CCTs are based on the yield of the last issued 6 month treasury bill plus a fixed spread while the coupon rate of OATi's are based on the level of the French price index. Also, the coupon of CCTs are paid on a semi-annual basis while OATi's are paid on an annual basis.

With respect to the primary auctions, the Italian treasurer announces its auction calendar for the next year in September. The way these auctions are conducted for BTPs and CCTs is through the Dutch auction mechanism, the same method also used for German securities. For the Italian markets, members can post a maximum of 5 bids where the minimum acceptable spread between the bids is at least 5 basis points.

2.2 Secondary Market: The MTS System

Let us now turn our attention to the secondary market. There are two ways in which bonds can be traded in the secondary market of the Eurozone. The traditional way is through an organized exchange were trading has been 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[8] reports that some 6.4 billion euro of BTPs were traded on an average base in 2002 by the MTS trading platform. According to an older paper by

[6]According to the Italian treasury, the outstanding debt is around 1200 billion euro including debt issued by state authorities.

[7]The word 'equivalent' can be misleading as both bonds where not Euro-denominated before 1999.

[8]Quarterly bulletin-3rd quarter 2002

the Italian debt office, this accounts for some 65% of all secondary market activities[9].

The original MTS market was first 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 of the MTS system into MTS Spa took place in 1997 and later in 1999 EuroMTS was created. In 2001, both 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[10]. 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. The final stage of development of the MTS platform was the creation of MTS Credit in May 2000 where only non-government bonds are traded. 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 bonds that they are assigned to in a two-way proposal for at least five hours a day. Table 2 gives us an overview of participants on the MTS trading system. As we can see in this table, the largest part 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 on the local platform[11]. 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". 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. The maximum spread of these securities are pre-specified depending on liquidity and maturity. Proposals must be formulated for a minimum quantity equal to either 10, 5 or 2.5 million Euro depending on the market and maturity of the bond. In addition, a maximum spread of these proposals exist and is pre- specified depending

[9]The Italian Treasury and Securities Markets: Overview and Recent Developments. *Public Debt Management Office, March 2000.*

[10]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.

[11]Financial institutions who are designated as market makers must fulfill some financial requirements which differs among the platforms. For example, market makers for Belgian securities must have assets of at least EUR 250 mio. For the EuroMTS, market makers must have assets of minimum net worth of EUR 375 million.

on the liquidity and maturity of the security[12]. Orders in round lots are executed automatically according price priority and the time that they are sent (first in first out). Odd lots are subject to the market makers' acceptance. 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 therefore works as a limit order book. The live market pages offered to participants show the following functionalities:

- *The quote page* offered to market makers enables them to insert new offers. Posted proposals can be modified, suspended or reactivated;
- *The market depth page* allows participants to see the best 5 bid and ask prices for each security chosen together with its aggregated quantity.
- *The best page* shows for all products the best bid-ask price together with its aggregated quantity;
- *The incoming order page* permits the manual acceptance within 30 seconds of odd lots.
- *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.
- *Live market pages* shows for every bond the average weighted price and the cumulative amount being traded sofar.

Remember that all trades are anonymous and the identity of the counterpart is only revealed after a trade is executed for clearing and settlement purposes. The aggregated observed quantity is the sum of all quantities chosen to be shown by the market maker. 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. For example, a market maker who has a position of EUR 50 million in a market where the minimum quantity is EUR 10 million can construct 5 drip quantities of 10 million. If we assume that he is the only market maker that time of the day, then the aggregated observed quantity as observed by the market will be 10 million. On the other hand, the market maker can post one block quantity of 50 million creating an aggregated observed quantity of 50 million euro. The MTS trading mechanism consist of two trading platforms where bonds can be traded. For most securities, the market maker can post any prices on both the local MTS (like MTS Belgium, MTS Amsterdam, MTS Italy and MTS France) but also a European system (EuroMTS).

[12]The longer the maturity the higher the spread. The maximum spread is not binding. 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.

The latter platform offers trading only in the running benchmark bonds while the local platforms offers trading in non-benchmark bonds as well. For example, 55 BTP bonds are traded on the Italian market while just 11 of these bonds are traded on the EuroMTS system[13]. So at first sight, the EuroMTS might seem redundant as all bonds being traded on this market are also traded on the domestic trading system. However, the existence of both trading platforms suggests differences and we therefore ask ourselves the following question: *Why would a market maker with entrance to the local platforms also would like to operate on the EuroMTS trading platform?* In order to answer this question, a detailed study on the costs and the dynamics of price formation is needed. Before we start however, we introduce our dataset.

2.3 Dataset

Our dataset covers every transaction of Italian, French, German and Belgian government bonds being 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 3 shows us the volume in the various markets including the number of transactions. A total of 867.901 trades took place reflecting more than EUR 4.9 trillion of market value. Here, 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 some EUR 460 billion and EUR 233 billion respectively.[14] 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 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 trading in all fixed income instruments of the federal republic of Germany and sub sovereigns fixed income bonds of Kreditanstalt für Wiederaufbau (KfW), the European Investment Bank and the States of the German Federal Government. 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. For example, the Bund future is the most traded contract in Europe with an average daily trading volume of some 800.000 contracts on the EUREX reflecting an underlying value of EUR 800bn on a daily basis[15]. The last bond market that we study is Belgium with a trading volume of EUR 316bn. The most important bond of the Belgian treasury are linear bonds, or OLOs as they are known after their combined acronym in French and Dutch (*Obligations Linéaire-Lineaire Obligaties*). These are straight non-callable

[13] As of January 2003.

[14] Long term French bonds are divided into OATs, fixed coupon bearing bonds with a maturity between 7 and 30 years and inflation linked bonds called OATi. Short term bonds have maturity between 2 and 5 years and are called BTANs. All these bonds are calculated on an actual/actual basis with annual coupon payments.

[15] Source Eurex website. Every bund futures contract requires delivery of EUR 100.000 face value of a bond with a maturity between 8.5 and 10.5 years at the moment of delivery.

bonds with fixed -coupon and redemption value. Table 3 also shows the percentage of trading activity taken place on the local and European MTS platform. German securities are mostly traded on the European platform together with the French medium term notes. Italian and Belgian securities are rarely traded on the European platform 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 either 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 most important reason for this difference is the relative small size of the participants on the domestic Italian platform. Now we are ready to calculate some different measures of spread on both the EuroMTS and the local trading platforms. 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.

3 Liquidity on the MTS Market

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 measuring 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.[16] Define the indicator I_h^z as:

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

The volume weighted quoted spread associated to a trade size equal to L is

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

Table 4 reports the Volume Weighted Quoted Spread measure for class A, B, C and D benchmark bonds for Belgium, France, Germany and Italy, on the domestic and EuroMTS platforms[17]. Our findings are that the quoted spread is similar across countries and for class A and B bonds, around 2 or 3 basis points from the best prevailing midquote. For class C bonds, the quoted spread is

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

[17] The estimates are based on data from 4-8 and 11-15 February 2002.

slightly higher 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 higher for the longest maturity bucket D (13.5 to 30 years), ranging from 11 to 18 basis points, 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 bigger 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 basis points, for a large trade of 25 million the quoted spread is still below 4 basis points. 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 bigger 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 a inaccurate indication of actually incurred trading costs. Therefore, we also calculate measures of the effective spread. The effective spread is 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 in time is closest to 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 5 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 trade and midquote. Table 5 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 6 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 2 shows the same information graphically. Table 6 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 3 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 kicks off with a relative large spread around 3 basis point in the early morning, falling to 2 basis points in the late morning and gradually increasing to 4 basis points in the late afternoon. Figure 4 shows the intraday pattern of effective and realized spread for the 10 year Italian bond. Again, a U-shaped pattern is being observed in here as well.

Summarizing these results, this section provided us some insights in the pricing behavior of market makers on both the local and EuroMTS trading platforms. We conclude that the quoted spread across countries is similar for bonds with a short maturity. For long term bonds differences exist. At first sight, the data suggest that the quoted spread varies over time while being lower on the domestic platforms. Effective spread estimates based on transaction prices show a very similar pattern across maturities. However, when testing differences in spreads between the domestic and EuroMTS platforms, we find that differences exist for a few bonds and in general, both markets are very integrated. Hence, there appears to be no difference between both markets with respect to the quoted bid-ask spreads. The MTS order book for these 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 that the quoted spread show a U-shaped pattern.

