Markets Committee

Electronic trading in fixed income markets

Report submitted by a Study Group established by the Markets Committee

The Group was chaired by Joachim Nagel (Deutsche Bundesbank)

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Preface

Electronic trading has become an increasingly important part of the fixed income market landscape in recent years. It has contributed to changes in the market structure, the process of price discovery and the nature of liquidity provision. The rise of electronic trading has enabled a greater use of automated trading (including algorithmic and high-frequency trading) in fixed income futures and parts of cash bond markets. Innovative trading venues and protocols (reinforced by changes in the nature of intermediation) have proliferated, and new market participants have emerged. For some fixed income securities, "electronification" has reached a level similar to that in equity and foreign exchange markets, but for other instruments the take-up is lagging.

Against this background, in January 2015 the Markets Committee established a Study Group on electronic trading in fixed income markets (chaired by Joachim Nagel, Deutsche Bundesbank) to explore how ongoing developments are affecting market structure and functioning.

This report presents the Group's findings. It is based on information from a range of sources, including structured interviews with market participants and a survey of electronic trading platforms. It argues that advances in technology and regulatory changes have significantly affected the economics of intermediation in fixed income markets and that electronification is changing the behaviour of investors. The rise of electronic trading is creating efficiencies for many market participants, improving market quality in normal times, lowering transaction costs and reducing market segmentation, while at the same time posing challenges to some participants. Electronic trading, in particular automated and high-frequency trading, also poses a number of challenges to policymakers, including the need to monitor its effect on market liquidity and functioning and to ensure appropriate governance of automated trading. The report identifies a number of core areas for further policy assessment.

The report is a timely and important contribution to the ongoing discussions about the quality of market functioning and its implication for market design.

Guy Debelle

Chair, Markets Committee
Assistant Governor, Reserve Bank of Australia

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Executive summary

Electronic trading in fixed income markets has been growing steadily. In many jurisdictions, it has supplanted voice trading as the new standard for many fixed income asset classes. Electronification, ie the rising use of electronic trading technology, has been driven by a combination of factors. These include: (i) advances in technology; (ii) changes in regulation; and (iii) changes in the structure and liquidity characteristics of specific markets. For some fixed income securities, electronification has reached a level similar to that in equity and foreign exchange markets. US Treasury markets are a prime example of a highly electronic fixed income market, in which a high proportion of trading in benchmark securities is done using automated trading. However, fixed income markets still lag developments in other asset classes due to their greater heterogeneity and complexity.

This report highlights two specific areas of rapid evolution in fixed income markets. First, trading is becoming more automated in the most liquid and standardised parts of fixed income markets, often importing technology developed in other asset classes. Traditional dealers too are using technology to improve the efficiency of their market-making. And non-bank liquidity providers are searching for ways to trade directly with end investors using direct electronic connections. Second, electronic trading platforms are experimenting with new protocols to bring together buyers and sellers.

Advances in technology and regulatory changes have impacted the economics of intermediation in fixed income markets. Technology improvements have enabled dealers to substitute capital for labour. They are able to reduce costs by automating quoting and hedging of certain trades. Dealers are also able to better monitor the trading behaviour of their customers and how their order flow changes in response to news. Dealers are internalising flows more efficiently across trading desks, providing greater economies of scale for trading in securities where volumes are particularly high. But the growth in electronic trading is posing a number of challenges for traditional dealers. It has allowed new competitors with lower marginal costs to reduce margins and force efficiency gains, and it has required a large investment in information technology at a time when traditional dealers are cutting costs.

Electronification is also changing the behaviour of buy-side investors. They are deepening their use of execution strategies, in particular complex algorithms. Large asset managers are further internalising flows within their fund family. And a number of asset managers are supporting different competing platform initiatives that are attempting to source pools of liquidity using new trading protocols.

Electronic trading tends to have a positive impact in terms of market quality, but there are exceptions. There is relatively little research specific to fixed income markets, but lessons can be drawn from other asset classes. Evidence predominantly suggests that electronic trading platforms bring advantages to investors by lowering transaction costs. They improve market quality for assets that were already liquid by increasing competition, broadening market access and reducing the dependence on traditional market-makers. But platforms are not the appropriate solution for all securities, particularly for illiquid securities for which the risks from information leakage are high. For these securities, there is still a role for bilateral dealer-client relationships.

The impact of automated and high-frequency trading is a matter of considerable debate. Studies suggest that automation results in faster price discovery and an overall drop in transaction costs (at least for small trade sizes). The entrance of principal trading firms with lower marginal costs than traditional market-makers has intensified competition.

It remains to be seen whether the benefits of automation observed in normal trading periods also prevail during periods of stress, when the benefits of immediacy are particularly high. Competition over speed might displace traditional broker-dealers who may be more willing to bear risks over longer horizons. There is a risk that liquidity may have become less robust and prices more sensitive to order flow imbalances. Some recent episodes covered in this document shed some light on these issues. These episodes highlight that multiple drivers are likely to be at play, rather than conclusive evidence pointing to a predominant impact of automated trading alone.

Electronic trading, and in particular automated trading, poses a number of challenges to policymakers. The appropriate response may differ across jurisdictions because of the heterogeneous nature of fixed income markets as well as the varying degrees of electronification.

The report identifies four core areas for further policy assessment:

- First, the steady advance of electronic trading needs to be appropriately monitored. Access to better data is required. A supplement to better monitoring is to establish regular dialogue between regulatory bodies and industry participants.
- Second, further investigation is required to gauge the impact of automated trading on market quality. While there has been an improvement in certain metrics, liquidity may have become more fragile during stress episodes. More sophisticated measures need to be used to capture the multiple dimensions of market quality.
- Third, electronification has created additional challenges for risk management at market-makers, platform providers and end investors. Algorithm developers should follow guidelines for best practices. Policymakers should be conscious of the growing dependence on critical electronic trading infrastructures.
- Fourth, regulation and best practice guidelines should be living documents. They should be repeatedly reviewed and adapted as markets evolve. It may also be worth considering whether current regulatory requirements contribute to a level playing field amid the changing market structure and/or whether, for example, a code of conduct applicable to all significant market participants may be appropriate, when warranted by the specific circumstances.

When responding to these challenges, regulators should strike a balance between prescription and room for healthy innovation in market design. A flexible approach can enable platforms to compete to discover new ways to increase efficiency and integrity.

1. Introduction

Electronic trading has become an increasingly important part of the fixed income market landscape in recent years.[1] The rise of electronic trading has enabled a pickup of automated trading (including algorithmic and high-frequency trading) in fixed income futures and parts of cash bond markets. Innovative trading venues and protocols (reinforced by changes in the nature of intermediation) have proliferated, and new market participants have emerged. These recent changes have resulted in a transformation of the fixed income market structure, the process of price discovery and nature of liquidity provision. Electronic trading is advancing amid these structural changes, while implications for market quality and functioning are yet to be fully explored.

This report provides a view of the rising use of electronic and automated trading in fixed income and related derivatives markets – a process we refer to as "electronification". The primary goal of the report is to take stock of this development and to assess how electronification may be affecting market structure and quality. It is concerned with the impact of increasingly sophisticated and automated trade order and execution technologies. And, it takes a detailed look at the new challenges for policymakers.

The remainder of this report is structured as follows:

- Chapter 2 sets the stage, by providing a definition of electronic trading and describing its evolution in fixed income markets from a historical perspective. It also introduces key concepts and provides a categorisation of different trading styles, venues and protocols.
- Chapter 3 provides an overview of the current state of electronic trading. To derive its main conclusions, the chapter draws on an extensive series of interviews with market participants and provides quantitative figures from a survey conducted among electronic trading platforms geared towards fixed income.
- Chapter 4 looks at the broader impact of electronic trading. It discusses how electronification alters the market ecosystem, as well as the behaviour of different players that supply or demand intermediation services. Also, the impact of electronification on market quality is discussed.
- Chapter 5 outlines the challenges for policymakers at the current juncture.

A separate glossary is provided at the end of the report.

[1] Electronic trading in fixed income markets still remains less prominent compared with other asset classes, though. A key factor for the slower adoption of electronic trading in fixed income has been the greater complexity of the asset class (eg different coupons, maturities, embedded options, covenants) and the resulting higher degree of fragmentation.

2. What is electronic trading and how has it evolved?

2.1 What do we mean by "electronic trading"?

The term "electronic trading" covers a variety of activities that are part of the life cycle of a trade. In this report, electronic trading refers to the transfer of ownership of a financial instrument whereby the matching of the two counterparties in the negotiation or execution phase of the trade occurs through an electronic system.

Electronic trading broadly covers: trades conducted in systems such as electronic quote requests, electronic communications networks or dealer platforms; alternative electronic platforms such as dark pools; the quotation of prices or the dissemination of trade requests electronically; and settlement and reporting mechanisms that are electronic. For example, this includes both high-frequency trading on exchanges and trades negotiated by voice but executed and settled electronically.

The electronification of all these aspects of fixed income trading has been steadily increasing. There are now a variety of electronic trading platforms (ETPs), systems that match buyers with sellers, that differ in terms of the composition of their clients and their trading protocols.

2.2 How has electronic trading evolved in fixed income markets?

The voice era: an over-the-counter (OTC) market with dealers at its core[2]

Traditionally, fixed income trading has been organised around dealers (large banks or securities houses) and their relationship-based networks of clients. A physically centralised marketplace or organised exchange has generally been absent.[3] Dealers predominantly traded bilaterally via the telephone, either with other dealers or with their customers. The process of matching buyers and sellers required a fair amount of intermediation and involved significant search costs (Duffie (2012)). A customer wishing to trade a specific security would often contact one or more dealers by phone, asking for currently available prices to buy and sell. This market structure is known as a quote-driven market, a market in which executable prices are offered in response to counterparties' requests to trade.

The fixed income market has historically been marked by a segmentation between the *inter-dealer* segment, in which dealers trade with one another, and the *dealer-customer* segment, in which dealers trade with their clients (eg asset managers, pension funds, insurance companies, corporations). In other words, end users do not trade directly with other end users (Graph 1, left-hand panel). In the

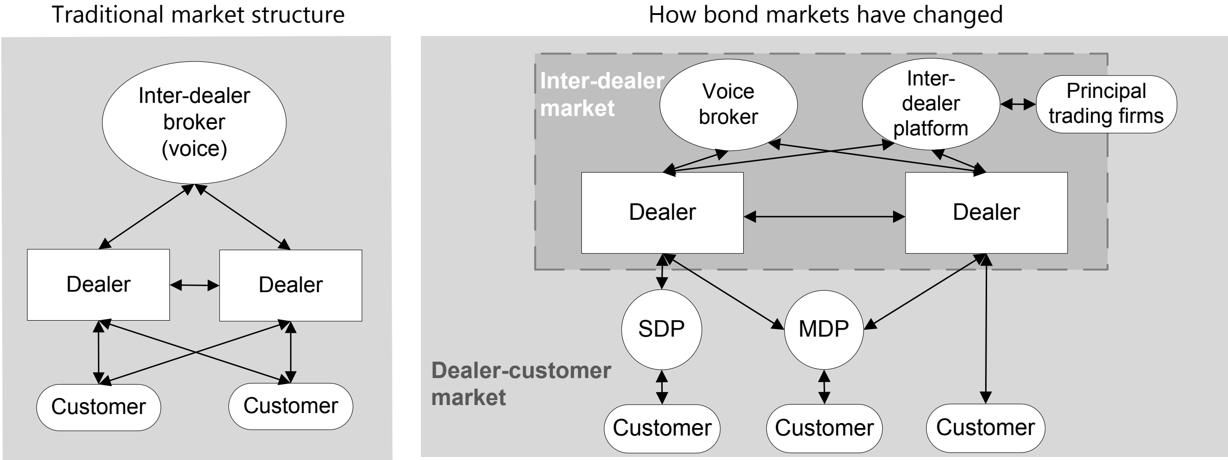
2 BIS (2001) describes the pickup in electronic trading in foreign exchange and fixed income markets in the late 1990s. Mizrach and Neely (2006) provide an insightful discussion of the first stages of electronification in US Treasury markets. Other earlier surveys that provide a discussion of the evolution of trading in fixed income markets include Hendershott (2003) and Fleming et al (2014).

3 Historically, however, bonds in the United States were once traded on the New York Stock Exchange (NYSE). Corporate bond trading on the NYSE was still fairly active until the late 1940s, before migrating to OTC markets (Biais and Green (2007)).

inter-dealer market, dealers traditionally traded either bilaterally over the phone or multilaterally (and anonymously) via voice brokers.

Bond trading has also generally been somewhat more opaque than trading in other asset classes. Details of a deal are often known only by the counterparties, and price or volume information is not disseminated to the wider investing public. Due to the market's segmentation, quotes and trade prices for the same bond at the same time could vary greatly across dealers.

How bond market structure has evolved — Graph 1



MDP = multi-dealer platform; SDP = single-dealer platform.

The rise of electronic trading in the inter-dealer market

Fixed income markets experienced a major shift starting in the late 1990s as electronic communication networks (ECNs) started to gain traction in inter-dealer markets for liquid sovereign bonds. An ECN is a system that electronically matches buy and sell orders for securities. ECNs operate as virtually centralised marketplaces, aggregating offers to trade and matching them against incoming trade requests. In contrast to the dealer-client markets, which were quote-driven, these platforms were generally order-driven. An order-driven market is a market in which executable prices are offered in advance of any requests to trade.

ECNs often use the trading protocol of the central limit order book (CLOB). A CLOB is a trading protocol in which outstanding bids and offers by market participants are stored in a queue and must be executed in a priority sequence. In the inter-dealer market, CLOBs are often pre-trade transparent to participants, in the sense that any ECN member may view the set of bids and offers at which one can sell or buy, respectively, at any time. Moreover, many ECNs enabled anonymous trade subject to pre-defined limits on their order books. Transaction prices and volumes were often disclosed post-trade. Another key advantage of the ECNs was the automated processing and settlement of trades, so-called straight through processing (STP).

