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Intermediation in US and EU bond and swap markets: stylised facts, trends and impact of the coronavirus (COVID-19) crisis in March 2020

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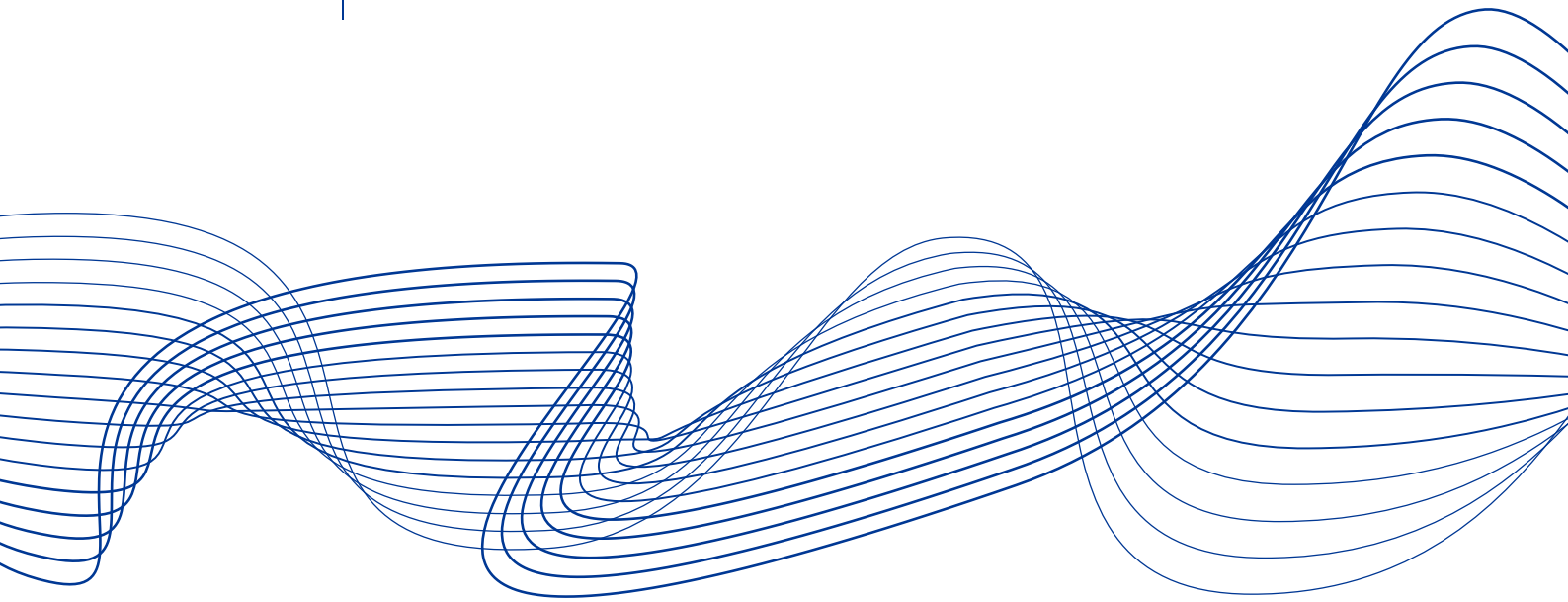

ESRB
European Systemic Risk Board
European System of Financial Supervision

Abstract:

The trading of bonds and swaps largely relies on bank dealers as core market-makers. Dealers provide liquidity and trade the instruments with smaller or less active firms, in part by using their own balance sheets for inventory holding or hedging purposes. The reforms carried out in the aftermath of the global financial crisis (GFC) and the low interest rate environment have extensively changed the mechanisms and costs of trading fixed income instruments. This paper sets out to analyse the structure of trading in key over-the-counter (OTC) fixed income markets. We focus on three questions: (1) how are bonds and swaps currently traded and how liquid are these markets?, (2) how do the structural changes affect the dealer business model and market functioning?, and (3) how did the coronavirus (COVID-19) shock in March 2020 affect the OTC bond and swap market in its new post-reform set-up? To answer these questions, we combine an institutional and research perspective with a focus on key EU markets. We use public data and findings from the rich body of academic literature to describe the dealer business model and its post-GFC evolution. Overall, we argue that OTC fixed income trading is becoming "faster" due to the progress of electronic trading and the rise of non-bank traders, which has led bank dealers to make some adjustments to their market-making activities. The ongoing challenges faced in ensuring resilient provision of liquidity were also highlighted by the US bond market dislocation in March 2020.