4 The Price Impact of Trading in Interdealer Markets

The analysis in the previous section provides us some useful insights in the trading costs on the MTS trading platforms. A dynamic structure however will give us additional information. Our data also contains the exact time of the days in which a trade occurs, giving us the opportunity to take the trading intensity into account. The theoretical literature is not unanimous about the effect of trading intensity on price 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) or trading intensity is high (Easley and O'Hara, 1992). These papers argue that there exist a positive relationship between information and trading intensity as more informed traders are active during high market activity[18]. This means that any unexpected trade during active trading has a higher impact on prices. On the other side, Diamond and Verrechia (1987) argue that informed traders always trade, no matter what the nature of the information is as they can take long or short positions. However, 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 relationship 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). More recently, Dufour and Engle (2000) show for stock market data that a higher trading intensity is related to stronger price impacts. This suggest that a larger trading size or trading intensity is likely to be an informational event as the market maker increase its bid ask spread in response to trades. The same results are reported by Spierdijk (2002). She shows using NYSE stock trading data that, during trading intensive sessions, a new trade has a larger impact on prices. Before we start with the introduction of the model, it is worthwile to give a reconcilliation of previous research on interdealer trading.

4.1 Interdealer Trading: An Overview

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

[18] 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. In Easly and O'Hara (1992) they argue that absence of trades reflects no-news creating a safer environment for a market maker to lower its spread.

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 suggest 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 *et al.* paper analyze the motives and characteristics of interdealer trades but do specifically 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 having a positive but smaller impact on prices than during quiet periods for numerous reasons. The first reason are the searching costs involved in inventory control. Hansch, Naik and Viswanathan's argument of *changing* mean reversion in inventory depends on the searching cost for a counterpart[19]. 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 argues that the direction of trade depends on the anticipation of a trade[20] which emphasizes the importance of order flows in the

[19]The cost of this sure execution is the fact that you cannot sell (buy) at your own bid (ask) price but at other market makers ask (bid) price. These searching costs are already known from the limit book literature. See e.g. Foucault et al. (2001) and Parlour (1998) and the references therein. This point was also pointed out by Flood et al. (1999) in an experimental setting.

[20]They note that if a order is anticipated, then *"interdealer trades will precede customer trades in the same direction"* e.g. if the dealer expects customer flows of buy trades, he will also start buying in the interdealer market. In contrast, if the order flow was unanticipated, *"follow up trades will move in the opposite direction"* e.g. unexpected customer buy trades will result in the interdealer sell trades.

price process. If a market maker anticipates incorrectly, he can easier correct his mistake when trades arrive frequently[21]. The second reason lies in the information value of order flow. The type of private information in government bond market however 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). 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[22] explaining the empirical findings of Manaster and Mann (1996). The information acquired by market makers in these markets are 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 may 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. Closely related to this point is the additional noise that arise when inventory is repeatedly passed among dealers using market orders. Lyons (1997) showed in a theoretical setup that the repeated passing of inventory is harmful as it creates additional noise in the order flow. Hence, in order to avoid any sequence of hot potato trading, the impact of an unexpected trade in a quiet trading environment may have a larger impact on the price than under a high trading environment as this creates an incentive to pass the inventory to another market maker rather than to wait for an incoming order.

In this analysis, it is also important to take the role of macroeconomic announcements into account. Fleming and Remolona (1999), Balduzzi, Elton and Green (2001) showed that macroeconomic 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 portions 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).

Summarizing, order flow and trading intensity play an important role in interdealer trading.

[21]Garman (1976) expects market makers to control the entering of traders by adjusting their bid and ask price. He shows that there is less need to adjust the spread as traders enter the market on a frequent basis during high market activity.

[22]This strategy has been addressed by Madhavan (1995).

From the perspective of inventory control, price discovery is negatively correlated with trading intensity as the ability to control inventory is easier during high market activity. 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.

4.2 The Impact of Trading Intensity on Prices

In the previous section, we argued that in interdealer markets a reverse relationship between price impact and trading intensity may exist. To test this empirically, we have to model price impact by taking order flow order flow dynamics and trading intensity into account. We apply the VAR model proposed by Dufour-Engle (2000). The m odel 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. This is important for the reasons mentioned previously but also because market makers on the MTS trading platforms are able to extract information from the live market pages of the system[23]. Therefore, 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-Engle, we make the coefficients a function of trading intensity, defined as the reciprocal of the number of minutes between two 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). Prior to estimation, we skip 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 $t-1$[24], $t \in \tau$. The trading duration is now corrected for diurnal patterns by dividing by the average trading duration in interval τ as given by $\bar{T}_{\tau}$.Although we use the term trading intensity throughout the paper, we must keep in mind that this is inversely related to $\ln T_{t-i}$. In other words, the higher $\ln T_{t-i}$, the longer the duration was between trade t and $t-1$ and hence the lower the trading

[23]In the MTS platform, a market maker receive market updates with respect to cumulatives quantity (not signed) and the weighted average price from the past 5 minutes in the running hour.

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

intensity. With these ingredients, the full model is

$$\begin{aligned} r_t &= \bar{\alpha}^r + \sum_{i=1}^{P}\left(\bar{\beta}_i^r + \bar{z}_i^r \ln\frac{T_{t-i,\tau}}{\bar{T}_\tau}\right) r_{t-i} + \sum_{i=0}^{P}\left(\bar{\gamma}_i^r + \bar{\delta}_i^r D_{t-i} + \bar{\tau}_i^r \ln\frac{T_{t-i,\tau}}{\bar{T}_\tau}\right) Q_{t-i} + \varepsilon_{1,t} \\ Q_t &= \bar{\alpha}^Q + \sum_{i=1}^{P}\left(\bar{\beta}_i^Q + \bar{z}_i^Q \ln\frac{T_{t-i,\tau}}{\bar{T}_\tau}\right) r_{t-i} + \sum_{i=1}^{P}\left(\bar{\gamma}_i^Q + \bar{\delta}_i^Q D_{t-i} + \bar{\tau}_i^Q \ln\frac{T_{t-i,\tau}}{\bar{T}_\tau}\right) Q_{t-i} + \varepsilon_{2,t} \end{aligned} \tag{6}$$

where $r_t = 10000 \ln(P_t/P_{t-1})$ and Q_t is the signed quantity in millions of Euro's of the notional amount. Hence, Q_t is negative when a 'sell' occurred while being 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 the trade at t occurred on the European MTS and zero otherwise. Notice that the equation for the returns contains a contemporaneous effect of the signed trade quantity. For the identification of the model we therefore assume that the error terms are mutually and serially uncorrelated.

4.3 Empirical Results

In the estimation, we truncated the lagged variable at $p = 3$. Because of the likely presence of heteroskedasticity we report White heteroskedastic consistent standard errors for statistical inference. Further details of the estimation are given in the appendix. In order to preserve space, we focus our discussion on the Italian 2011 and 2012 bonds as these are the most actively traded securities in our dataset. The estimation results can be found in Table 7.

4.3.1 Return Equation

The effects of trades on the quote revision r_t are considered here and the most important set of parameters for our investigation are γ_i^r, δ_i^r and τ_i^r, which are the signed quantity indicator, market indicator and the interaction between signed quantity and duration. The interaction between signed quantity and return is reflected in the γ_i^r parameter. First, note that $\gamma_0^r = 0.105$. This indicates an instantaneous upward (downward) price movement when a buy (sell) order occurs. The magnitude depends on the quantity being traded. 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 and they argue that this is consistent with active position building. There is however not much variability in the quantities being traded as most trades are executed in units of 5 or 10 million euro.

With respect to the market indicator, 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 EUR 5mio.

The z_i^r parameter relates the change in r_t and its own lagged values. Table 7 shows us that its lagged variable is important and significant at a 10% confidence interval. The most important parameter for our analysis would be τ_i^r as it indicates the interaction of duration and signed quantity on return. Our estimates shows that the $\tau_0^r = 0.046$ and $\tau_1^r = -0.006$ are significant. In other words, the larger the quantity being traded, the stronger the instantaneous price reaction. This reaction will be even stronger when trading intensity is low. The expected instantaneous price reaction on a local market given a duration $\ln(\tau^*)$ is given by $(\gamma_0 + \tau_0 \ln(\tau^*)) = 0.105 + 0.046 \ln(\tau^*)$. On the other hand, $\tau_1^r < 0$ indicates an increase in price when the previous quantity was a "sell" and a decrease in price when the previous order was a "buy". Because we find a positive τ_0^r we argue that a transaction arriving after a long interval has a stronger impact on trades than a transaction after a short interval. This is in contrast to the findings of Dufour and Engle (2000) or Spierdijk (2002) who both find a stronger impact after a short time interval.