An example of an ECN is EuroMTS, which is a pan-European platform for benchmark sovereign bonds, agency bonds, and repos among other asset classes. It was launched in 1998 to address the need to integrate European sovereign bond trading under the common currency without altering the pre-existing close ties between dealers and sovereign issuers.[4] Likewise, eSpeed and BrokerTec for US Treasury securities both launched in 1999 and emerged as major inter-dealer trading venues for benchmark US government securities. In Japan, the electronic trading platforms BB Super Trade and Tri-Trade launched in 2000 and 2006, respectively. These platforms serve as electronic trading venues for inter-dealer Japanese government bond (JGB) markets.

After the early 2000s, electronic trading infrastructure debuted in many other jurisdictions, including emerging market economies, with some exceptions. In markets such as Brazil, India, Korea and Singapore, electronic inter-dealer markets for sovereign bonds successfully developed with the benefit of public sector support: Selic in Brazil, NDS-OM in India, KTS in Korea and E-bond in Singapore. Voice brokering continues to dominate in jurisdictions such as Hong Kong and Mexico.

The rise of electronic trading in the dealer-client segment

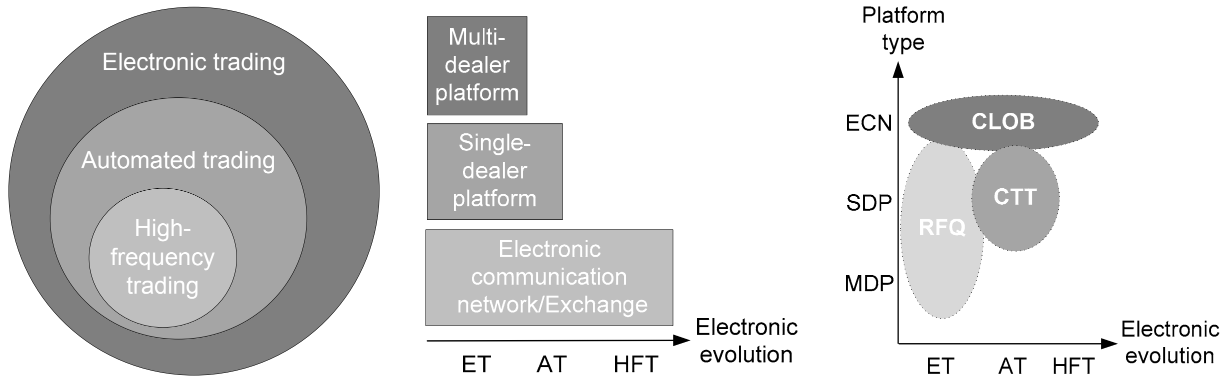
Electronic trading grew in the dealer-client market in the late 1990s and took two forms: single-dealer platforms (SDPs) and multi-dealer platforms (MDPs). SDPs are proprietary trading systems offered by a single dealer to its customers. Trading via SDPs can essentially be seen as an electronic version of the bilateral dealer-client market. Multi-dealer platforms (MDPs) also emerged in the late 1990s. MDPs reduced search costs by allowing end investors to request quotes to trade from a number of dealers simultaneously. MDPs also automated record-keeping, making it easier to audit best execution.

Dealer-to-client platforms are typically based on the request for quote (RFQ) trading protocol. An RFQ is a protocol in which platform users may query platform market-makers to request prices on an order of a particular size. RFQ systems range a great deal in terms of: whether the quote requester or quote receiver reveals its identity; whether the sign of the order (buy or sell) is revealed; how many and what kind of participants may receive RFQs; and whether the quotes are executable or indicative. In most fixed income RFQ systems, clients query only dealers and only in limited numbers.

A major landmark was the launch of Tradeweb in 1998 by Thomson Reuters, with stakes held by 11 banks that also served as key liquidity providers on the platform. Other major multi-dealer platforms include BondVision, introduced in 2001 (later acquired by MTS), and Bloomberg. These developments led to a more diverse market structure (Graph 1, right-hand panel). Today's market features greater connectivity among market participants, more transparency and a greater variety of opportunities to trade.

[4] In fact, MTS had been an innovation promoted by the Italian Treasury and the Bank of Italy as a trading venue for Italian Treasury securities. In 1997, MTS was privatised, the coverage was expanded and MTS transformed itself into the main inter-dealer venue for European sovereign bonds. In 2007, MTS was acquired by the London Stock Exchange.

Taxonomy of trading styles, platforms and protocols Graph 2



AT = automated trading; CLOB = central limit order book; CTT = click-to-trade; ECN = electronic communication network; ET = electronic trading; HFT = high-frequency trading; MDP = multi-dealer platform; RFQ = request for quote; SDP = single-dealer platform.

Automated trading and the rise of new market-makers

The rise of electronic trading platforms enabled automated trading (AT) – a common feature in other asset classes for more than a decade – to become prevalent in certain segments of fixed income markets. AT is a trading technology in which order and trade decisions are made electronically and autonomously (Graph 2, left-hand panel). A notable form of AT is high-frequency trading (HFT), which relies on speed and tight intraday inventory positions. A closer look at AT and HFT is presented in Box 1.

The presence of new market participants pursuing AT/HFT strategies – labelled in this report as principal trading firms (PTFs) – is affecting the nature of liquidity provision and intermediation in fixed income markets. Even traditional market participants have invested in AT technology in recent years. Liquid sovereign bond markets (especially benchmark US Treasuries) have seen a significant rise in AT activity. Traditional inter-dealer platforms such as BrokerTec and eSpeed have granted access to PTFs, which generate large trading volumes. Recent estimates suggest that over 50% of trading volumes in benchmark US Treasury securities on formerly exclusive inter-dealer venues can be accounted for by PTFs (US Joint Staff Report (JSR) (2015)).

The most advanced AT and HFT strategies thrive in markets with CLOBs that were fairly liquid even before algorithmic trading, such as futures and benchmark sovereign debt. HFT strategies require a capacity to: generate a large number of orders, ensure that open positions are held for short periods (often seconds or less), and cancel a large share of orders that they generate (often over 80%).

By contrast, trading protocols such as RFQ are amenable only to AT strategies in which speed is less critical, such as auto-quoting and trade execution. An RFQ system does not present algorithms with a continuous market. It should be no surprise that less liquid bond market segments, such as the markets for non-benchmark sovereign bonds or corporate bonds where CLOBs are not the common trade protocol, do not see much HFT and only limited AT.

Box 1

What are automated trading and high-frequency trading?

Automated trading (AT) is a trading technology in which order and trade decisions are made electronically and autonomously (BIS (2011)). High-frequency trading (HFT) is a subset of AT in which orders are submitted and trades executed at high speed, usually measured in microseconds, and a very tight intraday inventory position is maintained. HFT strategies seek to gain advantage from the ability to process information on market conditions quickly and react instantaneously. The strategies tend to result in a large number of small trades that are held for short periods and also tend to generate a high volume of message traffic between the platform and high-frequency traders. To gain an edge in terms of computing speed, principal trading firms locate their servers physically close to an electronic platform's matching engine (co-location) and hence minimise latency.①

AT and HFT strategies can be roughly grouped in three categories:②

Trade execution. Algorithms for trade execution generally split a large trade into smaller trades, which they execute over time and across venues. Execution algorithms are often concerned with minimising the price impact of a transaction. Such algorithms are used by broker-dealers as well as end investors (eg asset managers) for establishing or exiting a position at low cost.

Market-making. Algorithms generate indicative or live screen quotes or may be used to reply to requests for quote (so called auto-quoting). HFT algorithms in particular do business by standing ready to trade at a publicly quoted bid and ask price. The main purpose is to profit from the bid-ask spread, while ensuring tight risk control over inventory positions and minimising the risk of transacting with an informed counterparty.

Directional, relative value and arbitrage strategies. AT and HFT may also be used to implement various strategies that attempt to exploit systematic short-term patterns in asset prices or arbitrages. For example, HFT algorithms identify short-lived trading opportunities from price and order flow information and act on such signals quickly. HFT may also implement strategies identifying arbitrage opportunities in markets with fragmented liquidity.

① While the above conceptually explains what HFT is about, it is not an easy exercise to exactly identify HFT flows, let alone determine what entities should be labelled as HFT.

② Note that algorithms often do not follow a single trading strategy, but may also switch between strategies over time.

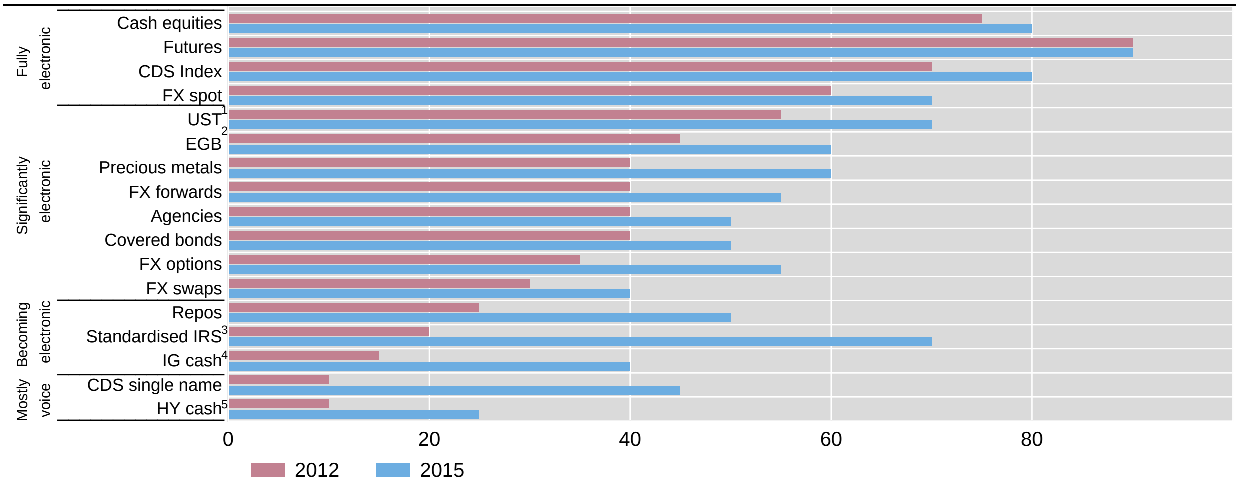
3. What is the current state of electronic trading in fixed income markets?

The extent of electronic trading in fixed income markets varies significantly, but has been growing over time globally. Despite the phenomenon's growing importance, policymakers' direct access to continuous and comprehensive data on electronic trading in fixed income markets is so far limited. The data that exist differ significantly in terms of comprehensiveness, quality and comparability across jurisdictions. This section therefore relies on numerous interviews with market participants as well as existing research and industry surveys. It also presents the results of an ad hoc survey of over 30 platform providers conducted by the Markets Committee Study Group.

In some fixed income segments, electronification is now nearly as developed as in cash equities and foreign exchange. Electronic trading is most advanced in those markets in which assets are most standardised and highly liquid – in particular, futures and the inter-dealer on-the-run US Treasury market. It is less advanced in less liquid and more heterogeneous markets, such as credit markets, as illustrated in Graph 3. In some markets, an increase in electronic trading has been driven directly by technological improvements that have facilitated a reduction in the marginal cost of providing intermediation services and lowered the barriers to entry for companies with a technology advantage. In others, still, it has been catalysed by regulatory change (see Box 2 on the main drivers of electronification).

State of electronification in various asset classes

In per cent | Graph 3



[1] US Treasuries. [2] European government bonds. [3] Standardised interest rate swaps. [4] Investment grade cash bonds. [5] High-yield cash bonds.

Sources: Greenwich Associates (2014); McKinsey & Company and Greenwich Associates (2013).

Fixed income futures

Today's fixed income futures markets are highly electronic. Similarly to the modern equity and spot FX markets, around 90% of transactions in fixed income futures occur electronically (Graph 3). A variety of end investors and market-makers use automation and electronic means of execution. PTFs are the main providers of (short-term) liquidity and account for the majority of the trading volume. They are financially incentivised to do so by exchanges. Banks rarely act as market-makers on exchanges, but will take principal risk as market-makers for large trades conducted off-exchange and subject to delayed reporting (known as block trades).

On futures exchanges worldwide, more and more latency-dependent strategies have been observed in the last decade. Particularly since the introduction of co-location – that is, the ability to place one's server in the vicinity of the exchange's matching engines – the activity of PTFs engaged in automated trading has increased substantially. The Chicago Mercantile Exchange began offering co-location services in late 2006, and over time it has become a primary arena for principal trading firms engaged in AT and HFT. Over a similar period, co-location was introduced at Eurex, the primary venue for German bund futures contracts. Various system upgrades (eg from a 10 Mbps line to a 1 Gbps line in 2010 and then a 10 Gbps line in 2011) have allowed Eurex's co-location clients to trade at ever greater speed. Likewise, the main venue for JGB futures, Osaka Exchange Inc, in 2011 introduced the derivatives trading system J-GATE, which provides high order processing capacity with co-location.

Box 2

Key drivers of electronic trading

There are many forces that have promoted the adoption of electronic trading. The drivers can broadly be categorised under three headings: (i) technological evolution which lowers costs; (ii) market structure features that influence demand; and (iii) the regulatory framework contributing to changes in dealers' business models.

Technology. Technological innovations tend to reduce costs. A commonly cited benefit of electronic trading is that, if the electronic trading platform (ETP) is used on a sufficient scale, it can generate very low marginal and average trading costs. Recent innovations have also reduced the fixed cost of building new trading systems, which has lowered the entry barriers for new platform providers. However, the costs of adopting the technology may be high. ETPs can also lower the indirect costs of transacting by bringing down search costs. They can do this because they provide the capacity for increased transparency through the more efficient dissemination of market information to more market participants. Furthermore, ETPs can reduce search and transaction costs to the extent that they offer liquidity benefits via pooling transactions, reducing market segmentation and fragmentation and promoting competition among market participants.

Market structure features. The scalability for an ETP depends on the capacity of the technology (described above), but also on the size of the market and features of the market structure. For instance, there is greater potential for economies of scale to be realised for standardised products that are traded frequently or for a market with a large number and diverse range of investors. The usage of a particular ETP may also depend on its ancillary benefits, such as its capacity to provide solutions for clearing, settlement, risk management, and regulatory, reporting or market-making requirements.