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Key words: Fixed income, market structure, liquidity, swaps, bonds, dealers;

JEL code: G12, G15

Introduction

The bulk of bond and swap trading takes place in "darkness". Most categories of bonds and interest rate or credit derivatives, which in notional terms account for a large share of financial market instruments,[1] are bought and sold in private bilateral transactions rather than on centralised exchanges (Duffie, 2011). The over-the-counter (OTC) market sets risk-free rates, the price of collateral for repo lending and margining, and defines the market price of credit risk, thereby setting funding costs for sovereigns and major corporates. One driver of OTC trading is the high degree of heterogeneity in many asset classes. For example, a major industrial firm would typically only have one or two classes of shares outstanding and listed on an exchange, but may have hundreds of bonds issued in different currencies, with varying maturities and cash flow structures.[2]

OTC markets rely on two distinct groups of participants: (1) a core set of intermediary firms ("dealers"[3]) that actively trade among themselves and with all other market participants and (2) a group of smaller participants on the periphery of the network. These participants only trade with core dealers but not with other firms on the periphery. A primary role of dealers is to make markets by managing the price setting process and providing market liquidity. How well they execute this function depends on their capital position and access to funding. Dealers therefore internalise the interaction of market liquidity and funding. Their business model allows them to profit from opacity and information advantages. The OTC market structure is characterised by the absence of all-to-all trading, which distinguishes this segment from exchange trading.[4] Up to now, the dealer sector has typically been composed of subsidiaries of globally systemically important banks (G-SIBs) (see Sections 1 and 2 for more details).

The regulatory reforms implementing the G20 Pittsburgh Declaration in 2009[5] in the aftermath of the global financial crisis (GFC) have fundamentally altered how OTC markets function. This has significantly reduced systemic risk and global policymakers have focused on reducing the opacity, complexity and interconnectedness of the OTC trading network for derivatives and repos (cf. Financial Stability Board (FSB), 2017). Three key measures, all of which have been implemented in the United States and the European Union (EU), are the obligations to clear most swaps in central clearing

[1] According to Wooldridge (2019), OTC markets are "larger and more diversified than ever". Over three years, daily turnover in interest rate derivatives increased by 143% to USD 6.5 trillion (Ehlers and Hardy, 2019).
[2] The OTC markets have not always dominated bond trading. Before the Second World War, there was an active market in corporate and municipal bonds on the New York Stock Exchange. Activity dropped dramatically in the late 1920s for municipals and in the mid-1940s for corporate bonds as trading migrated to the OTC market. Biais and Green (2018) describe the evolution of the US bond market microstructure in the 20th century.
[3] A dealer is commonly defined as a firm that provides market making and therefore continuously offers two-way pricing to other market participants (see MiFID II). A related concept in MiFID is the systematic internaliser (SI), who "on an organised, frequent, systematic and substantial basis, deals on own account when executing client orders" outside a regulated market or recognised trading venue. A "primary dealer" is a market participant who actively intermediates transactions in secondary markets and has therefore been given access to the corresponding primary market (e.g. debt auctions held by the debt management office). Under US regulation (Securities Exchange Act of 1934), a "broker" is "engaged in the business of effecting transactions in securities for the account of others", while a "dealer" is "engaged in the business of buying and selling securities for its own account, through a broker or otherwise". Nowadays, many US broker-dealers are part of bank holding companies.
[4] For a discussion on exchange trading and high-frequency trading, see Aquilina et al. (2020).
[5] G2O leaders' declaration, Pittsburgh 2009.

counterparties (CCPs) ("clearing obligation"), to trade key OTC derivatives on transparent electronic platforms ("trading obligation") and to comprehensively margin remaining bilateral OTC trades with an initial margin (IM) and a variation margin (VM).[6]

Structural changes since the GFC have affected the viability of the bank dealer business model. We note the rising role of non-bank financial institutions (NBFIs) and the increasing electronification of trading. These two trends have combined in the emergence of principal trading firms (PTFs), which are now among the most active traders in equities, US Treasuries and standardised derivatives. These firms provide a material share of liquidity in many market segments and are moving into territory that bank dealers held throughout the 20th century. More stringent capital requirements (such as the leverage ratio) may have also reduced incentives for dealers to run large inventory positions. Furthermore, the trading obligation for many swaps has reduced opacity and therefore the information advantage that dealers have in OTC swap trading.

The market turmoil that followed the outbreak of the coronavirus (COVID-19) in March 2020 illustrated the fragility of some OTC segments and highlighted the importance of OTC market analysis. In March 2020, US Treasuries, corporate bonds and municipal bonds saw a dislocation of trading. Demand for market making suddenly exceeded the capacity of bank dealers to intermediate between buyers and sellers. Consequently, the Federal Reserve System intervened to support the bond markets. This episode of market stress in crucial OTC segments (the "world's safe assets") therefore also sheds light on how a large exogenous shock affects the OTC fixed income market in its new, post-reform set-up.[7]

The purpose of this paper is to summarise the key developments in the OTC fixed income market and corresponding dealer sector since the GFC. We analyse public data, describe regulatory changes and draw on findings from a large body of academic research. Given its central role in the global financial system, the OTC market has been the subject of extensive academic analysis, including theoretical modelling and empirical studies. The post-crisis reforms have made granular exposure data available for derivatives and bonds,[8] which has fostered strong growth in empirical research. This large and fast-growing body of literature offers many insights into the OTC fixed income markets over the last decade.