With respect to the results of the return equation for the other 2011 bond series[25], we do find differences between the domestic platform and EuroMTS in these markets; the δ_0 parameter is significant for Belgium ($\delta_0 = 0.067$) and Germany ($\delta_0 = -0.226$). This explains the fact that Belgium bonds mostly being traded on the local market while the German bonds are traded on the European platform. We do find a positive γ_0^r for the other bond series, which runs from 0.007 for Belgium to 0.39 for Germany. The lagged variables γ_i^r are all not significant. We find a significant τ_0 parameter for Belgium ($\tau_0 = -0.047$) and France ($\tau_0 = 0.035$). Note that the Belgian parameter is positive which means that the impact of a trade during a period of high trading intensity is larger.

Turning our attention to the 2012 bond series, we see that the reported results also for the BTP 2012 bond. Here $\tau_0 = 0.054$ and again, a trade after a quiet period has a larger impact on price compared to the same trade in a busy period. Again, δ_0 is negative and equals 0.057 and the total impact of a one million 'buy' trade on the EuroMTS platform is therefore $\gamma_0 + \delta_0 = 0.144 - 0.057 = 0.087$ or 0.44 basis points for a 5 million euro trade. The same trade has an impact of 0.72 basis points on the local platform resulting in a difference of approximately $0.15bp$. For the other 2012 bond series, we cannot find any significant τ_0 and δ_0.

4.3.2 Quantity Equation

Let us now focus on the effect of trades on the quantity equation. As in the return equation, we estimate the model using heteroskedastic consistent standard errors. Again, we base our discussion

[25] To preserve space, we do not present their estimation results. They are available upon request

on the estimation results for the Italian 2011 bond. 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 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 for the BTP 2011 bond 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 with 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[26].

Because the estimation results for both 2011 and 2012 bonds suggest some interaction between duration, signed quantity and price impact we test whether these coefficient are jointly zero in the return equation using a Wald test based on the White estimator. The results of this test is shown in Table 8. Specifically, we test whether $\tau_0^r = \tau_1^r = \tau_2^r = \tau_3^r = 0$, which is $\chi_{(4)}$ distributed under the null hypothesis. The null hypothesis is rejected for the Belgian 2011 and French 2011 bonds and the only time series being consistent are the Italian bonds.

Cohen and Shin (2003) also analyses the impact of trades on return for the US treasury market. Their VAR estimations are based on different subsamples of high and low trading intensity. They find that the impact on return on high trading intensive days is larger compared to days of low trading intensity. However, their approach is somewhat different as they do not take into account the irregular time interval between observations and the diurnal patterns observed. Interesting is their analysis of impulse response function for February 3, 2000 which was a very volatile day with a lot of uncertainty in the market. The nature of this shock, which occurred the day before[27], was so unique that uncertainty still existed several days after. Our approach described above however does not isolate volatile days, instead it averages the trading intensity throughout the dataset. It is however interesting to see how trading responses to news. Our dataset is detailed enough to incorporate the impact of macroeconomic news on the trading mechanism. We therefore divide our dataset into a sample with no news and a sample with macroeconomic news anoouncements. The same model is used and the outcome is the subject of our next section.

4.4 The Impact of News Announcements

We re-estimate the Dufour-Engle model for the Italian 2011 bond by incorporating news with the highest trade impact by following the outcome of Fleming and Remolona (1999) and use

[26]These effects are also found for the BTP 2012 bond.

[27]On February 2, the Treasury announced the reduction of future supply in especcially the long end of the curve. This resulted in a significant flattening of the curve in the 10-30yr area.

the European equivalents of their outcome[28] . 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. 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)[29]. Because we focus on the return equation, we omit the superscript r. Our data could be divided into days with no news announcements (40043 observations) and days with news announcements (105 days, 20781 observations).

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 ($\gamma_0^{(news)} = 0.109$ versus $\gamma_0^{(no-news)} = 0.104$). The lagged variables γ_{t-i} are all positive but insignificant[30]. The impact of a trade on return for the MTS and EMTS platform can be analyzed through the δ_i parameters. We find that δ_0 is significant and smallest during days without news announcements ($\delta_0^{(no-news)} = -0.0253$ versus $\delta_0^{(news)} = -0.0223$). All other lagged market indicators appears not to be significant. Because this parameter is negative, it means that the impact is smaller on the EMTS trading platform but the difference becomes smaller during announcement days. Overall, the estimated magnitudes show that the instantaneous impact of a trade on the EMTS during an announcement day is larger compared to a non-announcement day and that its difference per EUR 5mio trade is $5 \times 0.008 = 0.04$ basis point [31]. Interesting are also the τ_i parameters which reflects the impact of duration on return. Our estimates are positive, significant and larger for days without news announcements ($\tau_0^{(no-news)} = 0.049$ versus $\tau_0^{(news)} = 0.043$). It shows that the instantaneous price impact of order flow is stronger in periods with low trading intensity and this effect is even stronger in days without announcements.

We can conclude the following: The impact of trades are larger during days where news are announced and 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, although the impact during days with news announcements is larger, the magnitude becomes even larger when intraday trading intensity is lower.

[28]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.

[29]The tables with estimation results are ommited in here but available upon request.

[30]The exception is $\gamma_3^{(news)} = 0.0065$.

[31]Combining the results for δ_0 and γ_0, we find that the impact of a trade on the EMTS per EUR 1mio face value is the largest during announcement days $\delta_0^{(news)} - \delta_0^{(no-news)} + \gamma_0^{(news)} - \gamma_0^{(no-news)} = 0.008$.

4.5 Impulse Response Functions

In order to analyze the price and trade volume dynamics we calculate the impulse response function using the estimated coefficients for the local trading platform[32]. 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 EUR 5mio occurs in the market. Here, we use the average trading intensity for analyzing the systems dynamics and the model changes into

$$\begin{aligned} r_t &= \bar{\alpha}^r + \sum_{i=1}^{P} \bar{\beta}_i^r r_{t-i} + \sum_{i=0}^{P} \bar{\gamma}_i^r Q_{t-i} + \varepsilon_{1,t} \\ Q_t &= \bar{\alpha}^Q + \sum_{i=1}^{P} \bar{\beta}_i^Q r_{t-i} + \sum_{i=1}^{P} \bar{\gamma}_i^Q Q_{t-i} + \varepsilon_{2,t} \end{aligned} \tag{7}$$

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 5 and 6. 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 and 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 $0.4bp$ to $0.6bp$ for the BTP 2011 and $0.4bp$ to $0.9bp$ for the BTP 2012. The bid-ask bounds arises in the 2nd trade which 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 up by additional buy orders and the system therefore does not instantaneous move back to its equilibrium, instead it takes approximately 9 trades before the system is back to its equilibrium. 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 $0.45bp$ to $0.9bp$ with a 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 announcements into account. As we can see in figure 7 and 8, the accumulated impact of a EUR 5mio buy trade has resulted in an $0.57bp$ increase in return in case when no news arrives and $0.64bp$ when news arrives. However,

[32]The appendix provides details on the calculation of the impulse responses.

the impact is larger during periods with a higher trading intensity as the accumulated response stands at 0.65bp for no-announcement days and 0.7bp for announcement days.

5 Conclusions

This paper offers some insights in the microstructure of the European government bond market. This platform is the largest pan European interdealer system in which market makers are obligated to quote two sides. Our analysis focuses on the benchmark bonds of Belgium, France, Germany and Italy. An interesting feature of this market is that we have both a local and EuroMTS trading platform where the securities can be traded. At first sight, the EuroMTS platform appears to be redundant as the local markets provide a larger number of securities while attracting the largest part of the order flow. We analyzed a number of reasons which might explained the existence of the EuroMTS platform. 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. For some securities there are small differences between the spreads on the MTS domestic trading platforms and EuroMTS. The domestic markets typically offer slightly better spreads (both quoted and effective) although differences are small, and if they exist, they turn into the local platforms favour. Any reasons favoring the existence of the EuroMTS system cannot be based to differences in spreads or price impacts of order flow. We think that this issue traces back to the request of treasury agents to have a domestic platform for monitoring rather than one dominant European platform. In addition, although the local systems provides us a richer menu of bonds, some participants are willing to trade only the benchmark securities.

We then turn our attention to the price impact of trades and trading duration. The interdealer literature suggest 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 creates 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 impact of order flows are much larger under days with announcements. This effect is even magnified under low intraday trading intensity. Finally, when analyzing the price impacts of a trade, we find that the EuroMTS turns out to be a better channel for trading large trades although the reported differences are very small. We therefore conlude that both trading platforms are very much integrated.