Regulatory changes. The regulatory drivers of the usage of ETPs can be broadly divided into those that are directly concerned with the arrangements of trading venues and markets and those that may have an indirect impact on their usage. The former are broadly framed by principles outlined by IOSCO. The latter include some regulatory changes introduced since the financial crisis which have had the objective of ensuring that banks are not a source of liquidity contagion. Due to changes in the regulatory environment and in dealers' business models, the relative cost of providing intermediation services via electronic means, rather than voiced means, has changed. Due to a strong level of competition in many markets, dealers have been unable to fully pass on higher trading costs to clients. At the same time, the potential for them to withdraw from market-making activities is limited by client relationships and certain obligations, especially when acting as primary dealers. Consequently, dealers have scaled down high-cost market-making and increased their provision of lower cost structures by providing customers with a capacity to transact via electronic trading platforms.

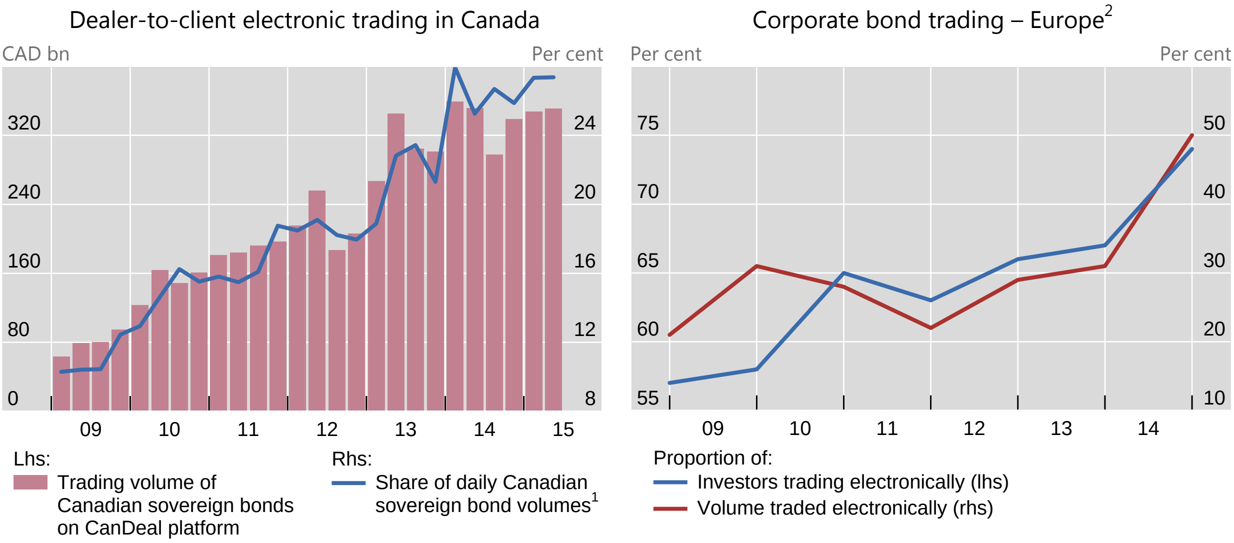
Sovereign bond markets

US Treasury markets are nowadays also highly electronic, on a similar scale to futures markets (Graph 3). The inter-dealer market for on-the-run US Treasury securities is almost entirely electronic, with a CLOB and a large presence of PTFs that employ AT technologies similar to those in FX and equity markets.

As part of another very recent development, PTFs have expanded their footprint in the on-the-run US Treasury market further by offering facilities that allow traditional market-makers to transact directly with them (via direct application programming interface (API) connectivity) rather than simply via a CLOB. This allows market-makers that have a technological disadvantage to effectively outsource their market-making activity – a development akin to that in other highly electronified markets, eg foreign exchange. Currently, some PTFs are also looking to provide liquidity directly to end users by offering to provide liquidity directly on major dealer-customer platforms.

Traditional market-makers too are making much greater use of technology. Competition from PTFs, cost pressures and changes in market microstructure have put pressure on incumbents to reduce the marginal costs of their market-making activities. Different approaches have been adopted, however. Most use a variety of algorithms when transacting in inter-dealer markets. A number of major dealing banks have competed directly with PTFs by creating their own sophisticated HFT market-making algorithms. Others are attempting to better exploit their economies of scale by better "internalising" flow between market-making desks that use on-the-run US Treasuries or futures to hedge their interest rate risk. As has happened in FX markets, dealers have invested in better internal matching systems and have been able to internalise a higher portion of their traded volume, depending on their risk appetite, the sophistication of IT systems and trading volumes across complimentary products.

Rise of electronic trading in the dealer-to-client segment   Graph 4



[1] Share of sovereign volume on the CanDeal platform of non-anonymous sovereign volumes reported in the Canadian Market Trade Reporting System. [2] Based on responses from an annual average of 360 investment grade credit investors in Europe.

Sources: CanDeal; Greenwich Associates (2014); BIS.

Intermediation in the off-the-run Treasury market, however, is still almost exclusively provided by traditional bank dealers, with little involvement of non-bank market-makers. Although the degree of automation in off-the-run Treasuries is less advanced, there have been some notable developments. In the dealer-to-customer market, more than half of customer trading volume occurs over RFQ platforms, with the remainder transacted by voice. Dealers have attempted to reduce their marginal costs by automating large parts of the trade process, including the pricing (auto-quoting) and risk management (auto-hedging, by instantly trading in on-the-run US Treasuries or futures in a model-determined and -executed manner) of certain positions.

Other highly developed bond platforms for liquid government bonds, such as MTS in Europe, operate in a similar manner to US Treasury markets, but with fewer of the elements of advanced technologies.[5] One similarity to the US market is that inter-dealer markets will typically operate on CLOBs. Another is that dealer-customer transactions often occur on electronic RFQ platforms. This is the case for dealer-to-customer European sovereign bond transactions on the MTS platform. The same is true for the Canadian market, in which electronic trading volumes, primarily through the CanDeal marketplace, have also picked up in recent years (Graph 4, left-hand panel). However, in many markets outside the United States, many large primary dealers still employ human market-makers to manually quote on trading requests, even if conducted over an RFQ platform. There are also fewer attempts to use technology to internalise flow. And the presence of PTFs in advanced fixed income markets outside the United States is largely limited to futures markets, with no significant presence in cash markets yet.

Interest rate swaps

Interest rate swap (IRS) markets have quickly transformed from voice-quoted markets to ones that use electronic platforms and automation. The main changes have occurred in those jurisdictions that have mandated trades to be centrally cleared and conducted on ETPs, with voice execution still prominent where transactions are not mandated to be conducted on ETPs. For example, the US dollar IRS market has transitioned to a highly electronic market, with around 50% of all cleared trades being conducted across swap execution facilities.

The majority of swap trading still occurs in response to an RFQ, rather than via a CLOB. The growth in electronic trading has allowed some PTFs to enter as liquidity providers, but banks remain the dominant market-makers. Banks and non-banks are gradually using more technology to automatically price, quote and hedge electronically traded IRS, but this is less widespread than in on-the-run US Treasury markets. Although Europe is somewhat lagging the United States in implementing the G20 OTC derivatives market reforms, electronic trading on the euro IRS market increased strongly since 2010 and now represents more than a half of volumes. Electronic trading in IRS in several other currencies is also expected to increase in response to forthcoming regulation (FSB (2015)).

Corporate bonds

Given the high degree of heterogeneity of many corporate bonds and the often very low frequency at which they trade, electronic trading is less prevalent in the corporate bond market (Graph 3).[6] While trading via electronic venues has recently picked up (Graph 4, right-hand panel), market participants note that most electronic

[5] One factor that may explain the different path of electronification is the relationship between primary dealers (PDs), platform providers and issuers in some European sovereign debt markets. When the issuer de facto becomes a relevant stakeholder, inter-dealer platforms may end up being accessible only to PDs. The situation in US secondary markets is quite different in that inter-dealer platforms have granted more lenient access to non-bank players, including PTFs. Thus, governance features are an important element for understanding the process of electronification across jurisdictions, platform characteristics (eg with regard to access conditions, trading protocols, transparency) and the business models of the platform providers.

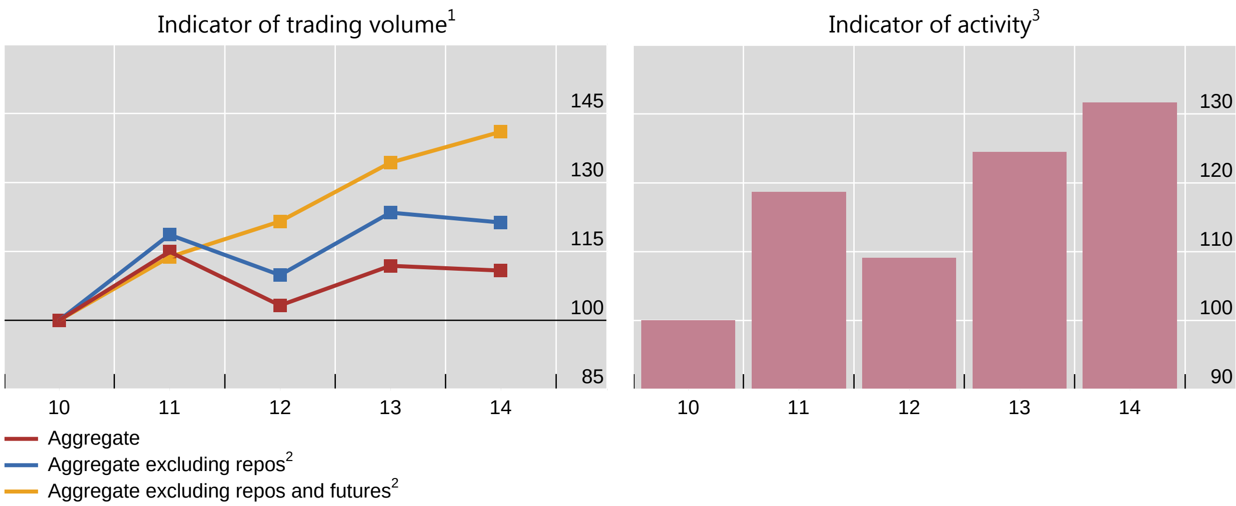
[6] For example, a survey by McKinsey (2013) suggested that about 15–20% of corporate bond trading in the US investment grade corporate bond market was conducted electronically, while Greenwich Associates (2014) found that around 50% of trading volume was conducted electronically in European investment grade corporate bond markets and 20% in high-yield markets.

trades are relatively small in size, with an estimated 85% of electronic transactions being for trades with less than $1 million of notional value, with large trades still conducted primarily using voice-quoted means.

Nevertheless, most recently there have been significant pockets of innovation in credit markets. A large variety of new trading platforms have emerged that facilitate corporate bond intermediation. The innovation has been spurred by increased concerns about liquidity in credit markets, which has prompted market participants to investigate whether alternative trading protocols could help overcome such challenges. One innovation has been electronic all-to-all trading platforms; market participants estimate that around 5% of electronically traded investment grade and high-yield bond trades are conducted on all-to-all platforms. This has pressured buy-side participants into reconsidering their position in the market, and some of them have acted to develop infrastructure that allows them to respond to trade enquiries. For asset managers, this poses some challenges in terms of proving best execution. Other innovations include new platforms that use technology in various ways to increase the chance of matching two participants with offsetting interests at a given price. Overall, however, it should be noted that, despite innovation, the bulk of corporate bond trading is not conducted via such new venues yet.

Trends in trading volume and activity on fixed income electronic platforms

2010 = 100 Graph 5



[1] Based on average daily trading volume. [2] Excluding repo and fixed income futures volume from the average daily trading volume of selected platforms. [3] Based on the number of transactions.

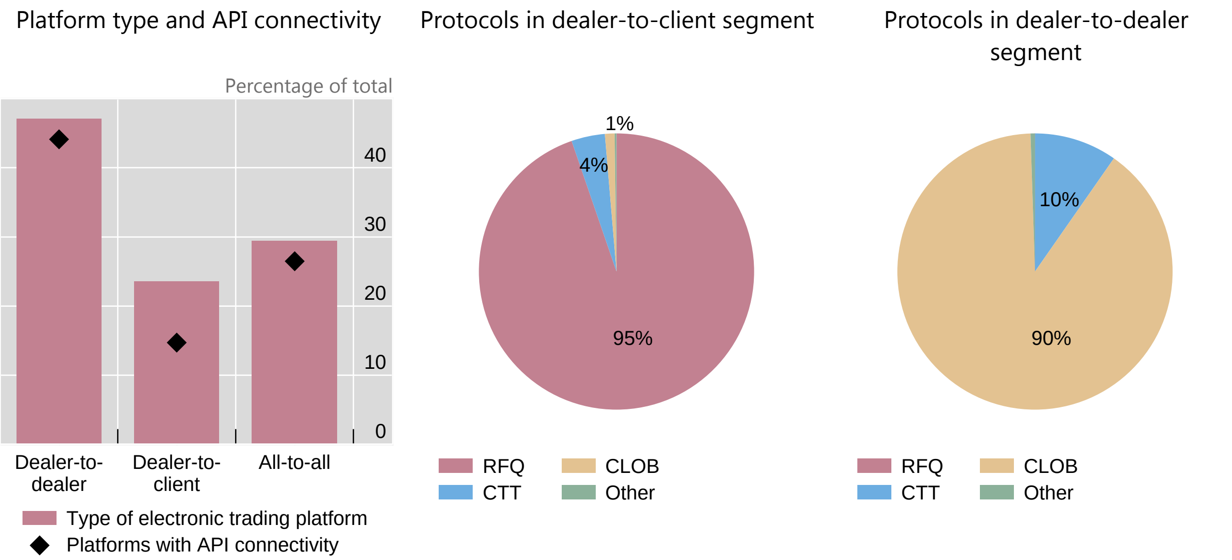
Sources: Markets Committee survey of electronic trading platforms, BIS calculations

A survey of electronic trading platforms

The Markets Committee Study Group surveyed more than 30 trading platforms to gain further insight into the amount of activity undertaken and how this had changed over the last five years. The survey sample covered inter-dealer platforms, multi-dealer platforms and all-to-all platforms, operating across the globe (including several emerging market economies).