We focus on the key US and EU OTC markets: US and major EU government bonds, US corporate bonds, interest rate swaps (IRSs) and credit default swaps (CDSs). Given that derivatives and underlying cash markets are closely connected through arbitrage mechanisms, our approach provides a broader perspective than papers that focus on just one segment.[9] In the paper, we provide key

[6] The role of dealers has also been shaped by extensive regulatory developments in the 20th century, such as the Glass-Steagall Act or the "Big Bang" in the UK stock market in 1986. In parallel, the rise of the universal bank business model (i.e. a depository institution with retail operation and full central bank access) was reinforced in the aftermath of the GFC, when Goldman Sachs and Morgan Stanley converted to bank holding companies.

[7] Spatt (2020) provides a comparison of March 2020 with the GFC. Duffie (2011, 2019) discusses the GFC.

[8] See Abad et al. (2016) for a discussion on derivatives data and Bessembinder et al. (2019) on US bonds, in particular corporate bonds with the TRACE dataset.

[9] Earlier overviews of dealers and OTC markets are provided by Madhavan (2000), Bessembinder et al. (2019, US bond market), Duffie (2011), Duffie (2017), FSB (2017, with emphasis on the impact of regulatory reforms), Adrian et al. (2018, with emphasis on the dealer business model), Bomfim (2022, CDS) and FSB (2022a, focus on core government bond markets).

stylised facts for these markets, building a comprehensive picture of activity in the major segments. We also add a European perspective, as researchers have so far overwhelmingly focused on US corporate bonds and Treasuries, even though German Bunds are also used as a major safe asset. In this context, the capital markets union (CMU)[10] plan helps us to better understand how financial markets function and the structure of intermediation in key segments of the EU financial system.

Overall, we argue that bank dealers continue to hold a unique position in the market for bond and swap trading. Nevertheless, changes in recent years have encroached on their dominant market position. The increasing use of trading platforms in some OTC segments (which is mandatory for many swaps) and the interlinked steady rise of PTFs in steadily increasing electronic markets provide tentative evidence that we are evolving towards a market ecosystem in which non-bank dealers may play a material role. It remains to be seen whether this system is more resilient by offering more robust and potentially higher market liquidity, as we have yet to reach a steady state. This is also highlighted by the market turmoil caused by COVID-19 and the launch of further reforms, particularly in the US Treasury market.

The rest of this paper is organised into five sections. We start with an overview of the two main fixed income markets run by dealers in Section 1, which describes the market structure and activity in US and European government and corporate bonds. Section 2 provides an in-depth analysis of swaps. In Section 3 we focus on key trends in the post-GFC evolution of bank dealers. Section 4 discusses potential lessons learned from the COVID-19 crisis, which provided the first stress test for the OTC market since the reforms in the 2010s. We present our conclusions in Section 5.

1) How are bonds currently traded and how liquid are these markets?[11]

General background

The government bond market is one of the oldest and still one of the largest segments of the financial market. Government bonds play an essential economic role in the modern financial system. They set the price for collateral, the risk-free rate and the corresponding term structure (e.g. from overnight to 30-year maturity). They also underpin the market price of credit risk and thus the cost of funding for firms and sovereigns. In general, the regulation of bond markets focuses on transparency and trading platforms.[12] There are also extensive rulebooks for auctions and the activities of primary dealers.

The US bond market

The largest segment in the sovereign category is the market for US Treasuries, which at the time of writing measures USD 25 trillion outstanding (more than 100% of US GDP).[13] In the market for bonds issued by the private sector, US issuers once again take the lead with financial firms accounting for around USD 16 trillion and non-financial firms for USD 6 trillion. In terms of bond trading activity, the

[10] The CMU is a plan of the European Commission to mobilise capital in the EU by creating deeper and more integrated capital markets and therefore complement direct bank financing.
[11] To preserve readability, we omit reference dates for all the individual numbers mentioned in the main text.
[12] The MiFID framework (of which the current version is MiFID II/MiFIR) prescribes pre-trade and post-trade transparency for fixed income instruments. In addition to regulated markets (RMs) and multilateral trading facilities (MTFs), organised trading facilities (OTFs) have been included specifically to cover certain types of trading commonly used for non-equity instruments (cf. Hogan Lovells, 2017).
[13] BIS –Summary of debt securities outstanding.