A Econometric details

This appendix gives details on the econometric methods used in the Dufour-Engle model. Instead of estimating model (6) per equation, we estimate the model as a dynamic simultaneous equation model. Following Hasbrouck (1991a), we first rewrite the model into vector notation

$$\mathbf{Y}_t = \sum_{i=1}^{P} \bar{\mathbf{A}}_i \mathbf{Y}_{t-i} + \bar{\mathbf{a}} + \sum_{i=1}^{P} \bar{\mathbf{B}}_i \mathbf{X}_{t-i} + \sum_{i=0}^{P} \bar{\mathbf{C}}_i D_{t-i} Q_{t-i} + \bar{\mathbf{G}} \mathbf{Y}_t + \bar{\mathbf{F}}_0 \ln T_t Q_t + \boldsymbol{\varepsilon}_t \tag{8}$$

where

$$\mathbf{Y}_{t-i} = \begin{bmatrix} r_{t-i} \\ Q_{t-i} \end{bmatrix}, \mathbf{X}_{t-i} = \begin{bmatrix} \ln(T_{t-i,\tau} \bar{T}_\tau^{-1}) r_{t-i} \\ \ln(T_{t-i,\tau} \bar{T}_\tau^{-1}) Q_{t-i} \end{bmatrix}, \tag{9}$$

and

$$\bar{\mathbf{a}} = \begin{bmatrix} \bar{\alpha}^r \\ \bar{\alpha}^Q \end{bmatrix}, \bar{\mathbf{A}}_i = \begin{bmatrix} \bar{\beta}_i^r & \bar{\gamma}_i^r \\ \beta_i^Q & \bar{\gamma}_i^Q \end{bmatrix}, \bar{\mathbf{B}}_i = \begin{bmatrix} \bar{z}_i^r & \bar{\tau}_i^r \\ \bar{z}_i^Q & \bar{\tau}_i^Q \end{bmatrix}, \tag{10}$$

$$\bar{\mathbf{C}}_i = \begin{bmatrix} \bar{\delta}_i^r \\ \bar{\delta}_i^Q \end{bmatrix}, \bar{\mathbf{C}}_0 = \begin{bmatrix} \bar{\delta}_0^r \\ 0 \end{bmatrix}, \bar{\mathbf{F}}_0 = \begin{bmatrix} \bar{\tau}_0^r \\ 0 \end{bmatrix}, \bar{\mathbf{G}} = \begin{bmatrix} 0 & \bar{\gamma}_0^r \\ 0 & 0 \end{bmatrix} \tag{11}$$

Here the $\mathbf{Y}_t$ variables are endogenous as it contains the output of the system while $\mathbf{X}_t$ contains the observable input variables and therefore being exogenous. The reduced form of the t-th equation in model 8 is given by

$$\begin{aligned} \mathbf{Y}_t &= \left(\mathbf{I}_2 - \bar{\mathbf{G}}\right)^{-1} \left[\sum_{i=1}^{P} \bar{\mathbf{A}}_i \mathbf{Y}_{t-i} + \bar{\mathbf{a}} + \sum_{i=1}^{P} \bar{\mathbf{B}}_i \mathbf{X}_{t-i} + \sum_{i=0}^{P} \bar{\mathbf{C}}_i D_{t-i} Q_{t-i} + \bar{\mathbf{F}}_0 \ln T_t Q_t + \boldsymbol{\varepsilon}_t \right] \\ &\equiv \sum_{i=1}^{P} \mathbf{A}_i \mathbf{Y}_{t-i} + \mathbf{a} + \sum_{i=1}^{P} \mathbf{B}_i \mathbf{X}_{t-i} + \sum_{i=0}^{P} \mathbf{C}_i D_{t-i} Q_{t-i} + \mathbf{F}_0 \ln T_t Q_t + \mathbf{v}_t \end{aligned} \tag{12}$$

Where the disappearance of the accent above denotes a multiplication with $(\mathbf{I} - \mathbf{G})^{-1}$. For example

$$\mathbf{A}_i = \begin{bmatrix} \beta_i^r & \gamma_i^r \\ \beta_i^Q & \gamma_i^Q \end{bmatrix} \equiv (\mathbf{I}_2 - \mathbf{G})^{-1} \bar{\mathbf{A}}_i = \begin{bmatrix} \bar{\beta}_i^r + \bar{\gamma}_0^r \beta_i^Q & \bar{\gamma}_i^r + \bar{\gamma}_0^r \gamma_i^Q \\ \bar{\beta}_i^Q & \bar{\gamma}_i^Q \end{bmatrix} \tag{13}$$

The error term is $v_t \sim N(0, \Xi_v)$ where $\Xi_v = (\mathbf{I}_2 - \mathbf{G})^{-1} \Xi_\varepsilon (\mathbf{I}_2 - \mathbf{G})^{-1\prime}$. The model as such is not identified as we cannot track the structural parameters using its reduced form (12). This identification problem arises as the reduced model is not able to identify the $\bar{\gamma}_0^r$ parameter of the original model without some additional restrictions on the model. However, we can calculate its value from the relation $v_{1,t} = \varepsilon_{1,t} + \bar{\gamma}_0^r \varepsilon_{2,t}$ which implies

$$\bar{\gamma}_0^r = \frac{Cov\left(v_{1,t}, v_{2,t}\right)}{Var\left(v_{2,t}\right)} \tag{14}$$

The $\bar{\gamma}_0^r$ parameter can be interpreted as the instantaneous impact of an incoming trade on the return residual and therefore on return itself and it must be strictly positive due to the bid-ask price. Note that this contemporaneous correlation also implies that we cannot analyze the dynamics of the system by simply isolating a shock in the order flow innovation $\varepsilon_{2,t}$ as a shock in $\varepsilon_{2,t}$ tells us something about $\varepsilon_{1,t}$ and hence about the dynamics of the total system. However, Lütkepohl (1993) shows that the impulse response dynamics can still be calculated by simply multiplying both sides of equation (8) with the upper Choleski decomposition of the residuals variance-covariance matrix $\mathbf{\Xi}_v$. Because or model contains AR-terms, it is useful to rewrite model (12) compactly in its final form for estimation purposes

$$\begin{aligned} \mathbf{Y}_t &= \mathbf{A}\left(\mathbf{L}\right)^{-1}\left[\mathbf{a} + \mathbf{B}\left(\mathbf{L}\right)\mathbf{X}_t + \mathbf{C}\left(\mathbf{L}\right)D_t Q_t + \mathbf{F}_0 \ln T_t Q_t + \mathbf{v}_t\right] \\ &= \mathbf{Z}_t \mathbf{\Lambda} + \mathbf{u}_t \end{aligned} \tag{15}$$

where $\mathbf{Z}_t = \left(\boldsymbol{\iota}_2, \mathbf{X}_t, D_t Q_t, \ln T_t Q_t\right), \mathbf{\Lambda} = vec\left[\boldsymbol{\alpha}, \mathbf{\Phi}_1, \mathbf{\Phi}_2, \mathbf{\Phi}_3\right]$ and $\mathbf{u}_t = \mathbf{A}\left(\mathbf{L}\right)^{-1}\mathbf{v}_t$where the lag operators are defined as $\underset{(2\times 2)}{\mathbf{A}\left(\mathbf{L}\right)} = \mathbf{I}_2 - \sum_{i=1}^{p}\mathbf{A}_i\mathbf{L}^i, \underset{(2\times 2)}{\mathbf{B}\left(\mathbf{L}\right)} = \sum_{i=1}^{p}\mathbf{B}_i\mathbf{L}^i, \underset{(2\times 2)}{\mathbf{C}\left(\mathbf{L}\right)} = \sum_{i=0}^{p}\mathbf{C}_i\mathbf{L}^i$ and $\mathbf{\Phi}_1 = \mathbf{A}\left(\mathbf{L}\right)^{-1}\mathbf{B}\left(\mathbf{L}\right), \mathbf{\Phi}_2 = \mathbf{A}\left(\mathbf{L}\right)^{-1}\mathbf{C}\left(\mathbf{L}\right)$ and $\mathbf{\Phi}_3 = \mathbf{A}\left(\mathbf{L}\right)^{-1}\mathbf{F}_0$. The final form representation implies that $\mathbf{Y}_t|\mathbf{\Lambda}_t \sim N\left(\mathbf{Z}_t\mathbf{\Lambda}_t, \mathbf{A}\left(\mathbf{L}\right)^{-1}\mathbf{\Xi}_v\mathbf{A}\left(\mathbf{L}\right)^{-1\prime}\right)$ and we calculate the joint density of the endogenous variables using Maximum Likelihood. An illustration of this method is given in Hamilton (1994).