The survey shows that there has been a pickup in the use of electronic trading platforms in fixed income markets. Survey recipients reported that trading volumes (excluding repos and futures) rose significantly between 2010 and 2014 (Graph 5, left-hand panel). Over the period, there was rapid growth in trading activity judged by the number of transactions on the surveyed platforms (Graph 5, centre panel).

Survey of electronic trading platforms and usage of trading protocols Graph 6



CLOB = central limit order book; CTT = click-to-trade; RFQ = request for quote (request for market).

Sources: Markets Committee survey of electronic trading platforms; BIS calculations.

The majority of electronic platforms included in the survey are geared towards dealer-to-dealer markets (Graph 6, left-hand panel). Only around a third of surveyed platforms facilitate all-to-all trading or dealer-client trading. A closer look at the data suggests, however, that the pickup in the aggregate trading volume on electronic platforms is largely due to a rise in trading volumes via all-to-all platforms, albeit from a lower base. A key factor could have been greater use of electronic trading methods for interest rate derivatives. Trading on dealer-to-client platforms has also picked up, but less so than trading via all-to-all platforms. As a result, inter-dealer trading volume, which grew slowly over the period, now accounts for only a third of trading volumes on the platforms surveyed, down from around half of the volume in 2010.[7] Most of the platforms allow for API connectivity – a prerequisite for automated trading. API connectivity is notably less prevalent on multi-dealer platforms geared towards dealer-customer markets, but is a common feature of all-to-all platforms and inter-dealer platforms.

[7] A similar decline in inter-dealer trading has also been observed in other asset classes, eg in FX markets, and may be attributable to greater internalisation of customer flows (Rime and Schrimpf (2013)). Internalisation could affect market quality and the market ecosystem in inter-dealer markets, as it may lead to fewer uncorrelated flows passing through primary transparent venues.

The Study Group platform survey confirms that RFQ was still the dominant protocol in 2014 in dealer-to-customer markets, accounting for a share of 95% of total transaction volume (Graph 6, centre panel). At 4% and 1%, respectively, Streaming (CTT) or CLOBs account for only a rather negligible volume of trading on dealer-to-customer platforms. The situation in inter-dealer markets, however, is quite different, with CLOB the dominant protocol (Graph 6, right-hand panel). That said, direct streaming of executable prices also accounted for about 10% of trading volumes in inter-dealer markets in 2014.

4. Impact of electronic trading

Electronic trading is having a significant impact on the structure of fixed income markets and the interplay of various participants in the market ecosystem. It has introduced a variety of new trading protocols that have influenced investor behaviour, may have affected relative liquidity across different subsets of fixed income, and increased competition among platform providers. Electronic trading has also contributed to changes in market-making business models, a growing presence of firms employing automated trading, and greater weight being placed by investors on improving execution. Finally, electronic trading in fixed income markets and the resulting shift in various aspects of market structure have had a noticeable impact on market quality and its optimal measurement.

4.1 Impact on infrastructure and the market ecosystem

Platform innovation and competition

Improvements in technology have lowered the costs of creating and upgrading electronic trading infrastructure, leading to more intense innovation and competition among trading venues. By lowering the fixed costs of creating a platform, it has allowed greater competition among platform providers and innovation in some market sectors. And, the improvements in technology have increased access to a variety of market participants.

Electronic platforms compete in a variety of ways. For example, some compete over their ability to better match participants, including by trying to make it less costly for investors to find a dealer that holds a position that is well suited to their needs. Some providers are offering platforms that attempt to match end users directly with each other. Most platforms compete to some extent over the information they make available to participants, both prior to and after trading. And, they also compete over their capacity to provide ancillary services such as risk management, audit, settlement and reporting services.

Many platforms have expanded access to their trading venues to a wider range of participants, driven by competitive pressures to increase market share and/or by regulatory changes. This is reducing the segmentation between inter-dealer markets and the dealer-customer markets; in some cases, this is thought to be a market-led response to the perceived reduction in secondary market liquidity. As noted in Chapter 2, historically there has been a separation between the two markets, with bid-offer spreads typically narrower in inter-dealer markets.[8] Although the barriers to entry have fallen, there remains some resistance to changes from traditional dealers in certain markets, with a competitive advantage still being enjoyed by pre-existing dominant platforms.

Evolving trading conventions

Changes in trading protocols are an important part of the evolution in fixed income trading. There are an increasing number and variety of protocols that allow investors to negotiate with multiple participants outside the traditional dealer-intermediated market, particularly in corporate credit markets. There are many differences between the protocols, but they typically share the objective of pooling liquidity and enabling multilateral communication of trading intentions. The success of these new trading protocols has been limited thus far, with dealer-to-customer RFQs and CLOBs continuing to be the primary means of trading, in dealer-to-customer and dealer-to-dealer markets, respectively.

A number of these initiatives have been based on variations of the RFQ protocol, as the illiquid nature of some fixed income markets makes them unsuitable for CLOBs. Other platforms have begun to blend RFQ and CLOB protocols. For example, some RFQ platforms provide dealers with the option of submitting firm quotes (or sometimes require them to do so). Many platforms are also experimenting by including the ability to submit RFQs to selected non-dealers (or to all participants at once), counter-offers to dealers, or anonymous RFQs. Some platforms are enabling RFQs for a list of securities, while others are allowing dealers to submit RFQs to clients and clients to submit a limit order to dealers.

Platform providers are also considering protocols that allow market participants to negotiate with each other. Participants may submit indications of interest to a non-public order book and receive notice of indications of similar size and price from other market participants. Some "dark" platforms – so-called because they match participants anonymously – are allowing buyers and sellers to negotiate directly, but anonymously, through an instant message system. Others are looking to create standardised secondary market auctions (creating a window of liquidity in specific instruments) to centralise previously untapped pools of liquidity.

Recent dealer demand for more efficient balance sheet usage has further induced the development of new technology solutions in inter-dealer markets. Some platforms have introduced odd-lot session-based matching whereby dealers can post small amounts of securities that they need to buy or sell, with trading taking place when matches occur. In derivatives, platforms have developed more efficient mechanisms for cancelling offsetting positions between counterparties.

4.2 Impact on market participants

Suppliers of intermediation

Traditional dealers. The price at which intermediation services are provided by market-makers should be, to a large extent, related to the expected marginal costs

8 See eg Green et al (2007) and Dunne et al (2014) for the US municipal bond and Italian sovereign bond market, respectively.

they incur from such activity. Bank dealers, as the traditional fixed income market-makers, have recently experienced a rise in the cost of providing immediacy services, driven by both market-based factors and regulation, as discussed in BIS (2015). On the one hand, the global financial crisis appears to have reduced market-makers' willingness to take on risks. On the other hand, capital and leverage requirements are likely to make the use of balance sheets more costly, reducing banks' ability to borrow, hold or lend inventory. But it is also important to understand how developments in technology and the growth of electronic trading have impacted dealers' business models. Some developments have resulted in greater comparative advantages for dealers, while others have diminished them.

The growth in electronic trading has reduced the costs of market-making in various ways. First, it has allowed dealers to substitute labour for cheaper capital. Dealers are able to replicate market-making behaviour by automating the quoting and hedging of trades, facilitated by quicker identification and execution of hedges. Second, the expected holding period for positions may have been reduced by lowering the costs of connecting to a large network of end investors. Electronic trading makes it easier for dealers to monitor the behaviour of their customers and how their supply and demand for securities change in response to economic and financial news. Third, technology has allowed dealers to internalise flows in a more efficient manner, offsetting transactions between different trading desks within a firm. Internalisation ultimately provides greater economies of scale while also allowing bank dealers to capture more of the spread from traditional market-making activities that can be lost when a transaction is offset using the inter-dealer market. Internalisation also allows bank dealers to reduce the amount of information leakage from publicly offsetting trades in the inter-dealer market. This has become an even greater factor due the fact that PTFs compete directly in certain inter-dealer markets.

Nonetheless, the growth in electronic trading has also posed challenges for traditional dealers. It has required large investment in information technology at a time when a number of dealers were looking to cut costs. In certain markets, there are significant differences in the sophistication of technology employed by market-makers. Some dealers have exited certain businesses and/or outsourced aspect of their market-making to specialist companies in the face of increased costs. And electronic trading has reduced barriers to entry, limiting the extent to which increased costs could be passed on to end users in the form of wider bid-ask spreads.

The shifting business model of bank dealers towards a more agency-based model (Box 3) is being facilitated by, and helping to drive, advances in electronic trading. Due to a variety of both market-led and regulatory drivers, traditional market-makers have become less willing to absorb large positions. As a result, market-making has gravitated to an increasingly order-driven and/or broker model in order to reduce risk (BIS (2014)). New venues and protocols allow bank dealers to more efficiently link potential buyers and sellers as well as give dealers a more efficient way to offset any unwanted inventory.

Principal trading firms (PTFs). The changing nature of market-making has given rise to competition from non-traditional and largely automated market-makers in some fixed income markets. Often these firms are characterised by their comparative advantage in trading electronically and, in many cases, by capital levels substantially lower than those of bank dealers. PTFs typically require the underlying securities to trade in a CLOB with deep liquidity and high trading volumes. Hence, they focus on standardised, liquid products such as futures contracts, interest rate swaps and on-the-run sovereign bonds that trade on platforms or exchanges. Successful firms are ultimately those that can provide intermediation at the lowest marginal cost. PTFs are typically more nimble given their smaller size and fewer regulatory requirements compared with bank dealers that potentially experience diseconomies of scale in terms of adapting the most sophisticated technology, thus providing PTFs with a comparative advantage.

Box 3

Dealers as intermediaries: principal vs agent

The role of dealer intermediation in a quote-driven market can take two basic forms, even though in practice these distinctions are not always clear-cut. When trading with a client, the dealer may act as either a principal or an agent.

When acting as a *principal*, the dealer commits its balance sheet to match the client order. A dealer will charge a bid-offer spread to compensate it for the risk this entails, which will be closely related to its marginal costs. The bid-offer spread is thus likely to be a function of various factors, including: the volatility of the asset price; the anticipated costs of finding an investor with opposing needs at close to current prices; the informational content of the trade; funding and capital costs; and other labour and technology costs. In most quote-driven markets, dealers have traditionally acted as principal traders.

When acting as an *agent*, the dealer is effectively acting as a broker. Its role is to place the customer order in the market and to find a counterparty willing to take the opposite position in the trade. The dealer runs no (or a very limited) inventory risk and typically charges a commission (or a bid-offer spread in some fixed income markets). Principal trading requires capital to be committed to each transaction whereas agency trading does not. From a customer's perspective, if a dealer takes on a principal position, the customer faces no execution risk, since this has been assumed by the dealer. If a dealer acts only as an agent, then the customer is exposed to execution risk, which may involve time delay and price movement.

Despite the increasing presence of PTFs in some traditional dealer-to-dealer venues, their presence in the dealer-to-client market remains small. This is largely due to the use of the RFQ protocol, which is not conducive to HFT strategies. But there are some nascent signs of a growing presence of PTFs in other segments of the market. Some PTFs now make markets directly in US government bonds, including for traditional dealers and a very small number of end investors via multi-dealer electronic trading platforms. Successful PTFs have been able to make inroads into the dealer-to-client market by providing firm quotes in a traditional RFQ market and then offsetting their risk by utilising algorithmic strategies in other correlated, more liquid markets.

Agency brokers. A recent development is the rise of technology-driven agents that provide direct access to trading venues and/or algorithmic trading services. Electronic exchanges and new technologies have allowed agency brokers to employ algorithms aimed at attaining best execution for larger orders by finding the optimal trade-off between a number of smaller trades and total execution time. Common clients of an agency broker include institutional firms with regular large block orders that are turning to electronic solutions to help improve their execution by breaking it into smaller packages and reducing average execution costs. But, to remain competitive, agency brokers have evolved to provide more services, offering insight into trading and portfolio strategies, and market microstructure. They have also developed their services across markets, with a growing number of formerly equity-only agency brokers expanding into fixed income in recent years.

Demanders of intermediation

As is the case with market-makers, the nature of participation by traditional buy-side investors (ie asset managers, mutual funds, sovereign wealth funds, central banks and hedge funds) is also changing, aided by electronic trading. They are adapting to the shift in the way market-makers provide liquidity, while their stakeholders are demanding liquidity more frequently and increasingly demanding proof of best price execution through trade cost analysis. As a result, buy-side firms are placing ever greater importance on the role of traders within their organisation as well as finding new ways to source liquidity in some less liquid markets, like corporate bonds. Providers of new platforms argue that they can help their participants find additional pools of liquidity while automatically providing the information and audit trail required by their stakeholders to conduct such analysis.

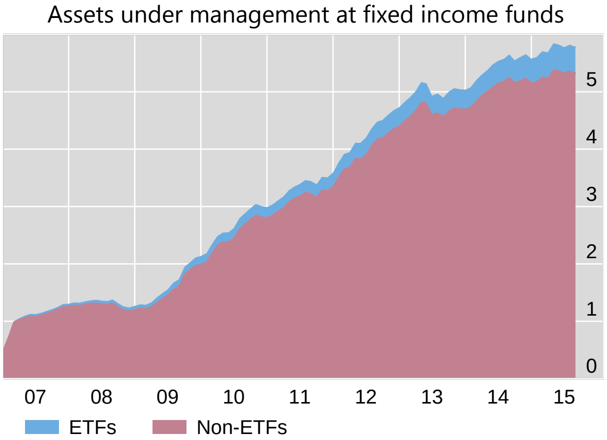
Investors are also adapting their execution strategies, especially for large volumes, in order to minimise the cost of transacting, eg through an internally managed transaction from one account to another within the same firm. This is common practice among large asset managers with multiple accounts and strategies. When no match is possible, the order is executed externally. To reduce the risk of impacting market prices, many investors are using strategies to break the order into smaller trades. However, splitting a large order into a number of smaller transactions requires more time between the decision to trade and final execution, increasing the risk of execution. From a purely electronic perspective, some buy-side firms have deployed trade execution algorithms of their own, while others rely on the algorithms of agency brokers. The expansion in the number of new platforms and data providers in the fixed income market has also provided investors with new means of transacting directly with each other or more transparent information with which to source potential pools of liquidity.