US Treasury market is also the most active, with a daily volume of USD 668 billion.[14] The depth and breadth of this market lead to bid-ask spreads of below 2 basis points (Box 1). While "on-the-run bonds" are the most actively traded Treasury bonds, accounting for more than half of total daily trading volumes, they make up less than 5% of outstanding marketable Treasury securities (G30, 2021). This concentration of liquidity in a small segment was a key driver of the market dislocation in March 2020. Roughly half of Treasury securities trading is carried out through interdealer brokers (IDBs), where dealers and other professional traders transact with one another, and roughly half occurs between dealers and clients. Baker et al. (2018) study the overall liquidity hierarchy in US Treasuries, showing that futures account for 44% of the volume and the cash market for around 55%, with "off-the-run" bonds contributing 13% of the total volume. We will return to the microstructure of US Treasuries in the context of the COVID-19 crisis.

At the other end of the scale, individual US corporate bond issues see less than one trade per bond per week (Ivanov et al., 2020) and many asset backed securities (ABSs) do not trade at all in the secondary market.[15] Bid-ask spreads for investment grade bonds are therefore much higher than for US Treasuries, with roundtrip costs estimated at 0.84% (Bessembinder et al., 2018). In the US market, the municipal bond segment is also substantial, with a notional size of around USD 3.6 trillion. This segment has recently attracted PTFs.

The market for secured funding has always been a major source of finance for dealers.[16] In the aftermath of the GFC, which was marked by a sharp decline in unsecured interbank borrowing, repos saw a steady increase in activity. The US repo market recorded a notional outstanding amount of USD 2.2 trillion in 2018.[17] Recurring episodes of volatility in this market in the last few years have not only further highlighted its importance, but also its vulnerability.[18] The US Treasury repo market consists of a tri-party repo segment with OTC trading among broker-dealers and repo trading that is centrally cleared at the Fixed Income Clearing Corporation (FICC), where larger dealers and banks lend to other dealers using platforms like Bloomberg or TradeWeb.

EU government bonds

Overall market activity in euro area government bonds is much smaller than trading in US Treasuries. According to AFME (2022), the average daily trading volume for euro area government bonds amounted to €86 billion as of the second quarter of 2022, with an additional €22 billion reported for bills.

The market for German government bonds (Bunds)[19] currently has an outstanding volume of €1,954 billion. New bonds are generally placed as single issues via auction with volumes of at least €1 billion and can be followed by several increases up to approximately €15 billion.

[14] US Treasury Securities Statistics.
[15] See Bessembinder et al. (2013) and O'Hara and Zhou (2019, 2020).
[16] Repos provide funding for dealers to finance their trading activity, but also allow them to source government bonds, for instance, without taking ownership (cf. Huh and Infante, 2021).
[17] US Repo Statistics.
[18] See Tarullo (2019) for a discussion on the causes and policy consequences of the repo turmoil. See Anbil et al. (2021) for more details on the US repo market.
[19] Data as of end-2021. Source: ECB.

The French government bond market has a size of €2,412 billion at the time of writing. It is composed of two categories of instruments defined by their maturity on issue. Obligations Assimilables du Trésor (OATs) are debt instruments with maturities that range from two to 50 years. Bons du Trésor à Taux Fixe et à Intérêts Précomptés are the French Treasury's (Agence France Trésor's) cash management instrument.

The Italian government bond market is the third major EU bond market with a notional volume of €2.2 trillion. Its two key instruments are Buoni Ordinari del Tesoro (BOTs; maturity of less than one year) and Buoni del Tesoro Poliennali (BTPs; maturity above one year). In addition, floating rate instruments (CCTs) are used. One of the distinguishing features of Italian government bond trading is the long-established use of electronic platforms. The Mercato dei Titoli di Stato (MTS) platform, which is categorised as a regulated market (RM) under the EU regulatory framework, was already set up in 1988 as one of the first platforms globally. Average daily turnover in November 2022 in all instruments was slightly below €12 billion.[20]

Box 1: Comparison of current trading conditions in US and EU government bond markets

As mentioned, limited data availability complicates the empirical analysis of trading activity and trading conditions in major bond markets. In this box, we make use of publicly available data sources[+)] to compare trading costs of French, German, Italian and US government bonds. The table below provides a snapshot of the average bid-ask spreads based on ten-year benchmark bond prices. Averages are calculated for the month of November 2022. For the purpose of comparison, we also report outstanding volumes from the debt securities statistics of the Bank for International Settlements (BIS) (due to the lack of consistent data on trading volumes covering both EU and US markets):

	Germany	France	Italy	United States
Outstanding volume (USD billion)	1,954	2,4212	2,102	26,853
Bid-ask (basis points)	2.5	4.2	7.3	1.6

Due to the highly active trading of on-the-run US Treasuries, their bid-ask spreads are less than 2 basis points (as also mentioned by Adrian et al., 2017), whereas the spreads for major EU bonds are currently between 2 and 7 basis points.