B Impulse Response Functions

We now turn to the details of the calculation of the impulse responses for the local trading platform. One way of constructing the impulse response function has been suggested by Hasbrouck (1991b). By making assumptions about invertability and covariance stationary components one can represent the VAR(p) model as an MA(∞) model. The coefficients of this MA model are then the quote revision parameters. In our case, we take as a starting point the reduced form model (12).

$$\begin{aligned} r_t &= \alpha^r + \sum_{i=1}^{P}\left(\beta_i^r + z_i^r \ln\frac{T_{t-i,\tau}}{\bar{T}_\tau}\right) r_{t-i} + \tau_0^r \ln\frac{T_{t,\tau}}{\bar{T}_\tau} Q_t + \sum_{i=1}^{P}\left(\gamma_1^r + \tau_i^r \ln\frac{T_{t-i,\tau}}{\bar{T}_\tau}\right) Q_{t-i} + v_{1,t} \\ Q_t &= \alpha^Q + \sum_{i=1}^{P}\left(\beta_i^Q + z_i^Q \ln\frac{T_{t-i,\tau}}{\bar{T}_\tau}\right) r_{t-i} + \sum_{i=1}^{P}\left(\gamma_i^Q + \tau_i^Q \ln\frac{T_{t-i,\tau}}{\bar{T}_\tau}\right) Q_{t-i} + v_{2,t} \end{aligned} \tag{16}$$

We assume that the system at time $t = 0$ is in its long run equilibrium, i.e. no one is participating in trades ($Q_{t-i} = 0, i = 1, \ldots, P$) while market makers are not actively making the market ($r_{t-i} =$

$0, i = 1, \ldots, P)$. The impulse response function of a time series r_t due to an unexpected shock in Q_t is given by I_R and is analyzed at time $t + n$ through the following expression

$$\begin{aligned} I_r\left(n, \varepsilon_{2,t} = \delta, -_{t-1}\right) &= E\left[r_{t+n} | \varepsilon_{2,t} = \delta, \boldsymbol{\varepsilon}_{t+1} = \ldots = \boldsymbol{\varepsilon}_{t+n} = \mathbf{0}, -_{t-1}\right] \\ &\quad -E\left[r_{t+n} | \varepsilon_{2,t} = 0, \boldsymbol{\varepsilon}_{t+1} = \ldots = \boldsymbol{\varepsilon}_{t+n} = \mathbf{0}, -_{t-1}\right] \end{aligned} \tag{17}$$

Here the first term of (17) reflects the system when it has been hit only once by a shock δ at time t while the second term assumes that the system stays in its long run equilibrium. Because both terms are conditioned under the same information set $-_{t-1}$, it analyzes the realization of a system which are identical up to time t. An important aspect pointed out by Koop et al. (1996) is the fact that the impulse response function in linear models do not depend on the history of the information set. This aspect is worth considering in our model as one can expect a different impulse response function for r_t during different trading intensity. We therefore apply two methods for calculating the impulse response function as given by system (16).

The first method is by simply substituting the average trading duration for $T_{t-i,\tau}$ which is by definition exactly equal to $\bar{T}_\tau$. As a result, system (16) changes into a linear VAR(p) model.

$$\begin{aligned} r_t &= \sum_{i=1}^{P} \beta_i^r r_{t-i} + \sum_{i=1}^{P} \gamma_i^r Q_{t-i} + v_{1,t} \\ Q_t &= \sum_{i=1}^{P} \beta_i^Q r_{t-i} + \sum_{i=1}^{P} \gamma_i^Q Q_{t-i} + v_{2,t} \end{aligned} \tag{18}$$

The second method that we apply in here is to compare the price impact of an unexpected buy during periods of high and low trading intensity. We analyze the system under the situation that a trade is conducted just once in a period of high and low trading intensity. To do so, we the 10-th percentile trade based on the distribution of $\tau_{high} = [10.00 - 10.30)$ am interval and the 90-th trade based on the distribution of $\tau_{low} = [17.00 - 17.30)$pm interval. On average, these intervals have the highest and lowest number of trades. In other words, for every bond we select two trades with duration $T_{t-i,\tau}^{high}$ and $T_{t-i,\tau}^{low}$ such that

$$\begin{aligned} T_{t-i,\tau}^{high} &= 10th - \text{percentile trade in interval } \tau = \tau_{high} \\ T_{t-i,\tau}^{low} &= 90th - \text{percentile trade in interval } \tau = \tau_{low} \end{aligned} \tag{19}$$

As a result, the system changes again into a VAR(p) model

$$\begin{aligned} r_t &= \alpha^r + \sum_{i=1}^{P} \beta_i^r r_{t-i} + \tau_0^r \pi_0 Q_t + \sum_{i=1}^{P} \gamma_1^r Q_{t-i} + v_{1,t} \\ Q_t &= \alpha^Q + \sum_{i=1}^{P} \beta_i^Q r_{t-i} + \sum_{i=1}^{P} \gamma_i^Q Q_{t-i} + v_{2,t} \end{aligned} \tag{20}$$

where π_0 is either $\ln \frac{T^{high}_{t-i,\tau}}{\bar{T}_\tau}$ or $\ln \frac{T^{low}_{t-i,\tau}}{\bar{T}_\tau}$.

Note that the dynamics of system (18) and (20) cannot be analyzed by simply isolating a shock in the order flow innovation $\varepsilon_{2,t}$. The reason for this is the contemporaneous correlation between the residuals. Hence, as a shock in $\varepsilon_{2,t}$ tells us something about $\varepsilon_{1,t}$ and hence about the dynamics of the total system. This is an important reason to use the MA(∞) model as the orthogonal innovations do not obscure the actual reaction towards the system. For example, both (18) and (20) can be written as $\mathbf{Y}_t = \boldsymbol{\varepsilon}_t + \sum_{i=1}^{\infty} \boldsymbol{\theta}_i \boldsymbol{\varepsilon}_{t-i}$ where the matrix $\boldsymbol{\theta}_n$ has the interpretation $\partial \mathbf{Y}_{t+n} = \boldsymbol{\theta}_n \partial \boldsymbol{\varepsilon}_t$. Instead of this MA($\infty$) approach, we continue to use the reduced form of system(16) and follow the approach of Lütkepohl (1994), page 51, which requires the use of a Choleski decomposition of the variance matrix.

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Tables Section

Table 1: Domestic government debt

Medium and long term government debt oustanding (billion EUR). *Source*:ECB: The EURO Bond Market.

Country	Debt	Average maturity
Austria	81	6.2
Belgium	173	6.1
France	573	6.2
Germany	599	6.8
Italy	885	6.1
Netherlands	169	6.3
Spain	225	5.5

Table 2: Number of MTS market participants

The first column shows the total number of participants on the local market. The second column shows the number of participants that have market making obligations while the third column shows the number of market makers which are both market maker on the local and EuroMTS market.

Market	Participants	Market Makers	Market makers (both markets)
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 3: Overview cash traded bonds

Description of our dataset in terms of trades and volume. The left part of the table shows the percentage of trades conducted on the EuroMTS and on the local platform and the overall average trading size. The Italian platform also offers trading facilities for German securities. The right part shows us the percentage of total trades in the various quantity buckets. OLO, OAT, DBR and BTP bonds are long-term bonds and the central focus of our analysis. All other bonds have either a medium or short time to maturity

Market	Type	Transactions	Volume	% EMTS (%Domestic)	ATS	%2.5mio	%5.0mio	%10mio	total
Germany	DBR	14683	90033	56 (37)	6.1	3	75	19	97
	OBL	9703	81184	67 (26)	8.4	0	46	49	95
	BKO	7128	62385	72 (28)	8.8	0	39	57	96
	Total	**31514**	**233602**						
					23.3				
Italy	BTP	518432	2851689	17 (83)	5.5	22	64	10	96
	CTZ	43698	230281	0 (100)	5.3	69	11	8	88
	CCT	139615	692323.5	0 (100)	5	66	10	9	85
	BOT	27875	126218	0 (100)	4.5	69	17	5	91
	total	**729620**	**3900512**		**20.3**				
France	OAT	33864	207018	41 (59)	6.1	8	66	24	98
	BTNS	29472	252045	55 (45)	8.6	0	31	67	98
	total	**63336**	**459063**		**14.7**				
Belgium	OLO	43431	316857	22 (78)	7.3	4	50	44	98

Table 4: Volume Weighted Quoted Spread for domestic and EuroMTS markets. Numbers shown are in percentage from midpoint of the best bid-ask price.