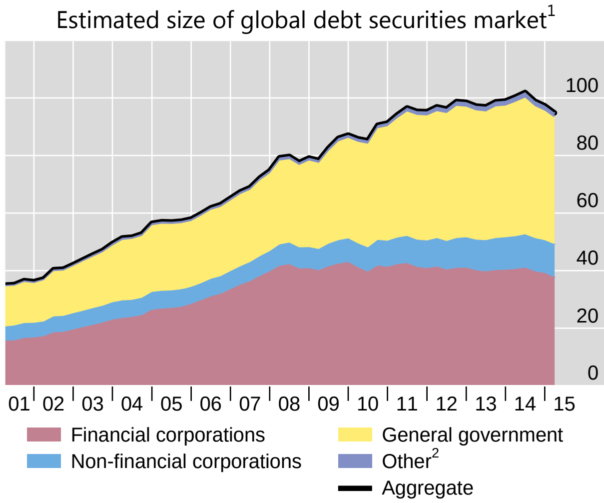
Investors looking for ways to quickly liquidate their holdings have increasingly used fixed income mutual and exchange-traded funds (ETFs). Given the low-yield environment, investors have moved into less liquid segments like the corporate bond market, yet still want to maintain instantaneous liquidity at all times, for instance via such funds. Assets under management at fixed income mutual funds and ETFs have grown significantly in recent years (Graph 7, left-hand panel). At the same time, there has been tremendous growth of fixed income markets, driven by large issuance activity in primary markets for corporate and sovereign bonds (Graph 7, right-hand panel).

Fixed income ETFs are in fact also a form of electronification of fixed income markets, as they are a product that moves fixed income onto an exchange-traded platform, allowing it to trade throughout the day – even if the underlying assets are not traded frequently. An issue for debate is the impact ETFs on overall liquidity. While these instruments do bring some form of liquidity transformation, it is not clear that they fundamentally improve the liquidity situation. This liquidity transformation may imply that investors are facing some degree of basis risk and may possibly also result in a form of liquidity illusion. Moreover, on a market structure level these inflows into instruments that give instantaneous liquidity may also increase the risk of disorderly moves due to the potential for herd mentality.

Growth in fixed income mutual funds, ETFs and global bond markets

In trillions of US dollars Graph 7





[1] Outstanding amounts; sum of international debt and domestic debt securities. Quarterly, by sector of issuer. The global size of the debt securities market was estimated by combining BIS securities statistics for countries in Table 18 (total debt securities (TDS)) in the Statistical Bulletin: Detailed tables, countries in Table 16 (domestic debt securities) not providing TDS, and countries in Table 11 (international debt securities) not providing TDS. This approach made it possible to maximise the contribution of individual country aggregates from the various BIS securities statistics data sets to the global aggregate. [2] Includes international institutions and non-profit institutions serving households.

Sources: EPFR; BIS.

4.3 How does electronic trading affect market quality?

It is fairly difficult to assess how electronification affects market quality (see Box 4 for a definition), both theoretically and empirically. This section seeks to provide a synthesised view by drawing on the insights from a variety of research papers and by providing some suggestive evidence.

The advent of electronic trading is changing market quality in at least two ways: first, through the increasing number and use of platforms; and second, through the increasing presence of autonomous trading algorithms that handle order placements and executions. Algorithms impact market quality not only for those using them but also for their counterparties. In the following, we thus focus on the two aspects: the pickup in the use of platforms, and the rise in automated trading.

Impact of platform trading

An electronic trading venue can enhance market quality due to the so-called liquidity externality. Concentrating a trade at one place and time reduces search costs and intensifies competition over price (Rochet and Tirole (2006)). Electronic venues can bring together a large and diverse participant pool and hence reduce the need for intermediaries that match demand and supply between segmented traders. Also, they can lower operational costs by automating processing, settlement and record-keeping. Still, venues must be carefully designed to avoid the unwanted dissemination of information. Participants may avoid venues if they believe negotiating or trading at the venue would expose their activity unnecessarily (information leakage). Knowledge that somebody needs to lay off a large “block” transaction can impact prices ahead of the trade (Brunnermeier and Pedersen (2005)). To be viable, platforms have to make sure they attract sufficient volume.

Unfortunately, there are few studies on the impact of platform trading in fixed income markets specifically. The existing evidence predominantly suggests that successful bond platforms can improve trading conditions for their customers, although this may not be the case for all securities. Especially older, longer-maturity and smaller bond issues may not necessarily benefit very much from trading on a platform. Thus, liquidity may be bifurcated. If there is overall poor trading interest in a security, the losses due to information leakage may outweigh whatever gains to centralisation and competition that might exist.

Box 4

Market quality

Market quality is defined as the degree to which a trader can transact at a price that accurately reflects an asset's underlying value, with immediacy and in volume. Two components of market quality are typically distinguished: market liquidity and price efficiency

Market liquidity is the cost-effectiveness of trading an asset with immediacy and in volume. A market is considered liquid when a trader can negotiate a price close to the market price, quickly and for a sizeable quantity. Two market participants rarely have a perfectly opposing interest in trading an asset, so typically one trader motivates the trade by compensating the other, by agreeing to pay more than or less than the asset value. In a "liquid" market, the size of that compensation – often called execution cost – is fairly small. It is difficult to measure market liquidity, not only because it has many dimensions but also because the various dimensions are not equally valuable in all situations. Nevertheless, the literature has proposed a number of liquidity proxies.

Typically, these proxies attempt to measure one or more of the three main dimensions of liquidity (Kyle 1985): (a) *market tightness*, the cost of buying and then selling a position of a typical size; (b) *market depth*, the size of the trade required to change prices by a given amount; and (c) *market resiliency*, the speed at which a market's tightness or depth recover after some event. Tightness is sometimes called "the price of immediacy" and depth "the price of volume". The three dimensions vary in their value depending on the type and size of the trade. For a small trade, the first dimension matters most. For a trader who does not plan to trade frequently, the first two dimensions matter more than the third. And for a trader who is tasked with establishing a large position or who actively manages a portfolio, all three dimensions are important.

Price efficiency is the accuracy of an asset price as an expression of its value given the available information. A price is considered informationally efficient if investors cannot outperform the market on a risk-adjusted basis by using all available information, particularly public information. Asset prices are made more informationally efficient when investors conduct research that produces new information or when there are intellectual or technological improvements in the ability to apply existing information. Prices also become more efficient when the marginal execution costs of acting on information decrease, so market liquidity is typically thought to support price efficiency. As with market liquidity, it is difficult to measure price efficiency. To do so would require knowledge of what the price should be according to a norm of how the available information should be used. Instead, common price efficiency measures aim for the lower standard of a joint hypothesis test (Fama (1991)). The measures test how well a particular model of an efficient price fits the data, and hence they are as good as the model assumptions. Common price efficiency measures quantify various deviations from this assumption at various time horizons.

Platforms seem to enhance liquidity in those assets that are already liquid. Studies find traders prefer platforms for the execution of newer, shorter-term and larger bonds. Electronic volumes are far higher for liquid securities such as benchmark bonds (Barclay et al (2006)). Transaction costs for securities with a high propensity to execute on platforms are significantly lower on platforms than for trades of the same securities executed via phone (Hendershott and Madhavan (2015)). Other studies, such as Mizrach and Neely (2006), also find that platforms offer superior liquidity.

Platforms assist in price discovery. Prices on electronic venues tend to lead those in the voice markets. Interestingly, voice trades still contribute more to price discovery on a per-trade basis than do electronic trades, but electronic markets simply update faster, particularly after news events (Man et al (2013)). Human intermediaries retain certain advantages – for example, in consummating customer orders when trading volume is low or the trade size is large (Barclay et al (2006)).[9] These findings for fixed income markets complement older findings obtained from equities and futures markets during their own periods of electronification.

Impact of ultra-fast traders on market quality

Whether automated and high-frequency trading improve or undermine market quality is a matter of considerable debate. Competing over speed has always been a key component of financial market activity.[10] But many market participants, trading venues and regulators are asking whether this particular instance of trading technology, and the way it is being implemented, may disadvantage a large proportion of the trading community, resulting in poor market conduct or market functioning. The argument is that a performance improvement of only milliseconds could impose costs to the counterparties of the fast traders without offering material benefits. Specifically, HFT could impose costs by enabling predatory strategies disproportionately or by spurring a wasteful technological arms race. A particular concern for financial stability is whether the improvements in average market quality measures are also replicated in states of the world where demand for immediacy or volume is considerably greater than normal.

The "latency arms race" has drawn particular attention. Firms have an incentive to overinvest in technology to gain an edge in terms of speed (Biais et al (2014)). They overinvest because the race to trade on new information often has a "winner take all" payoff. The race can impose externalities. As other participants invest in speed trading, less sophisticated traders may experience deteriorating market liquidity (Foucault et al (2015)).

One solution to the latency arms race would be to curtail the winner-take-all nature of the payoff. In this vein, Budish et al (2015) suggest batching execution in periodic auctions that take place perhaps every second. Inter-dealer FX markets already perform limited batching. Batch execution would require a large change in the way certain markets work operationally. Hence, many trading venues have opted for a simpler change with the same purpose: imposing delays on marketable orders, or "speed bumps".[11]

9 The overall picture painted by the older literature (surveyed in Domowitz and Steil (1999)) generally supports the notion that market quality improves as a result of greater platform trading.

10 For example, traders in the 18th century commissioned special packet boats to run orders between the London and Amsterdam stock exchanges (Koudijs (2014)).

11 Examples of speed bumps include the one applied at the Alpha trading venue in Canada. Also EBS, a primary inter-dealer venue in FX, introduced a latency floor in 2013 to provide a level playing field for its participants.

Automated trading in bond markets

Empirical works on the impact of AT and particularly HFT on market quality are numerous, but unfortunately relatively few studies focus specifically on bond markets due to a lack of data. What works exist concern the activity of HFT around macroeconomic news announcements.

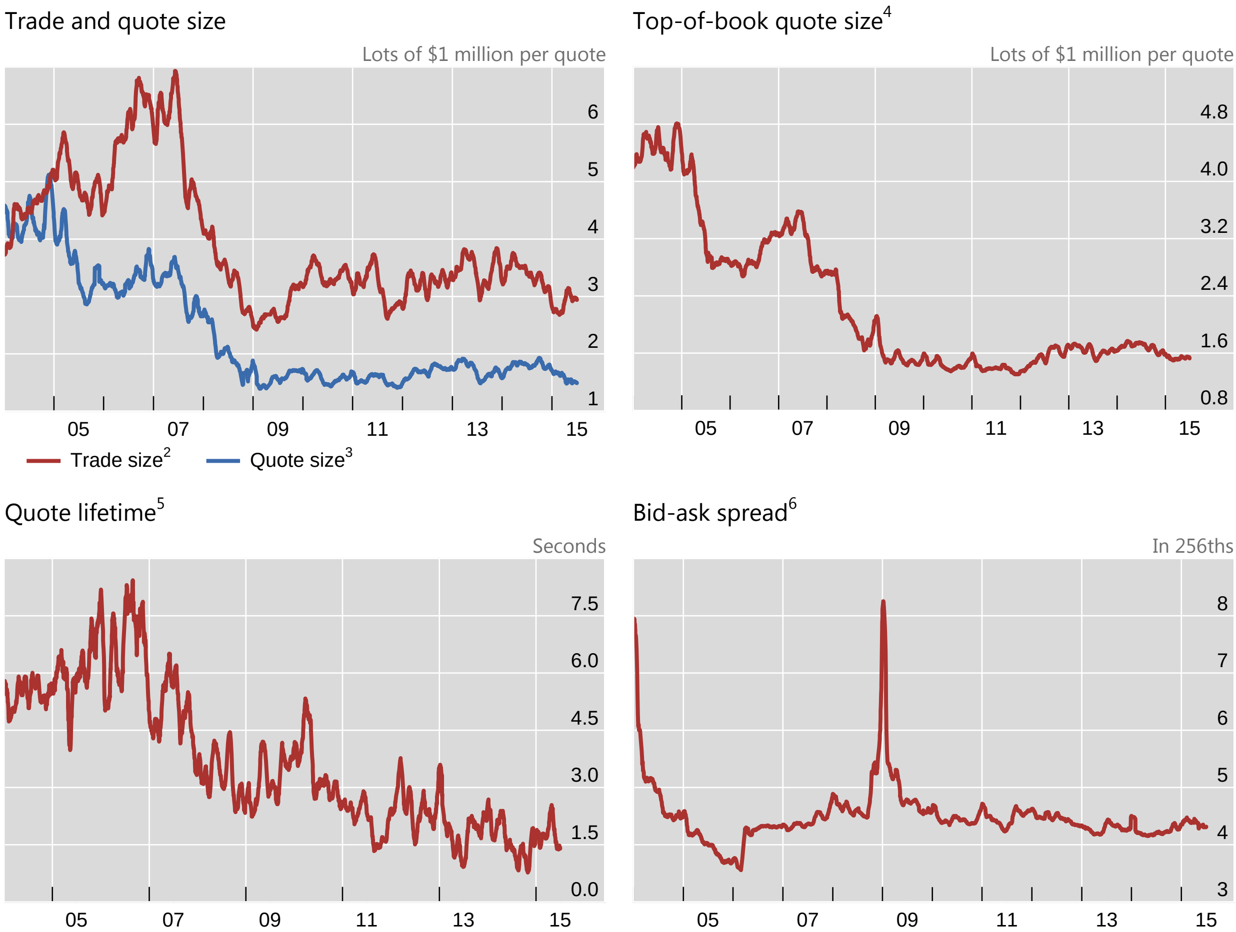
HFT activity has been found to result in news being incorporated into bond prices more efficiently around events, but at the cost of worse liquidity (Jiang et al (2014)). Trades that appear to come from HFT consume liquidity from the order book but contribute to price discovery. This behaviour is consistent with the idea that traders who are advantaged by speed are able to trade on news faster and are doing so successfully around public news announcements. Greater "order intensity" is associated with a faster movement of the price to its eventual destination (Jiang and Lo (2014)). It is particularly well associated when there is a jump in the price and there does not seem to be evidence of overshooting.