+) Sources: For bid ask spreads: Refinitiv and Bloomberg; monthly average. Outstanding volume: BIS - Table C2 (summary of central government debt securities markets, by instrument and maturity at end-September 2022, in billions of US dollars).

Finally, the euro repo market, which typically uses government bonds as collateral, is also fairly active. It had an outstanding volume of €9,198 billion at year-end 2021, of which 48.7% was collateralised with government securities (ICMA, 2022). The bulk of the notional volume is centrally cleared (e.g.

[20] Sum of daily averages for CCTs, BOTs and BTPs; source: Table 6 in Banca d'Italia (2022).

repos from the MTS segment) and has a one-day maturity. The tri-party structure[21] is much less common in the euro area than in the United States, where it accounts for two-thirds of the volume.[22]

Who are the bond dealers and what is the market structure?

Before we describe the institutional details, we will briefly summarise the key concepts of OTC market functioning. Unlike exchanges with full transparency for pre-trading and post-trading, OTC markets are sometimes characterised as "semi-centralised" (Weill, 2020) due to the vital role played by dealers. Typically, all details of a trade are known only to the counterparties. This bilateral trading leads to a lack of market-wide transparency about current price conditions for many investors. The main role of fixed income dealers is to match buyers and sellers of bonds and swaps.[23] Dealers aim not to take large proprietary positions in these instruments, thereby reducing their exposure to market risk (i.e. the impact of changing prices via mark-to-market losses on their portfolios). These structural features of OTC markets generate "frictions", which have played a major role in the development of the dealer business model.[24]

Most Treasury primary dealers[25] belong to G-SIB groups, but some are standalone investment banks. For example, Jefferies describes itself as an "investment bank and financial services company". US primary dealers' tasks include participating in open market operations and auctions. They also act as responsible counterparties and market participants "on an ongoing basis" in their overall conduct and support of market efficiency and liquidity.[26]

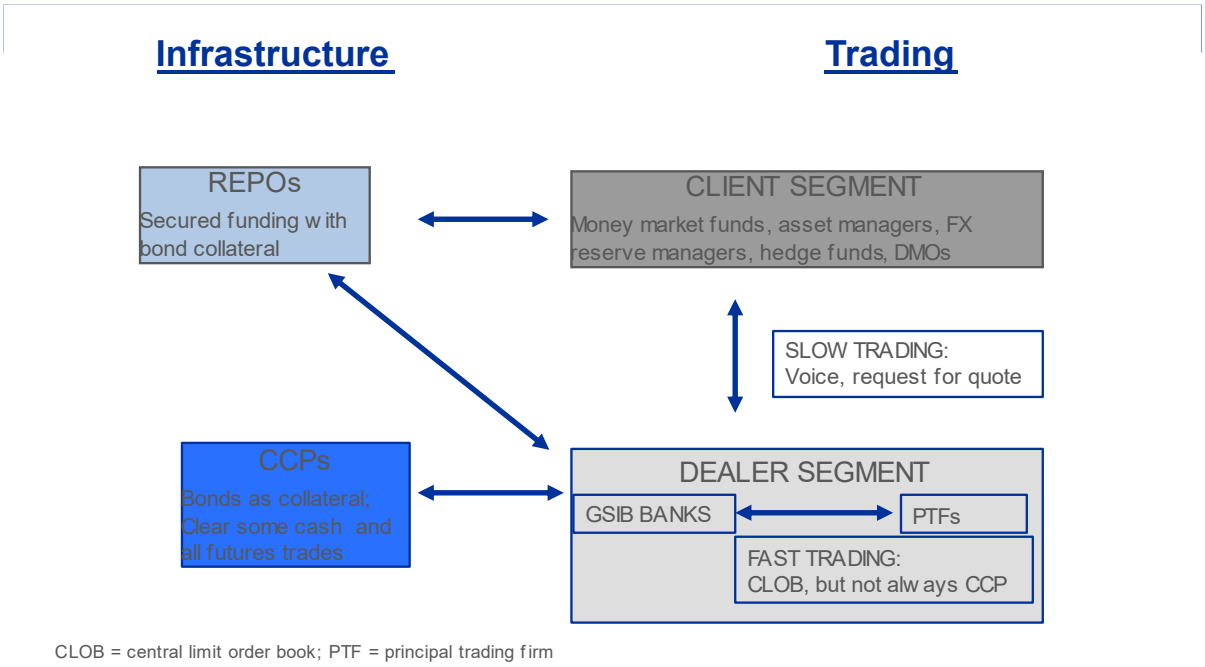
Up to March 2020 the largest holder of US Treasuries was the official foreign sector with USD 4.1 trillion, while banks and broker-dealers held around USD 1 trillion (Banegas et al., 2021). Foreign private investors held USD 2.8 trillion, US insurers and pension funds USD 3.3 trillion and mutual funds USD 1.3 trillion.