	Class A	Class B	Class C	Class D
Mts Italy				
Trade size	BTP 15/07/05	BTP 01/03/07	BTP 01/08/11	BTP 01/05/31
5	0.0199	0.0284	0.0270	0.1200
10	0.0230	0.0300	0.0291	0.1325
25	0.0288	0.0382	0.0350	0.1489
Mts France				
Trade size	BTAN 12/07/05	BTAN 12/07/06	OAT 25/10/11	OAT 25/10/32
5.0	0.0270	0.0252	0.0308	0.1255
10.0	0.0271	0.0256	0.0308	0.1373
25.0	0.0446	0.0300	0.0351	0.1554
Mts Germany				
Trade size	OBL 135 05/05	OBL 138 08/06	DBR 04/01/12	DBR 04/01/31
5	0.0307	0.0381	0.0330	0.1521
10	0.0343	0.0395	0.0354	0.1680
25	0.0393	0.0491	0.0397	0.1811
Mts Belgium				
Trade size	OLO 34 09/05	OLO 37 09/06	OLO3609/11	OLO 3103/28
5	0.0281	0.0299	0.0411	0.1407
10	0.0289	0.0300	0.0412	0.1504
25	0.0393	0.0339	0.0467	0.1657
Euromts: Italian government bonds				
Trade size	BTP 15/07/05	BTP 01/03/07	BTP 01/08/11	BTP 01/05/31
5	0.0225	0.0290	0.0280	0.1178
10	0.0245	0.0307	0.0300	0.1303
25	0.0292	0.0369	0.0363	0.1486
Euromts: French government bonds				
Trade size	BTAN 07/05	BTAN 12/07/06	OAT 25/10/11	OAT 25/10/32
5	0.0248	0.0248	0.0290	0.1249
10	0.0249	0.0254	0.0298	0.1380
25	0.0289	0.0310	0.0335	0.1576
Euromts: German government bond				
Trade size	OBL 135 05/05	OLB 138 08/06	DBR 04/01/12	DBR 04/01/31
5	0.0399	0.0380	0.0317	0.1523
10	0.0343	0.0400	0.0339	0.1626
25	0.0613	0.0495	0.0374	0.1784
Euromts: Belgian government bonds				
Trade size	OLO 37 09/05	OLO 3709/06	OLO36 09/11	OLO 31 03/28
5	0.0281	0.0299	0.0414	0.1386
10	0.0287	0.0299	0.0416	0.1482
25	0.0346	0.0344	0.0468	0.1648

Table 5: Effective and realized spreads for the domestic and EuroMTS markets.

Table offers a comparison of the realized spread and the average effective spread. The effective spread is defined as the absolute difference between price and previous midquote. The realized spread is the difference between the price and subsequent midquote. The T-statistics reflects the outcome of testing whether there exist a significant difference between the spreads on the domestics trading platform versus EMTS.

Maturity	Bond	Domestic Effective	EMTS Effective	T-stat (eff.)	Domestic Realized	EMTS Realized	T-stat (real.)
A	BTP 07/05	0.018	0.018	0.128	**0.000**	**0.005**	**3.544**
	OBL 05/05	0.358	0.444	0.208	0.319	0.413	0.243
	BTNS 07/05	0.032	0.019	0.753	0.012	0.002	1.601
	OLO 10/04	0.010			0.013		
B	BTP 03/07	0.026	0.029	0.634	0.003	0.006	0.108
	OBL 08/06	0.033	0.021	1.028	**-0.002**	**0.026**	**2.207**
	BTNS 07/06	0.032	0.022	1.088	0.016	0.000	1.674
	OLO 09/06	0.034	0.035	0.046	0.008	0.014	0.731
C	BTPS 08/11	0.038	0.041	0.674	0.004	-0.002	0.378
	DBR 01/12	0.044	0.044	0.023	-0.022	0.005	1.630
	AOT 10/11	0.046	0.049	1.025	0.006	0.010	0.296
	OLO 09/11	0.041	0.060	1.376	0.016	0.017	0.015
D	BTP 05/31	0.110	0.114	0.272	0.028	0.023	0.300
	DBR 01/31	0.143	0.138	0.104	0.021	-0.005	0.870
	OAT 10/32	0.111	0.060	1.376	0.007	0.072	1.324
	OLO 03/28	0.108	0.113	0.221	-0.065	0.094	1.083

BTP are Italian bonds, BTNS and OAT are French, OBL and DBR are German, OLO are Belgian bonds. The Belgium October 2004 (OLO 10/04) is not traded on the EMTS platform.

Table 6: Spread for absolute price changes for domestic and EMTS trading platforms.

This table shows spread estimates based on absolute price changes for class A, B, C and D benchmark bonds as a percentage of the price. We test Spread EMTS = spread domestic platform using a standard t-test. The numbers in bold face reflects significance at 5% level.

Class	A	B	C	D
	Btp 15/07/05	Btp 01/03/07	Btp 01/08/11	Btp 01/05/31
Euromts	**0.0335**	0.0550	**0.0496**	0.1326
Mts Italy	**0.0202**	0.0338	**0.0320**	0.0839
T-stat	**2.06**	1.68	**2.29**	1.18
	Btan 12/07/05	Btan 12/07/06	Oat 25/10/11	Oat 25/10/32
Euromts	**0.0434**	0.1038	0.0682	0.1754
Mts France	**0.0492**	0.0548	0.0758	0.3564
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	0.0378	**0.0401**	0.1699	0.1789
Mts Germany	0.0309	**0.0376**	0.0916	0.1618
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	0.0597	0.0439	0.0935	0.2631
Mts Belgium	0.0498	0.0560	0.0717	0.2827
T-stat	1.26	0.78	0.76	0.05

Table 7: Dufour-Engle estimates for the BTP 2011 bond

Estimation of the Engle-Dufour model using Maximum likelihood. The standard errors are corrected for heteroskedasticity using 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 equation and the right-hand side shows the estimation result for the quantity equation.

Parameters	Coefficient	White S.E	t-stat	Coefficient	White S.E	t-stat
	return equation BTP 2011			**Signed Quantity equation BTP 2011**		
β_1	-0.04200	0.01697	**-2.47451**	0.00169	0.01528	0.11036
β_2	0.01043	0.01071	0.97390	-0.04876	0.01530	**-3.18679**
β_3	-0.00765	0.00822	-0.92993	-0.06047	0.01517	**-3.98730**
γ_0	0.105					
γ_1	0.00206	0.00232	0.89017	0.26106	0.00483	**54.06128**
γ_2	0.00447	0.00216	**2.06620**	0.06278	0.00502	**12.51208**
γ_3	0.00347	0.00190	1.83051	0.04636	0.00490	**9.46441**
z_1	0.00573	0.01145	0.50029	0.02331	0.01070	**2.17844**
z_2	-0.01628	0.00886	-1.83687	0.03130	0.01081	**2.89564**
z_3	0.01225	0.00726	1.68867	0.04381	0.01076	**4.07265**
τ_0	0.04616	0.00300	**15.39971**			
τ_1	-0.00599	0.00259	**-2.31135**	-0.04161	0.00487	**-8.54999**
τ_2	-0.00291	0.00253	-1.15059	-0.04255	0.00488	**-8.72268**
τ_3	-0.00418	0.00223	-1.87480	-0.03278	0.00476	**-6.89203**
δ_0	-0.02452	0.00262	**-9.37369**			
δ_1	-0.00365	0.00248	-1.47361	0.01688	0.00869	**1.94345**
δ_2	0.00181	0.00286	0.63456	0.02826	0.00869	**3.25090**
δ_3	0.00480	0.00273	1.75676	0.03633	0.00869	**4.18295**
α	-0.00471	0.00837	-0.56235	0.08477	0.02333	3.63400

Table 8: Wald test for duration effects

Wald test for the joint hypothesis $\tau_0 = \tau_1 = \tau_2 = \tau_3 = 0$. Under the nullhypothesis this variable is $\chi_{(4)}$ distributed.

	Wald-statistic		Wald-statistic
OLO_11	13.53	OLO_12	5.92
OAT _11	20.20	OAT_12	1.02
DBR_11	3.16	DBR_12	2.48
BTP_11	242.03	BTP_12	54.86

Graphs Section

Figure 1: Spread between the Italian 10-year benchmark bond (BTP) versus the 10-year German Bund. The data of weekly observations runs from March 1991 until December 2002. *Source: Thomson Financials*