Impact of electronification in fixed income markets – suggestive evidence

Automated trading is leaving its footprint on major electronic inter-dealer platforms for benchmark bonds (Graph 8). A common sign of a rise in automated trading activity is a decrease in the size of limit orders outstanding in a limit order book. Algorithmic traders typically offer small quantities to limit their exposure to a price swing, as they often trade on margin and do not have deep reserves of capital. On BrokerTec, the average quote size was around $4 million during 2004–08, and fell beneath $2 million in 2008, where it stayed for five years. The same metric, but confined to limit orders at the best bid and best ask, has also dropped over the past decade (Graph 8, top right-hand panel). In 2004, it was around $5 million; and by 2010, it had levelled off near $1 million. In a similar vein, the resting time of a quote in the order book has trended downwards over the past decade as well (Graph 8, bottom left-hand panel), a sign of speed gaining significantly in importance.

Electronification of trading platforms is often associated with increased competition over price, which ensures low transaction costs (at least for small tickets). A centralised trading platform can bring together a large set of traders with opposing trading interests, reducing search frictions and raising competition to fill an order. Indeed, bid-ask spreads in on-the-run US Treasuries remained very tight. Ever after the crisis-related spike, they have remained very close to the minimum tick size (Graph 8, bottom right-hand panel). As discussed below, bid-ask spreads are no longer a useful metric of liquidity conditions in markets with a strong presence of automated trading.

Automated trading and its footprint in on-the-run US Treasuries markets[1] Graph 8



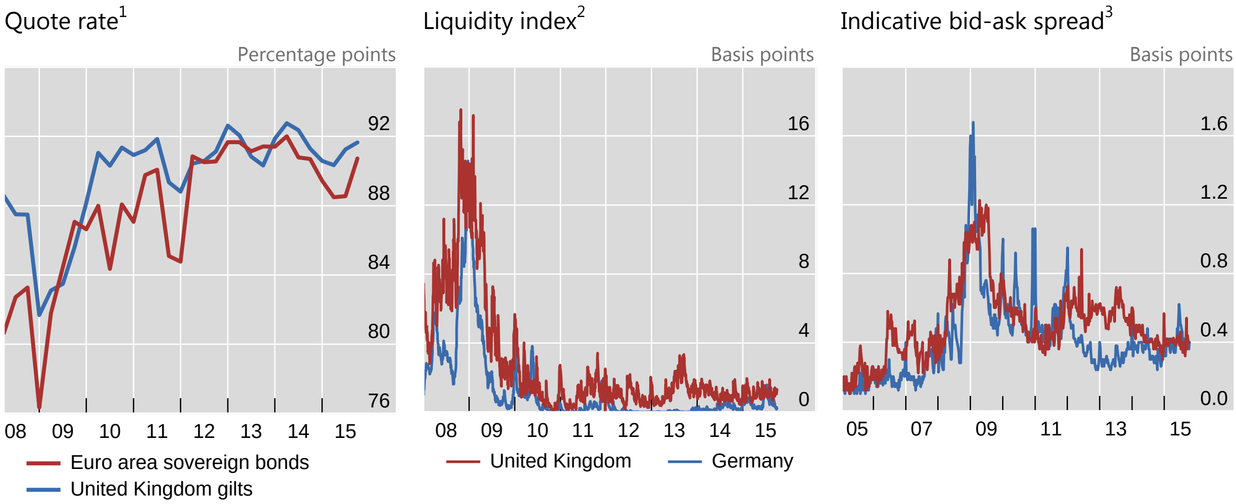
[1] Each series is computed from the US 10-year Treasury note from 07:00 to 17:00 (US Eastern time) and smoothed with a 21-day trailing moving average. [2] Summing all quantities from each trade, aggregating across different counterparties and price levels, and average over all unique trades on each day. For example, if a dealer placed a buy order of $100 million which matched with a resting order from another dealer of $50 million at $100 and a resting order of $50 million at $101, the trade size for this trade would be $100 million. Reported in lots of $1 million per trade. [3] Average size of all outstanding limit orders for the 10-year benchmark on BrokerTec, in millions. For each quote, anywhere in the order book, the size of the quote when it was placed into the order book is recorded, and averaged over all unique quotes on each day. Reported in lots of $1 million per quote. [4] Dividing the total top-of-book depth by the number of distinct quotes at the top of the book, and then averaging over all observations. Reported in lots of $1 million per quote. [5] Median value. [6] Average daily best bid less best ask price for the 10-year benchmark on BrokerTec in 256ths. Subtracting the best bid price from the best ask price, and then averaging over all observations; reported in 256ths.

Source: Study Group members' calculations based on BrokerTec data.

Market liquidity indicators available for the dealer-customer segment suggest that trade execution costs of liquid European sovereign benchmark bonds have ameliorated over the past five years (Graph 9, centre and right-hand panels). Also, the fraction of dealers responding to a request for quote has recovered from its crisis-related lows (Graph 9, left-hand panel). A companion study by the Committee on the Global Financial System (BIS (2016)) further explores liquidity conditions at the current juncture and the link to evolving dealer business models.

Market liquidity indicators in dealer-to-customer segment

Graph 9



[1] Percentage of dealers responding to a request for quote on the dealer-to-client platform. [2] Liquidity index computed by Tradeweb based on transactions data and prevailing bid-ask spreads. [3] Daily data converted into weekly by taking a simple average across daily observations.

Source: Tradeweb.

Further insights from other asset classes and various case studies

Although there are relatively few studies specifically for fixed income, additional insights into the impact of AT can be gleaned from similar studies on other asset classes. A brief synthesis of this growing literature is provided next.[12]

The literature on other asset classes has generally concluded that automated trading improves common gauges of liquidity conditions. AT has been found to have significantly narrowed bid-ask spreads over recent decades. Other liquidity measures have also been shown to improve with AT. Moreover, several studies have found that the presence of AT increases depth, dampens the price impact of trades and reduces volatility.

Other recent studies, however, have questioned whether the advantages in terms of transaction cost improvements are material and whether the benefits associated with AT/HFT outweigh the costs. Indeed, more work is needed on whether institutional traders benefit materially from the liquidity improvements attributable to the emergence of PTFs, which are generally thinly capitalised and hence have little risk-bearing capacity to add to the market. In addition, it is by now well established in the literature that not all HFT strategies improve liquidity. There are certain types of low-latency strategies, predatory in nature, that do not appear to improve liquidity or raise the efficiency of prices.

A shortcoming of many empirical studies is their focus on very narrow aspects of market liquidity. A holistic perspective on market quality is often missing. Measures such as bid-ask spreads may no longer be a sufficient monitoring device

[12] Appendix B presents a more detailed discussion of various empirical studies focusing on the impact of AT on market quality in other asset classes.

in a world characterised by a large presence of high-frequency market-makers that are able to submit tight bid and ask quotes even in highly volatile conditions (see eg US JSR (2015)). To better capture liquidity, metrics are needed that also reflect variations in the tail of the liquidity distribution. One such measure could be implementation shortfall (see eg Hendershott et al (2013)), which captures the total costs of establishing a position in a security of a given size.

Research is also looking to examine the activity of PTFs during specific periods of unexpected volatility and extreme market events. The picture regarding the role of algorithmic players is less positive here (as emphasised by some of the studies covered in Appendix B of this report). A description of some flash events and episodes of liquidity turbulence in fixed income markets is provided in Appendix C of this report. The flash rally of 15 October 2014 in the US Treasury market has already been the subject of intense scrutiny. Thus, we give more weight to the bund tantrum of May–June 2015 and recent gyrations in JGB futures markets in this section, while referring to US JSR (2015) regarding a detailed analysis of the US Treasury flash rally.

What these events have in common are the large intraday price swings with no obvious external driver. Tracing these gyrations to a single cause – such as the specific (inter)actions of a group of algorithmic players – has proven very difficult, although analysis of the events is ongoing.

5. Challenges for policy

It is clear that electronic trading in fixed income markets is advancing and that this is creating efficiencies for many market participants, improving transparency and reducing market segmentation. However, electronic trading, and in particular automated trading, is confronting policymakers with new challenges. The appropriate responses may differ across jurisdictions because of the heterogeneous nature of fixed income markets as well as the varying degrees of electronification. This chapter identifies four core areas for further policy assessment:

(i) data, disclosure and monitoring;

(ii) market quality and stability;

(iii) risks and risk management; and

(iv) trading practices and regulation.

5.1 Data, disclosure and monitoring

The advance of electronic trading in fixed income markets needs to be appropriately monitored. A prerequisite for monitoring the impact of structural changes on market functioning is public and regulatory access to more comprehensive data on an ongoing basis.[13] Moreover, in certain circumstances, staff

[13] In Europe, for example, the forthcoming regulatory regime for fixed income securities, the Markets in Financial Instruments Regulation (MIFIR), will introduce new rules for trade reporting to

in policymaking institutions may require data at high frequency and with more granularity. The analysis of the 15 October 2014 flash rally in the US Treasury market, for example, was predicated on obtaining access to detailed transaction and messaging data. Given the large amount of data required, such an exercise may involve significant amounts of qualified technical expertise. Policy institutions may need to evaluate their staff and IT capabilities in analysing such data.

A supplement to better monitoring is to establish a regular dialogue between regulatory bodies and private sector participants. The exact form may differ across jurisdictions, depending on the degree of prevalence of electronic trading in the respective jurisdiction. One example is the Treasury Market Practices Group (TMPG), sponsored by the Federal Reserve Bank of New York (TMPG (2015)).[14] This jurisdiction-specific approach could be supplemented by an exchange at international level.

5.2 Market quality and stability

Policymakers and market participants should continue to closely investigate the impact of electronic trading on market quality. The adoption of AT and HFT and continued influx of new market participants may create new price and liquidity dynamics. In some jurisdictions and markets, this has ensured very tight bid-ask spreads. However, this limited perspective may create a misleading impression of market quality. In fact, some market participants have highlighted that while liquidity is ample in normal times, it may have become more fragile in episodes of heightened demand for trading immediacy. Consider, for example, the different reaction functions of bank dealers and PTFs in times of stress as revealed in US JSR (2015). In particular, bank dealers widened their bid-ask spread while PTFs reduced the quantity of orders available for transactions. This could lead to a situation where liquidity risk may potentially be underestimated and therefore mispriced.

Policymakers should use a more comprehensive set of market quality metrics. As demonstrated in several recent episodes (see Appendix C), changes in the structure of fixed income markets may have increased the likelihood of episodic periods of volatility. To fully capture the evolving nature of market quality, more sophisticated measures are needed to capture its multiple dimensions (see the discussion in Section 4.3).

5.3 Risks and risk management

The shift towards electronic trading has resulted in many improvements in trade processing and clearing and settlement, but could also be accompanied by new risks. In particular, the speed of AT and HFT creates additional challenges for risk management. Electronic trading infrastructure has developed into a crucial part of the financial ecosystem and could pose broader risks in the event of failure. When warranted by the degree and style of electronic trading practices in a

supervisory authorities as well as the public dissemination of pre- and post-trade information (with some exemptions for large orders and less liquid markets).

14 Similar initiatives exist or have recently been established in the euro area, Japan and Canada.

jurisdiction, policymakers should thus look at the following areas to mitigate risks and improve risk management.

Policymakers should raise awareness of the new dimensions of operational risks that result from automated trading practices. For example, the possibility of a dislocation on an automated trading system or platform in one market spilling over quickly into other markets may often not be sufficiently considered. It is important that firms are aware of such new transmission risks, develop and maintain appropriate risk management systems, and conduct robust risk analysis under varying degrees of unfavourable financial conditions, ever shifting correlations between markets and any potential decoupling of well integrated markets.

Algorithm providers should follow best practice guidelines when coding new programs. In algorithmic trading, human judgment is applied in advance, when the algorithm is designed and initial parameters are established, and recalibrated or disengaged only after trading has occurred. Algorithms should behave as designed or intended and thus have to be carefully constructed and thoroughly backtested. The performance of the algorithm needs to be monitored in real time and its parameters regularly updated.

Settlement and clearing risks may have been impacted as well. For example, in the US Treasury market, there has been an increase in the share of inter-dealer trading that occurs outside the central counterparty clearing (CCP). This trend is the result of a growing percentage of bilaterally cleared fixed income transactions by PTFs looking for lower cost structures. However, the dependency of bilateral clearing arrangements for PTFs makes measuring these risks difficult. These arrangements could increase the likelihood of the failure of a non-CCP member spilling over to a prime broker in the CCP if that failure is big enough to impact the platform standing in the middle of the trade.

Policymakers have to be conscious of the potential for electronic trading to exacerbate the gravitation towards systemically important infrastructure. As liquidity gravitates to a few large platforms, they could become critical market infrastructure from a system-wide perspective. A technical failure on a major platform – caused, for instance, by an overload of message traffic – has the potential to severely disrupt broad financial markets. Policymakers need to foster discussions about mechanisms to restart the market in the event of market breakdowns. The appropriate use of circuit breakers is another issue that policymakers might want to look into.

5.4 Trading practices and regulation

Regulation and best practice guidelines should be living documents, continuously adapting to the evolving marketplace. Market participants should work to ensure that best practices and codes of conduct reflect the current state of the market and its risks.[15] These codes, where implemented, should apply to all

[15] One such code of conduct has been put in place in India, by FIMMDA – a representative body of market participants in the fixed income market – for dealers operating on the NDS-OM platform. In the United States, the Treasury Market Practices Group, an association of private sector professionals, has developed a set of best practices for market participants, including practices

significant market participants. Such codes might include best practices for automated trading strategies, or changes to such strategies, to ensure, for instance, that they are not disruptive, whether intentionally or unintentionally, to market functioning or that they do not create a false impression of market depth. In addition, codes could consider whether they should also cover the policies, procedures and disclosure practices of trading venues, exchanges and clearing and settlement systems.