Treasury trading consists of two segments (the structure is illustrated in Figure 1 and quantified in Figure 2). In dealer-to-dealer (D2D) trading, electronic trading is concentrated in on-the-run securities (current benchmarks), which account for almost 70% of the trading volume. D2D trading makes use of electronic platforms with exchange-like features – except that clearing is often on a bilateral rather than a centrally cleared basis. About 70% of interdealer trading takes place on electronic IDB platforms (such as BrokerTec) with active non-dealer participants. Electronic trading is less common for off-the-run bonds, which came to the forefront during the COVID-19 turmoil. The table below (Figure 2, second row) indicates that the bulk of outstanding Treasury volume (off-the-runs) is rarely traded.

[21] Post-trade collateral selection, management and settlement are outsourced to an agent.
[22] Is repo in Europe the same as repo in the US?
[23] See Ho and Stoll (1980) or Glosten (1987) for early analyis on the role of dealers in financial markets.
[24] Academic research has identified three key frictions in OTC markets: inventory, search and bargaining. See Duffie (2011) for an overview and Duffie et al. (2005, 2007) for key contributions on the theoretical framework. Pintér and Üslü (2022) offer a recent empirical investigation.
[25] At the time of writing, these are Amherst Pierpont, BAML, the Bank of Nova Scotia, BNP Paribas, Barclays, the Bank of Montreal, Citigroup, Credit Suisse, Daiwa, Deutsche Bank, Goldman Sachs, HSBC, Jefferies, J.P. Morgan, Mizuho, Morgan Stanley, Nomura, Royal Bank of Canada, Royal Bank of Scotland, Société Générale, Toronto Dominion, UBS and Wells Fargo. See Arnone and Iden (2003) for further discussion on primary dealers.
[26] Administration of relationships with primary dealers (there is no public list of primary dealers for the US corporate bond market).

To illustrate the group of primary dealers of Bunds, we turn to the list of the Bundesfinanzagentur. It is made up mostly of banks, which are more numerous than for the US group.[27] Primary dealers in Bunds are not subject to any obligations in their secondary market activity, whereas the national debt management offices in both France and Italy require their primary dealers to make firm quotations to clients and other dealers on the bonds as well as on repos with OATs and BTPs collateral respectively.[28] As an example, OAT primary dealers are expected to have a market share of at least 2%. Given the long-established use of electronic trading, MTS also imposes certain specific requirements on BTP primary dealers.

Figure 1: Structure of the US Treasury market



Sources: Federal Reserve System and author's analysis.

Italian and German bond trading differ in the choice of trading venues (Barone et al., 2022). As mentioned above, electronic trading is the most common option for BTPs, almost exclusively in the interdealer sector, whereas some voice trading is still seen in Bunds. This is also valid to some extent for client trades.

[27] The group comprises the following firms: ABN AMRO, Banca IMI, BAML, BBVA, Bankhaus Lampe, Barclays, Bayerische Landesbank, BNP Paribas, BPCE, Citi, Commerzbank, Crédit Agricole, Danske Bank, DekaBank, Deutsche Bank, DZ Bank, Goldman Sachs, HSBC, ING, Jefferies, J.P. Morgan, Landesbank Baden-Württemberg, Landesbank Hessen-Thüringen, Mizuho, Morgan Stanley, Nomura, Norddeutsche Landesbank, Nordea, Oddo BHF, Rabobank, RBS, Santander, Scotiabank, Société Générale, UBS and UniCredit Bank. See AFME – Primary dealers.

[28] For an international comparison, see Barone et al. (2022).

Figure 2: Breakdown of daily trading volume in US Treasuries (in USD billion)

Bond type	Dealer-to-client	Dealer-to-dealer direct	Interdealer broker: electronic	Interdealer broker: voice/manual	Memo: notional outstanding
On-the-run	142	25	190	39	5%
Off-the-run	111	10	0.0	36	95%

Sources: Federal Reserve System, He et al. (2020) and author's analysis.

The bond dealer business model

Due to the lack of direct trading among clients, intermediation in bonds relies more heavily on dealers than intermediation in exchange-traded stocks. The US corporate bond market is not only one of the largest bond segments, but it also provides a unique laboratory for the analysis of dealer activities due to the availability of comprehensive, fully granular transaction datasets via TRACE,[29] which cover a long time series. US Treasuries, Bunds, BTPs and OATs are less transparent, as there are no comprehensive publicly available transaction datasets.

Recent research[30] has identified the following stylised facts about dealer activity in corporate bonds (market liquidity will be discussed in the next section).