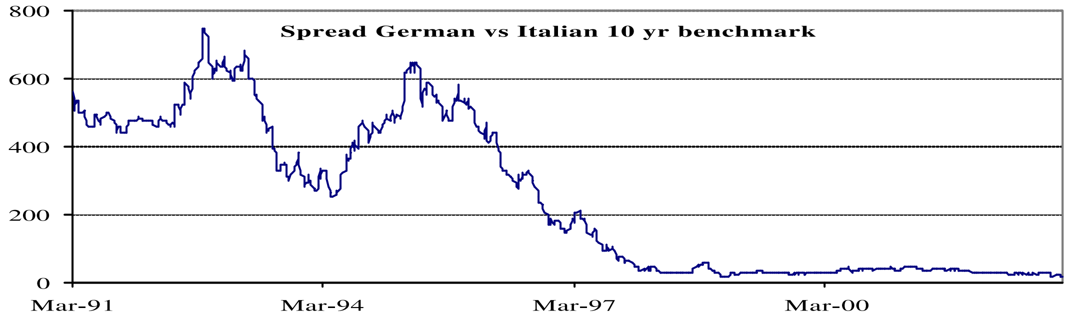
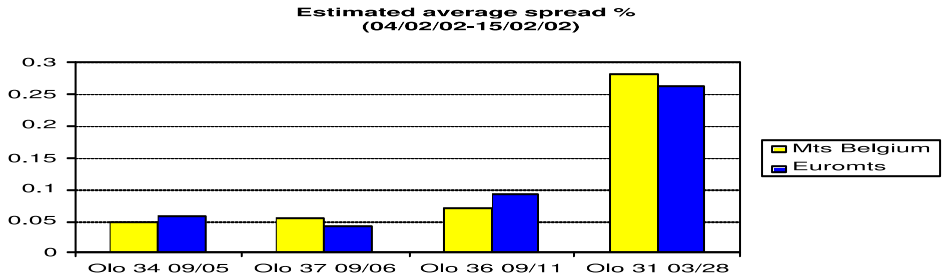
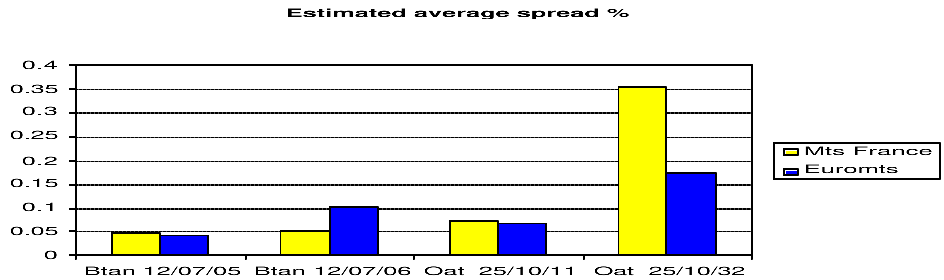
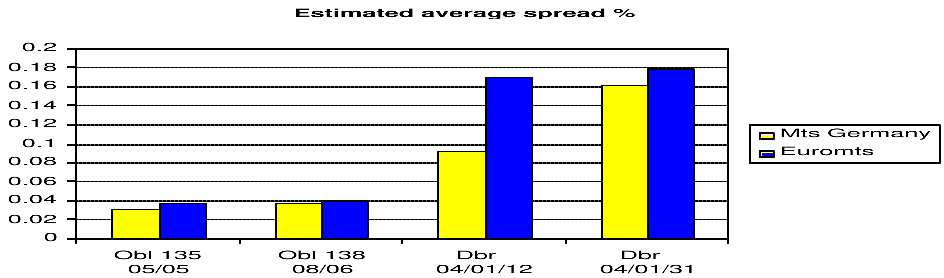


Figure 2: The estimated spread based on absolute price differences on the MTS versus the EMTS. Data runs from 4 February 2002 until 15 February 2002.







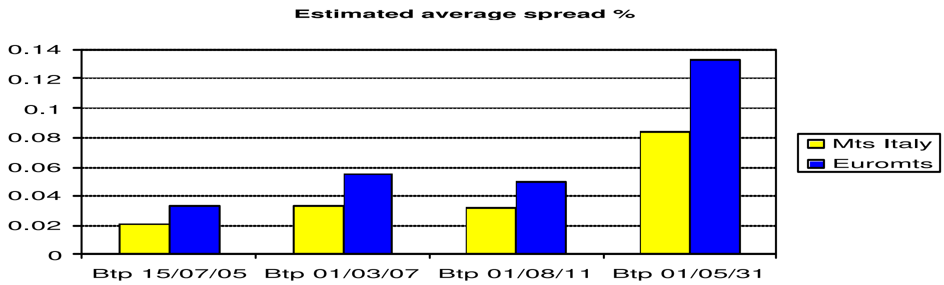


Figure 3: Intraday pattern of quoted spread for the BTP 2011.

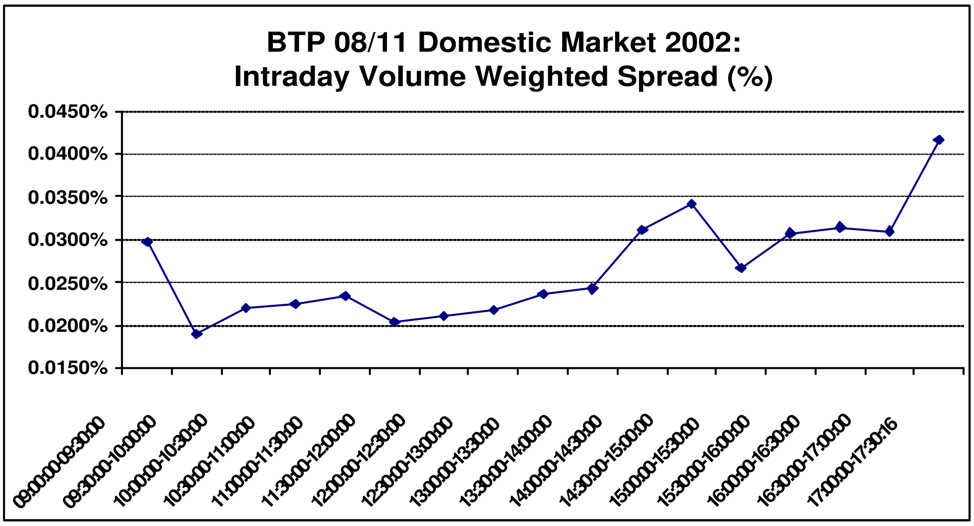
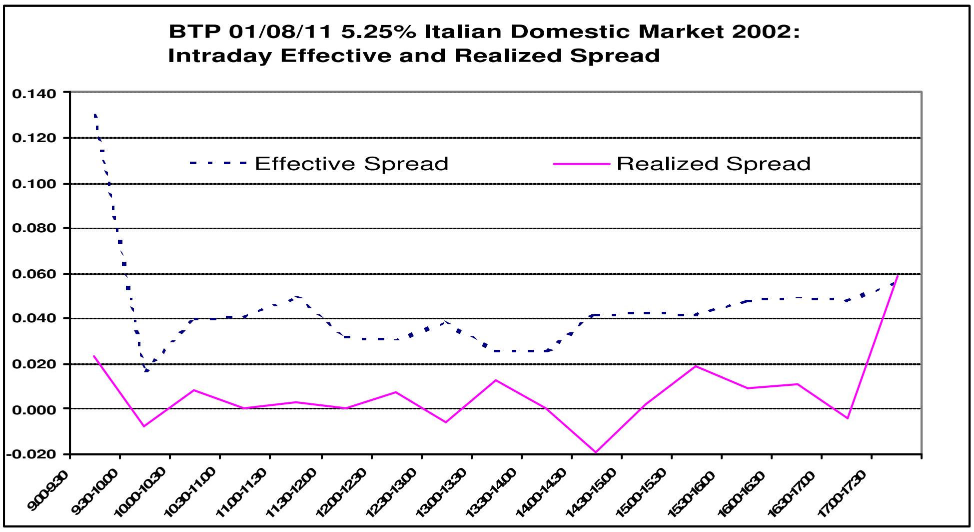


Figure 4: The average effective and realized spread.



Impulse Response Functions

The impulse response functions for the Italian 2011 and 2012 bonds using average trading intensity $T_{t-i,\tau}= \bar{T}_\tau$ are given in figure 5 and 6. By using the average duration, system (16) changes into a linear VAR(p) model. Specifically, the impulse response of the following system is analyzed:

$r_t = \alpha^r + \sum_{i=1}^{P} \beta_i^r r_{t-i} + \sum_{i=1}^{P} \gamma_i^r Q_{t-i} + v_{1,t}$
$Q_t = \alpha^Q + \sum_{i=1}^{P} \beta_i^Q r_{t-i} + \sum_{i=1}^{P} \gamma_i^Q Q_{t-i} + v_{2,t}$

The figures also show the impulse response functions for the securities using a fixed maximum and minimum trading intensity $T_{t-i,\tau}= \bar{T}_\tau$, system (16) changes into a linear VAR(p) model. Specifically, if taking time into account, we calculate the impulse response of the following system:

$$\begin{aligned} r_t &= \alpha^r + \sum_{i=1}^{P} \beta_i^r r_{t-i} + \tau_0^r \pi_0 Q_t + \sum_{i=1}^{P} \gamma_1^r Q_{t-i} + v_{1,t} \\ Q_t &= \alpha^Q + \sum_{i=1}^{P} \beta_i^Q r_{t-i} + \sum_{i=1}^{P} \gamma_i^Q Q_{t-i} + v_{2,t} \end{aligned}$$

where π_0 is either $\ln \frac{T_{t-i,\tau}^{high}}{\bar{T}_\tau}$ or $\ln \frac{T_{t-i,\tau}^{low}}{\bar{T}_\tau}$.