Recent efforts across numerous markets and jurisdictions have evolved to reflect new realities, but more may be needed to ensure a level playing field. In the European Union, for example, regulators have developed new rules on data transparency and access to trading platforms, among other dimensions (the aforementioned MIFIR and MIFID II). In particular, the forthcoming directive MIFID II requires that all market participants, including those from other member states, need to be authorised as investment firms when they use algorithmic trading techniques to deal on their own account (PTFs). In the United States, regulatory requirements for fixed income markets in the cash and futures markets continue to evolve, including regulations applicable to trading venues, broker-dealers and other market participants. The increase in the number of firms that are not registered as broker-dealers, and the growing share of trading that these firms conduct in US fixed income markets, have drawn attention from regulators in terms of the registration requirements. Regulations should therefore also consider whether current regulatory requirements are contributing to a level playing field given the changing composition of market participants.

Regulators should ensure that there is scope in the rules for trading platforms to experiment with market design. Regulators should strike a careful balance between prescription and room for healthy innovation. A flexible approach to regulation can enable platforms to compete to discover new ways of increasing efficiency and integrity while balancing the needs of their clientele, including client bases that trade both fast and slow. Platforms could pilot various new trading protocols or market design features, including proposals such as speed bumps, circuit breakers and frequent batch auctions.

applicable to automated trading in the Treasury, agency debt and agency mortgage-backed securities markets.

Appendix A: Study Group mandate

At its January 2015 meeting, the Markets Committee (MC) decided to establish a Study Group on electronic trading in fixed income markets to facilitate a better understanding of how ongoing developments affect market structure. Specifically, the Group is asked to explore whether and how the ability and willingness to engage in electronic trading are changing across products and market participants; assess technological, regulatory and business drivers of any observed trends; and present views on the broader implications that these developments may have, including for market functioning and practices.

Work will proceed in two stages. Stage 1 will be a fact-finding exercise, where the Group will pull together information on trends and drivers of electronic trading in fixed income markets from central banks and other sources, focusing specifically on sovereign and corporate debt and related derivatives. It will engage in outreach to both providers and users of electronic trading systems to establish how business models and execution in fixed income markets are evolving. As part of this, the Group will seek to develop a simple guide ("Electronic trading – a primer") describing key types of electronic trading, services and venues as well as how they differ from market setups in both fixed income and other financial assets. Based on the Group's assessment of the most relevant trends (given data availability and other considerations), Stage 2 will then focus on evaluating the associated market implications from a central bank perspective.

Key Questions Stage 1. Trends and drivers

- **Current trends:** What are the different types of electronic trading currently being employed in fixed income markets? How is the "supply" of electronic trading services growing (eg new venues and tradable assets)? How is the "demand" for electronic trading evolving? What are appropriate metrics (eg share of trading volume) to assess such trends and are these metrics available to central banks? How do trends in fixed income markets compare with developments in other markets (eg FX and equities)?
- **Drivers:** What are the drivers behind current trends in electronic trading of fixed income products? Are these drivers transitory (eg risk tolerance, funding costs) or structural (eg technological advances, buy- or sell-side pressure, changes to business models, regulation)? How important are domestic developments relative to international, cross-border ones?
- **Business models:** What types of business models are being employed? How tightly is the provision of electronic trading in one asset class connected to other asset classes? What factors (eg market structure, asset or product characteristics) determine the choice to enter or exit the provision or use of electronic trading?

Key Questions Stage 2. Potential implications for market functioning

- **Market structures:** To what degree are economies of scale or scope likely to dictate market structure in the future? Are there any structural impediments (such as technology or regulation) to the adoption of electronic trading in fixed income markets?

- **Market liquidity:** What is the impact or likely impact on market liquidity (ie the ability to excecute large transactions with limited price impact)? How are market participants responding (eg adjusting their trading behaviour and risk management)? How might the combined effects differ in (i) normal times and times of stress; (ii) domestically versus internationally; and (iii) for less vs more liquid instruments? Are there historical episodes (such as the US equity market "flash crash" and the events of 15 October 2014) that can be used to assess these effects?
- **Policy issues**: Are there lessons from adoption of electronic trading in other assets classes that should be kept in mind? To what extent does electronic trading introduce new risks. Are there policy measures that could help manage such risks (if any) – both in normal and stressed times? What are the implications of increased electronic trading in fixed income markets for central banks (eg in the context of central bank operations)? What practices or policies can be adopted to foster market functioning and effectiveness?

Process

The Study Group, chaired by Joachim Nagel (Deutsche Bundesbank), will work through teleconferences and face-to-face meetings. The Group will aim to reach out to the private sector through bilateral interviews and joint meetings, and would involve other public sector bodies as needed.

Based on its preliminary Stage 1 results, the Group will provide a **progress update** at the May 2015 MC meeting. Building on this and the guidance received from the Committee, **a draft report** would then be prepared for the MC meeting in November 2015.

Appendix B: Impact of automated trading – insights from other asset classes

There is a great deal of work on algorithmic trading in the asset classes FX, derivatives and equity which can inform about the likely impact of electronic/automated trading in fixed income. In general, research for other asset classes finds that algorithmic trading improves market quality during normal trading periods. Still, its benefit tends to be small in size and accrues more to the bid-ask spread and to price efficiency than it does to holistic measures of market liquidity.[16]

Impact on bid-ask spreads. AT has had its most dramatic impacts on bid-ask spreads. On the New York Stock Exchange from 2001 to 2005, the five years surrounding its 2003 automation of quote dissemination, transaction costs fell in order of magnitude (Hendershott et al (2011)). After a principal trading firm entered a European equity market, the bid-ask spread fell 50% (Menkveld (2013)). Many papers find similarly: Carrion (2013), Jovanovic and Menkveld (2012), Boehmer et al (2014) and Brogaard, Garriott and Pomeranets (2014) study automated trading in equity markets and find similar results, particularly when the principal trading firm employs a passive HFT strategy such as market-making (see Box 1).

Impact on depth, price impact and volatility. Bid-ask spreads are not the only liquidity measures that have been shown to improve with AT. Hasbrouck and Saar (2013) find that HFT presence increases depth and decreases the total price impact of trades as well as volatility. Brogaard and Garriott (2015) study multiple entry events of principal trading firms and find that particularly those engaging in passive HFT strategies can improve a variety of market quality measures. Hagströmer and Norden (2013) estimate that HFT activity particularly reduces short-term volatility, although the results on volatility are mixed in other papers.

Impact on price efficiency. AT also has a dramatic impact on short-term price efficiency, effectively eliminating many mispricings. Chaboud et al (2014) show that algorithmic traders enforce FX pricing relationships using triangular arbitrage, eliminating the vast majority of arbitrage opportunities, and that the arbitrage results in lower volatility. Similarly, Brogaard, Hendershott and Riordan (2014) find that HFT trades facilitate price discovery by trading in the direction of permanent price changes and in the opposite direction of transitory pricing errors. It is again particularly passive HFT strategies that seem to bring benefits (Menkveld (2013)). Boehmer et al (2014), Zhang and Riordan (2011), Zhang (2013), Carrion (2013) and Hendershott et al (2011) all find that HFT activity contributes to faster price discovery at least in the short term.

But are the gains material to institutional customers? Many liquidity metrics are either ex ante measures or per-trade measures. A holistic account of the impact of algorithms would need to study their impact on the total cost of implementing a series of trades that construct or deconstruct a position. Some limited work

[16] In the context of automated trading, comparisons across asset classes are more informative than they usually are in finance. Typically, comparisons across markets suffer from the problem of imperfect analogy. Risk factors, participant composition and custom can differ too greatly across asset classes to permit easy comparison. What differentiates finance at a millisecond frequency is that many aspects of the market other than its microstructure cease to matter (O'Hara (2014)).

available on institutional-sized trades shows no effect due to HFT (Brogaard, Hendershott, Hunt and Ysusi (2014)), although implementation shortfall costs have fallen substantially in the last 10 years (ITG (2014)). Recent working papers find mixed results: Tong (2015) reports that HFT presence increases institutional trading costs; and van Kervel and Menkveld (2015) report that PTFs supply liquidity to institutional customers for as much as one hour before it begins to trade in the same direction as institutional flows. More work is needed on whether large institutional traders benefit materially from the liquidity improvements attributable to HFT, which generally trades on margin and hence has little risk-bearing capacity to add to the market.

Not all HFT strategies improve liquidity. There are certain HFT strategies that do not appear to improve liquidity. HFTs can engage in order flow anticipation strategies that estimate the arrival time and direction of the next order and move prices against the order (Hirschey (2013)). HFTs can also be associated with the submission of huge volumes of orders in bad faith intended to mislead the market (Gai et al (2012)).

Impact in volatile periods and caveats. Research is looking to examine the activity of algorithms during periods of unexpected volatility and extreme market events. There the picture is less rosy. Ait-Sahalia and Saglam (2013) show theoretically that HFTs increase liquidity provision in normal times but withdraw from markets during unanticipated stress events. Gao and Mizrach (2013) find that HFT activity contributes significantly to market quality breakdowns, where volume and volatility are the prime causes of such breakdowns. Kirilenko et al (2011) find that, during the 6 May 2010 flash crash in US equities markets, HFTs exhibited trading patterns inconsistent with the traditional definition of market-making, sometimes aggressively trading in the direction of price changes. This activity comprised a large percentage of total trading volume, yet did not result in a significant accumulation of inventory. Some of the negative impacts are associated with PTFs employing aggressive HFT strategies: Benos and Sagade (2012) find that aggressive HFT activity generates both a significantly greater permanent price impact and significantly greater noise than non-HFT activity.

HFT research has a short shelf life. Some caveats should be noted regarding the current body of research. Even recent work relies on "old" data sets relative to the fast development in global financial markets. There is a three- to four-year time lag between current HFT practice and the available evidence. And, even though AT has spread to many financial markets worldwide, most studies are based on US equity markets. Another shortcoming is that evidence on AT/HFT activity is usually sampled from "normal" trading periods. Such evidence, either from bond markets or from other markets, is consistent with the story that AT uses well known and well understood trading strategies and sets them to work at a millisecond frequency. Such results could suffer from sample selection. Flash events such as the 10 May 2010 equity flash crash or the 15 October 2014 US Treasury flash rally suggest that algorithms may be interacting in intricate ways. Unfortunately, the scarcity of these events in the data makes it difficult to treat them in a systematic fashion, as each has very unique attributes.

Appendix C: Case studies

Lately, bouts of outsize intraday volatility have been observed in fixed income markets, which have been gaining increasing attention from market participants, policymakers and researchers alike. Although these events are unique in nature, they share some common features, eg strong intraday volatilities and liquidity deterioration which often cannot be attributed to a specific cause such as the release of important pricing-relevant news.

In trying to identify potential causes of these events, the role of automated trading has been subject to a large amount of attention. It has proven fairly difficult, however, to identify any triggers in a causal sense (ie a smoking gun), and research efforts are ongoing. The flash rally in the US Treasury market (15 October 2014) has already been the subject of a large amount of scrutiny. We thus only provide a quick summary here, referring the reader to the detailed report on the subject (US JSR (2015)). Hence we focus on the less covered events around the bund tantrum (May–June 2015) and recent gyrations in JGB markets.

The US Treasury market on 15 October 2014

On 15 October 2014, US Treasury yields recorded the fourth largest intraday price range since the crisis amid record-high trading volumes and strained liquidity conditions, all without a clear fundamental catalyst. The greatest price volatility was a 12-minute round-trip, starting at 09:33 US Eastern time, in which 10-year yields fell 16 basis points and then retraced. A US Joint Staff Report (2015) analysed Treasury market data from that day and found that the price action could not be attributed to one distinct catalyst, instead describing a range of potential factors. Importantly, the report also noted that such significant and unexplained volatility on 15 October signalled the need for a deeper analysis of the current US Treasury market structure more generally.

Among the factors that contributed to the unusual price movements that day were a weakening global growth outlook, highlighted by uncertainty about the monetary policy outlook in Europe and the reportedly negative tone of the annual IMF/World Bank meetings the previous weekend. Additionally, investors unwound "short" interest rate positions they had previously placed, which may have amplified the initial decline in interest rates that morning.

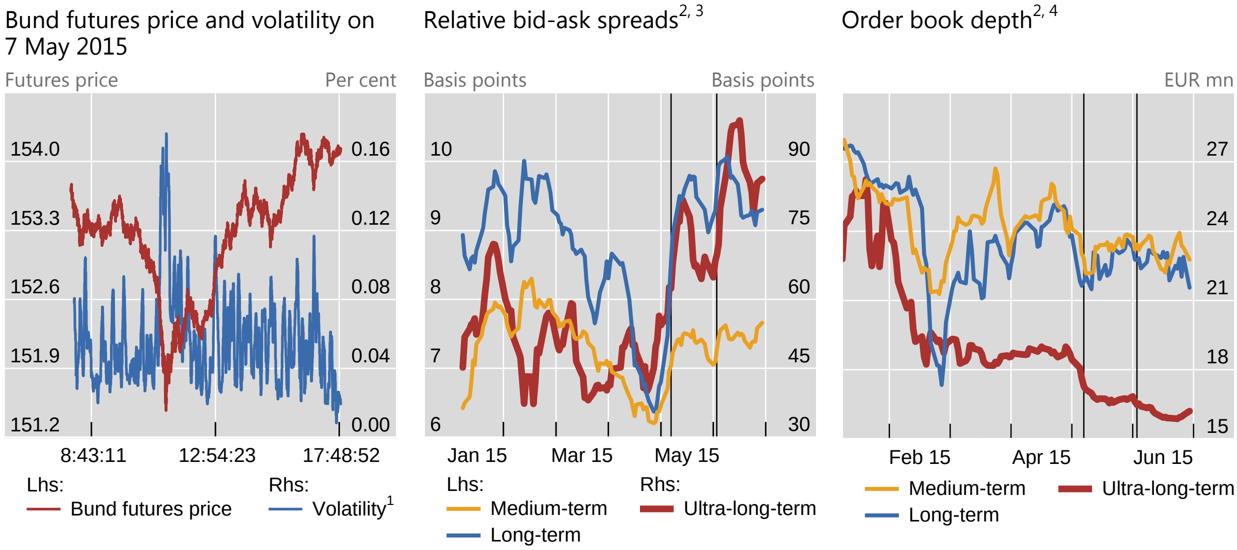
Electronic trading in the Treasury market could have also impacted price moves on the day. Principal trading firms and bank dealers both managed the risk of volatility by reducing liquidity to the market, with market depth as measured by outstanding orders in the central limit order book declining to very low levels right before the period of extreme volatility. Principal trading firms were the largest contributors to this decline in depth. Bank dealers also responded to the volatility by widening their bid-ask spreads.