- The US corporate bond market is dominated by a small group of dealers: 10 to 12 firms account for a market share of 70% of the total traded volume reported on TRACE.
- The network has a core-periphery structure with a few major firms at the centre of trading, which are highly active. The many smaller firms on the periphery trade infrequently and always access the market via a dealer.
- There is a clear hierarchy for transaction costs: dealers in the core of the network offer the lowest transaction costs, followed by high-quoting dealers and then moderate-quoting dealers.
- Holding inventory is costly and influences dealers' trading strategies. The necessity to commit capital leads them to offset inventory costs with trading costs. Despite the costs, dealers at the centre of trading are more willing to use their inventory to provide immediacy. This is also due to the fact that they can unwind it faster due to their higher level of interconnectedness.
- Dealers' positions in the trading network influence the prices of their trades. A "centrality discount" is observed in transaction prices between dealers and their clients, as dealers in the core of the network buy bonds at higher prices and sell at lower prices. In contrast, interdealer trading, which dealers often use to manage their inventory holdings, has a "centrality premium".

[29] The Trade Reporting and Compliance Engine (TRACE) was developed by the Financial Industry Regulatory Authority (FINRA) for the reporting of bond transactions.
[30] See Feldhütter (2012), Friewald and Nagler (2019), O'Hara and Zhou (2019), Harris and Mehta (2020), Dick-Nielsen et al. (2021) and Kim and Nguyen (2022) for empirical analysis.

- Core dealers exhibit significant market power, as they can charge higher spreads to firms on the periphery of the trading network.
- The volume of prearranged trades[31] has grown in the last 20 years. Core dealers use this mechanism less often than smaller traders, as their higher level of activity allows them to better manage portfolio imbalances. In contrast, smaller and often less connected traders need to manage their inventory more actively, as they have fewer opportunities to quickly sell positions they have just bought from clients.
- Electronic trading is growing steadily. It accounted for 45% of investment grade bonds and 35% of high yield bonds in 2022, which marks an increase of over 100% since 2017.[32] Correspondingly, trading costs have declined over the last decade. Electronic trading does not appear to improve the competitiveness of smaller dealers, as the market is still highly concentrated at the top: nine of the ten largest corporate bond dealers rank among the top 15 for both voice and electronic trading.

For European corporate bonds, there is relatively limited empirical analysis available due to the lack of long time series[33] of fully identified transaction data. One of the few recent and comprehensive studies investigates the UK corporate bond market (Coen and Coen, 2022). This supports many of the stylised facts listed above for US instruments.

- In a structure with a concentrated core and a large periphery, 8% of traders supply as much liquidity as the remaining 92% and the 6% most active traders account for 50% of transactions.
- Liquidity is highly vulnerable to shocks to these key liquidity suppliers: if the 4% most active traders stop trading, liquidity falls by over 60%.
- Trading is infrequent: the median UK corporate bond sees a trade only once a month.
- There is evidence for a centrality premium: the purchase price is negatively related to a trader's activity, while the sale price is positively related. Hence, dealers earn a spread.
- Dealer activity is related to capital requirements: when capital requirements are high, dealers manage their bond inventory more actively.

Market pricing and liquidity of government and corporate bonds

According to standard asset pricing models,[34] the yield on a bond can be decomposed into the risk-free rate and a risk premium, which is influenced by investor risk appetite, the underlying credit risk of the bond's issuer and market liquidity. Market liquidity is usually understood as the ease with which a trader can buy or sell an instrument at a price close to the observed market price prior to the transaction.[35] The following five dimensions are commonly captured by empirical analysis of market

[31] These brokered transactions are defined as a package of two trades on the same bond with opposing signs within less than 60 seconds, for instance. Transactions are typically executed electronically. Compensation occurs via mark-ups rather than charging clients a separate commission.
[32] Market maker Citadel set to accelerate credit trading transformation.
[33] For example, Feldhütter and Poulsen (2018) use a TRACE sample starting in 2002.
[34] See Duffie and Singleton (1999) for a theoretical framework.
[35] See IMF (2015) and Sarr and Lybek (2002) for more detailed discussions. These frameworks build on the earlier work of Glosten (1987), Kyle (1985), Ho and Stoll (1980) or Black (1971). Garbade and Silber (1976) provide one of the earliest studies of Treasury market liquidity.

liquidity (the square brackets illustrate the empirical implementation of these five dimensions in current literature).[36]

- Tightness reflects the direct transaction costs. [Estimation of the effective bid-ask spread based on the covariance of returns over two consecutive days].
- Immediacy represents the speed of execution in a market segment. A key driver of this speed is the activity of market-makers who quote the prices at which other market participants can trade. [Daily range = absolute difference between daily high and low prices].
- Depth captures the number of orders in an order book – the higher the number of orders, the more liquid trading is. [Average daily transactions].
- Breadth refers to the volume of orders – in a liquid market, large orders should not significantly affect prices. [Absolute return divided by trading volume].
- Resiliency measures the reaction of prices to imbalances driven, for instance, by new information about fundamentals. [Ratio of variance of weekly returns to variance of daily returns].