We calculate the response function of return given an unexpected buy trade at $t = 0$ of EUR five million. The lower graph shows the accumulated response of return.

Figure 5: Italian 2011 bond

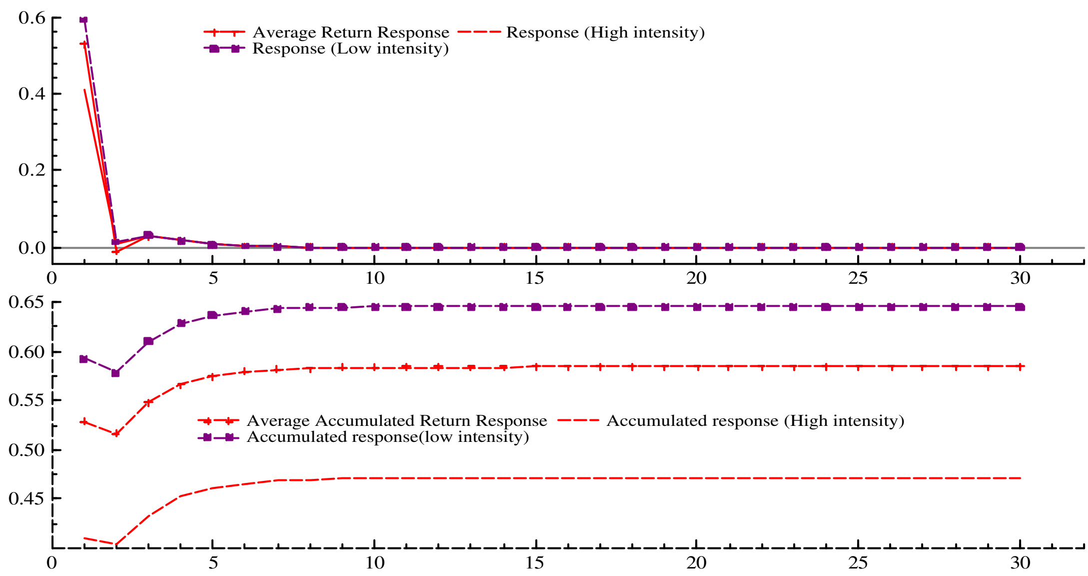


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Figure 6: Italian 2012 bond

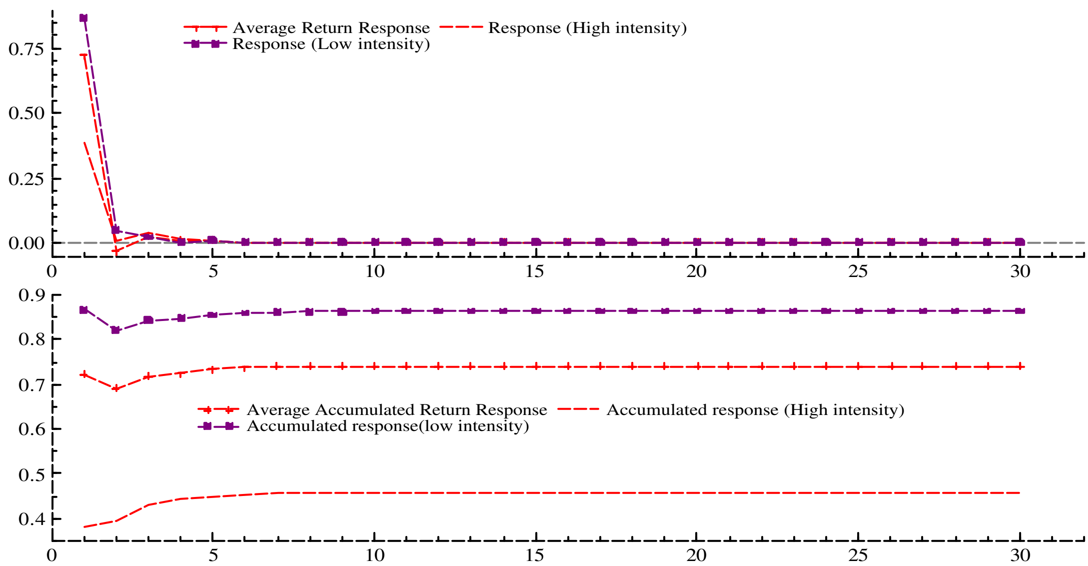


Figure 7: Italian 2011 bond (No news announcements)

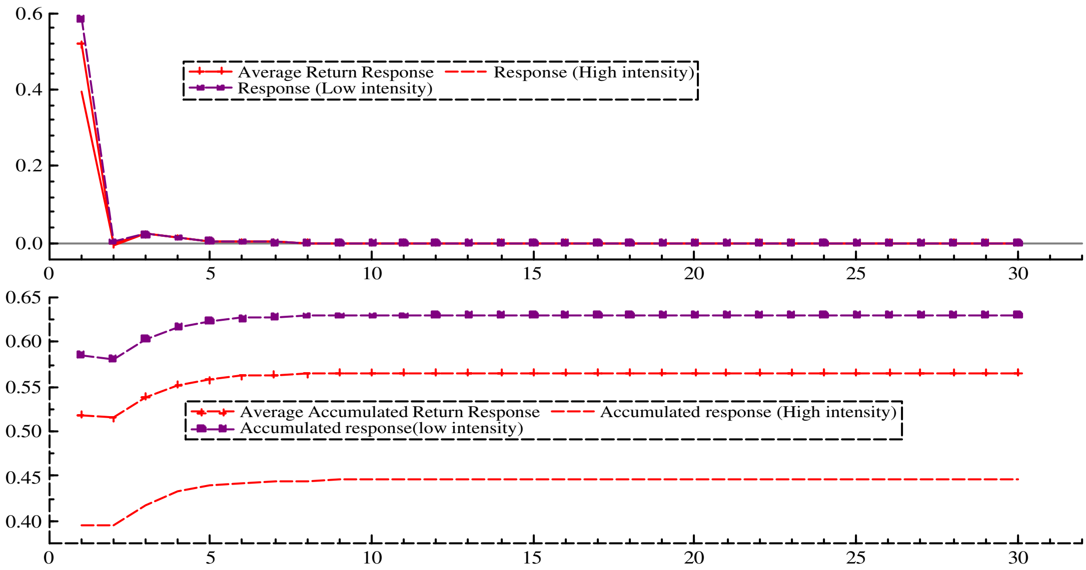
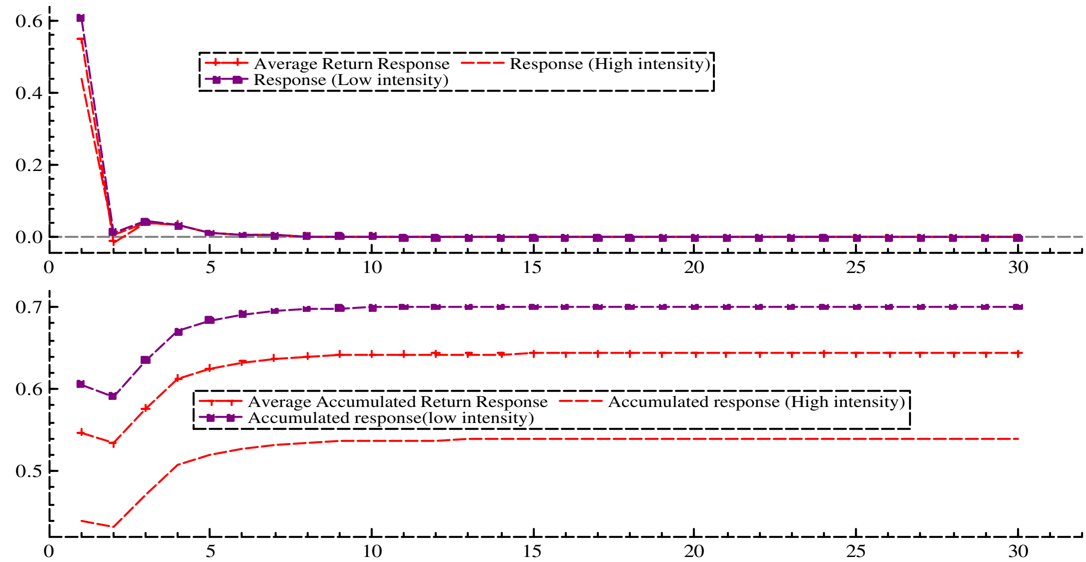


Figure 8: Italian 2011 bond (News announcements)



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