The JSR concluded by identifying four "next steps" or areas of ongoing consideration: (i) continued study of the impact on market liquidity of the evolving market structure; (ii) continued monitoring of risk management practices and review of applicable regulatory requirements; (iii) assessment of the adequacy of the data available to both officials and the public; and (iv) continued efforts to strengthen the surveillance and monitoring of trading across the US Treasury market.

The bund tantrum of May–June 2015

During May and June 2015, volatility in German bond markets was abnormally high compared with historical levels. One of the largest intraday moves occurred on 7 May 2015 (Graph 10, left-hand panel). The market break on 7 May does not appear to have been related to the release of any particular information. One factor that may have played a role, however, is an unwinding of long positions by levered directional investors in fixed income derivatives markets.[17]

Liquidity conditions during the bund tantrum of May–June 2015 Graph 10



The vertical lines show 7 May 2015, the date of the first outburst of the bund tantrum, and 3 June 2015, the date of the ECB policy announcement.

[1] Five-minute volatility. [2] Data are intraday from MTS-EBM for benchmark bonds for January–June 2015. Both panels show daily averages. [3] Relative bid-ask spreads are calculated as (ask – bid) / mid and are expressed in basis points. [4] Depth is calculated as (volume at bid + volume at ask) / 2.

Sources: Deutsche Bundesbank; Eurex; MTS Euro Benchmark Markets; BIS calculations.

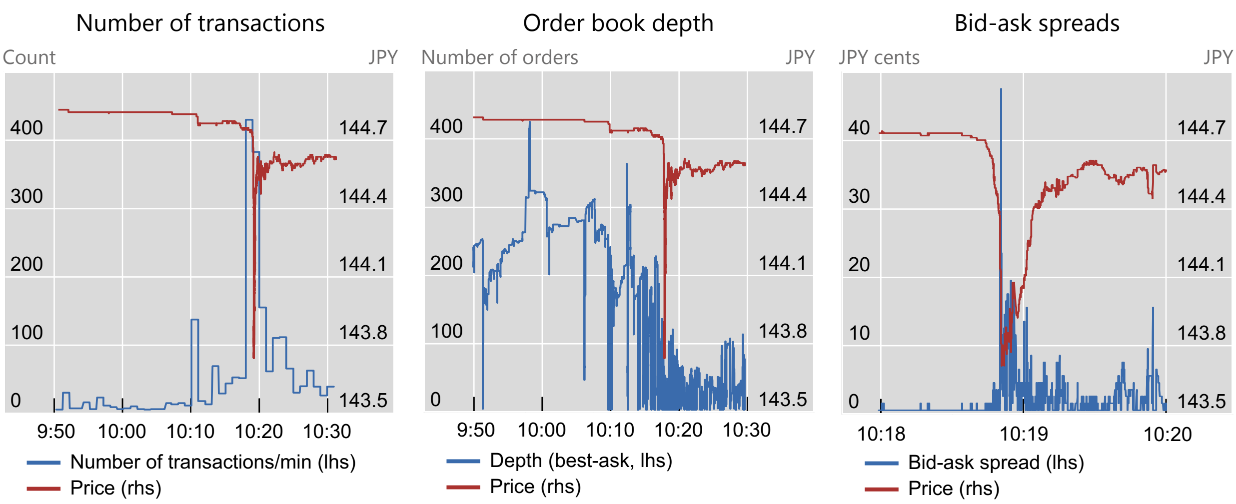
The increase in volatility coincided with a decline in market liquidity. Indeed, two common measures – the bid-ask spread and order book depth – illustrate strained market liquidity conditions during the period of increased volatility. The increase in the relative bid-ask spread (Graph 10, centre panel) – defined as the difference between the best available bid and the best available ask price, expressed in basis points relative to the mid-quote – shows the increase in round-trip execution costs for small trades. Ultra-long-term bonds (at least 12½ years' remaining maturity) exhibited the worst deterioration in bid-ask spreads.

[17] The anticipation of the ECB's asset purchase programme triggered massive speculation by leveraged players on a further decline in rates. When 10-year bond yields had fallen to below 10 basis points by mid-April, some market participants perceived the extreme fall as an overreaction not justified by any economic fundamentals. Some large investors considered this a good opportunity to short bunds.

Order book depth in the electronic inter-dealer market (Graph 10, right-hand panel) – defined as the total volume available for immediate transaction at the best available bid and offer prices – provides a better indication of the market's illiquidity than bid-ask spreads do. Over the study period, depth in the order book of German bunds was low, a factor which can potentially amplify price movements. Again, the most striking decline of depth is observed in ultra-long-term bonds, falling by more than a third over the six-month period, from €25 million to roughly €16 million. In an environment of decreasing market depth, large trades are likely to evoke extreme price moves similar to those seen in May–June 2015.

The overall decrease in bund liquidity may have resulted from diverse factors (Riordan and Schrimpf (2015)). As part of a longer-term trend, liquidity has been affected by intermediaries' scaling-down of inventory holdings in fixed income assets. Some observers have also suggested that the ECB's Public Sector Purchase Programme (PSPP) in early 2015 may have further reduced the supply of tradable bonds. This in turn reduced the availability of bonds for trading by intermediaries. The depth available in German bond markets fell around the time of the announcement on 22 January and continued to fall from the start of the PSPP on 9 March (Graph 10, right-hand panel). However, the effects were most pronounced, and appear to be permanent, in bonds of very long-term maturity. As the PSPP mainly focused on short- and medium-term bonds, other factors such as reduced risk-bearing capacity of intermediaries may have also played a role.

The JGB futures market on 13 March 2014 | Graph 11



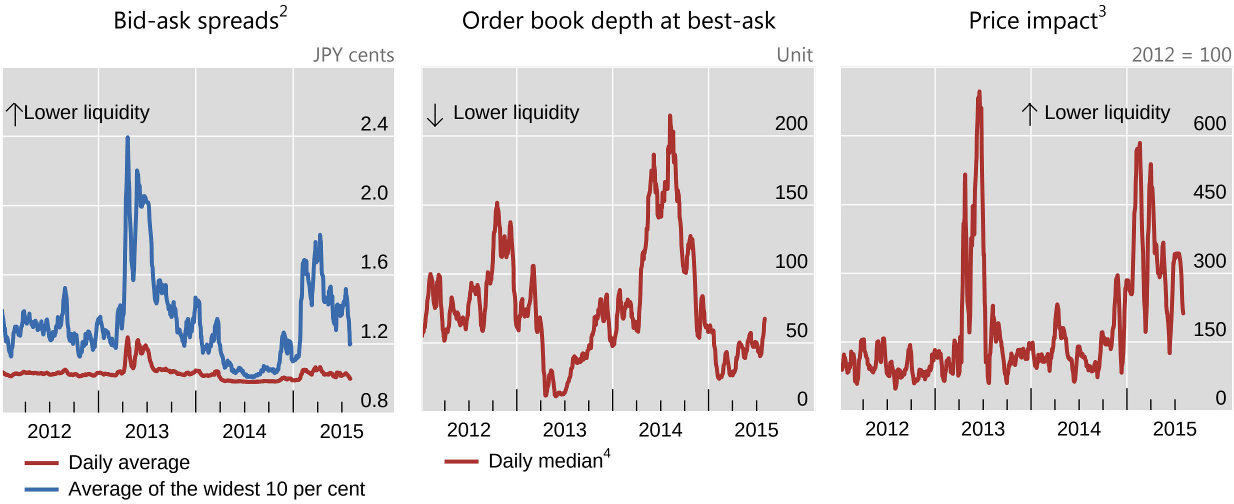
Sources: Bank of Japan calculations; Nikkei Inc, "NEEDS".

Gyrations in JGB futures markets

In contrast to the US Treasury and the bund market, the JGB market usually exhibits lower intraday volatilities, but flash events (extremely large price moves and reversals occurring over just a few minutes) are also observed in the JGB futures market. One example occurred on 13 March 2014. The possibility of Japanese markets also becoming unstable, such that there may be an increase in the number of flash events through further proliferation of AT, cannot be denied. Similar to the US Treasury market event of 15 October 2014 discussed above, flash events in the JGB futures market are characterised by liquidity evaporation along with a rapid reduction in order book depth (Graph 11), amid a sudden increase in trading volume. However, unlike the US case, no spillover to the JGB cash market occurred.

Kurosaki et al (2015) further examine JGB liquidity – around the expansion of quantitative and qualitative easing (QQE) in October 2014 – from various angles using high-frequency tick data from JGB futures. Traditional liquidity indicators of the JGB futures market such as the bid-ask spread and the transaction volume suggest that liquidity in the JGB market did not decline significantly, even after the expansion of QQE. However, the indicators newly formulated in this paper, such as the depth and the impact of a unit volume of transactions in the JGB futures market, suggest that liquidity in the JGB market has been declining since autumn 2014. Liquidity indicators have somewhat improved recently, although they are yet to fully recover to previous levels (Graph 12). While a decline in JGB liquidity may be a temporary phenomenon following the rapid decline in the long-term yield observed after the expansion of QQE as well as the short- and medium-term yields turning negative, it may also reflect other factors such as the massive purchases of JGBs by the Bank of Japan, structural changes in the markets and regulatory changes.

Liquidity indicators in the JGB futures market[1] Graph 12



[1] Ten-day backward-moving average. [2] Calculations based on bid-ask spread data with a one-minute frequency within each business day. [3] Estimation based on the Kalman filter with the developments smoothed; figures are calculated by taking the average of each business day. [4] Median of the volume of limit orders at the best-ask price with a one-minute frequency within each business day.

Sources: Bank of Japan calculations; Bloomberg; Nikkei Inc, "NEEDS".

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Glossary

Automated trading (AT): A trading technology in which trades are executed and order placement decisions are made autonomously using predefined algorithms.

All–to-all platform: A trading platform that allows any platform member to negotiate and trade with any other platform member. The best known all-to-all platform is the modern stock exchange.

Bid-ask spread: The difference (spread) between the bid price and an ask price of a market-marker in a security. Drivers of the size of the spread are the liquidity and volatility of the security as well as competition in the marketplace.

Block trade: A transaction that is large relative to the average trade size and for which the execution must be carefully managed to reduce its price impact, typically by dividing the block into multiple child orders ("working the order") or by arranging the trade bilaterally.

Buy side: The group of investors who are clients of financial intermediaries and who trade with intermediaries in order to construct or deconstruct a position.

Central limit order book (CLOB): A trading protocol in which outstanding offers to buy or sell are stored in a queue and are filled in a priority sequence, usually by price and time of entry. Orders to buy at prices higher than the best selling price and orders to sell at prices lower than the best buying price are executed. CLOBs are common for highly standardised securities and markets in which trade sizes can be small.

Click-to-trade (CTT): The capability to immediately trade at prices streamed by a dealer or set of dealers.

Dark pool: A trading platform in which pre-trade transparency is deliberately limited, typically by withholding information about market depth or about the likely transaction price. Dark pools limit transparency in order to induce liquidity suppliers to offer greater quantities for trade.

Dealer: A financial intermediary that offers the service of standing ready to buy or sell assets with its clients.

Depth: A market liquidity measure that indicates the size of a trade that can be executed without necessitating a significant concession on the price. It is often measured in the amount of a security that is available for immediate trade at a particular price.

Electronic communication network (ECN): A system that electronically matches buy and sell orders for securities. The best known ECN is the modern stock exchange.

High-frequency trading (HFT): A type of automated trading that submits orders and trades at high speed, usually measured in milliseconds, and that maintains a low inventory position.

Inter-dealer market: A private market for trades between large dealers. Dealers often maintain private markets to hedge exposures without fear of interacting with better-informed speculators.

Latency: The time (delay) between the transmission of an order to a trading platform and the completion of its processing on the platform. A lower latency is considered better, as the signal is sent and processed faster.

Limit order: An offer to buy or to sell a stated quantity of a security at a stated price.

Market-maker: A financial intermediary that offers the service of standing ready to buy or sell assets with other traders specifically by quoting bid and ask prices that are accessible to the registered participants of a trading platform.

Multi-dealer platform: A trading platforms that connects a set of dealers' clients with the dealers and enables electronic negotiation and execution in competition.

Off-the-run: An off-the-run bond is no longer the most recently issued bond for a certain maturity.

On-the-run: An on-the-run bond is the most recently issued bond for a certain maturity. On-the-run bonds are more liquid than off-the-run bonds.

Over-the-counter (OTC): Refers to trade negotiation that takes place bilaterally and outside a trading platform or venue such as an exchange.

Primary dealer: A dealer that buys government securities at issuance. In many countries, primary dealers are the only parties allowed to buy government debt directly from the government when it issues new debt. In some countries, primary dealers are obliged to maintain a liquid market in these securities.

Principal trading firm (PTF): A trading firm that typically deploys proprietary automated trading strategies on trading platforms. Some PTFs may be registered as broker-dealers although they have no clients.

Request for quote (RFQ): A query issued by a trading platform member to another member to request price quotations. Systems for sending RFQs vary according to: whether the sign of the order (buy or sell) is revealed; how many participants and what kind of participants may receive an RFQ; and whether the quotes are executable or indicative. In most fixed income RFQ systems, clients query only a limited number of dealers. A related trading protocol is request for market (RFM). RFM refers to a request for quote where the client does not reveal the sign of the desired trade (buy or sell). An RFM is a request to see a two-sided or "market" quote rather than a one-sided quote.

Single-dealer platform: A proprietary trading platform provided by a single dealer to its clients that connects the dealer with its clients and enables electronic negotiation and execution.

Straight through processing (STP): The complete execution of a transaction, including confirmation, clearing, payment, settlement and record-keeping, without any human interference.

Swap execution facility (SEF): An electronic platform on which participants can trade swaps. Under the Dodd-Frank Act, the use of SEFs is mandatory for centrally cleared swaps.

Voice broker: A financial intermediary that acts as a negotiator between buyers and sellers via telephone. A voice broker acts as an agent: It does not bear any trading position and charges a fee only for connecting a buyer with a seller.

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