Many researchers have used the bid-ask spread as a simple and directly available measure of market liquidity. Empirical analysis has identified at least three main drivers:[37] (1) adverse selection costs – specialist trade with investors who may be better informed than market-makers are about the value of the instrument, which creates an adverse selection problem for market-makers, (2) order processing costs (e.g. fees charged by the exchange, CCP or trading venue) and (3) inventory costs – warehousing a bond on the dealer's balance sheet with associated capital and funding costs.

A direct comparison of trading costs across key US fixed income instruments shows that Treasuries rank first in terms of market liquidity. The average bid-offer half-spread on the main interdealer limit order book for the five-year on-the-run Treasury note is 0.40 cent (Adrian et al., 2016). This compares with the average effective half-spread for corporate par bonds, which is estimated at 0.39 cent (for institutional-sized dealer-to-client trades, according to Harris, 2015). [38]

There are wide-ranging views about the long-term evolution of bond market liquidity (cf. CGFS, 2016 for an overview). Anderson and Stulz (2017) study US corporate bond bid-ask spreads, finding that liquidity has not fallen as suggested by many market participants.[39] However, they also find that completing trades at acceptable terms might be more difficult, which supports the practitioner view. The liquidity index developed by Adrian et al. (2016) points to a sizeable variation in US Treasury liquidity with poor conditions during the GFC and around the time of the near failure of long-term capital management in 1998. Dealers had a short position in US Treasuries around the time of the GFC, which quickly rose above zero in the aftermath.[40] Market liquidity in US Treasuries also tends to be strongly correlated with funding liquidity at times of market stress, further highlighting the feedback effects of the two categories of liquidity, in part via dealer balance sheets. The March 2020 stress episode, which led to a unique dislocation, highlighted the fragility of liquidity in US fixed income

[36] Broto and Lamas (2020), Poli and Taboga (2021) and Blix Grimaldi et al. (2021) provide recent empirical analysis.
[37] See Glosten (1987) as one of the first studies on the drivers of bid-ask spreads.
[38] Estimates of trading costs vary depending on the sample period, methodology and instrument under consideration (cf. Reichenbacher et al., 2020).
[39] See Blackrock: Viewpoint – Addressing market liquidity.
[40] See Federal Reserve System Z.1/L130 statistical releases for a time series.

markets. Chikis and Goldberg (2021) use a noise-based measure to show that average trading costs in corporate bonds were 14 basis points, compared with only 2.3 basis points for Treasury notes before that episode. Trading costs for corporate bonds then peaked at 50 basis points in March 2020 and fell to 17 basis points after the Federal Reserve System's intervention in the spring of the same year.[41]

Trading conditions for corporate and government bonds are strongly driven by dealer balance sheet management, e.g. inventory constraints. The inventory effect has been documented in both US Treasuries and US corporate bonds. Feldhütter and Poulsen (2018) find that dealer inventory is the main determinant of the variation in bid-ask spreads for US corporate bonds. Klingler and Sundaresan (2020) show that a key component of Treasury yields, the convenience premium, is largely related to lower demand from dealers in Treasury auctions and rising balance sheet constraints. Wu (2021) documents a significant premium for inventory variation in US credit spreads.[42] These findings once again confirm the unique role played by dealers in intermediation and the channel from balance sheet costs to market activity.

Liquidity in bond markets is also related to the level of transparency. According to Gündüz et al. (2021), there are two contrary effects. On the one hand, higher transparency reduces the asymmetry of information between dealers and clients and, by increasing participation, may improve liquidity. On the other, higher levels of transparency reduce dealers' rents and could therefore also reduce their incentives to provide liquidity. Hendershott et al. (2021) offer a discussion in the context of request for quote (RfQ) mechanisms.

Monetary policy, which at the time of writing is undergoing substantial change, also influences liquidity in the bond markets. In the euro area, Boneva et al. (2021) find that in the German corporate bond market, Deutsche Bundesbank purchases initially reduced bid-ask spreads from mid-2016 to the end of 2018. Measures of market liquidity also deteriorated with a shrinking stock of outstanding bonds. Bonner et al. (2018) study the drivers of market liquidity in Dutch bonds between 2014 and 2016. They find that favourable treatment in liquidity regulation increases the liquidity of bonds. The presence of high-frequency traders affects the liquidity of sovereign bonds but not of other bonds, with a reverse effect in more volatile periods. Shorter maturities and higher ratings are consistently associated with higher liquidity (as in the United States). Pelizzon et al. (2018) show that the ECB's bond purchases increased the basis between German and Italian government bonds, and their respective futures contracts, reaching an average level of 0.06 cent for a €100 position. They document three channels for the ECB's bond purchases: the deterioration of bond market liquidity, increased bond "specialness" on the repo market, which is essential for funding bond positions, and higher cost of carry.

Concerns about market liquidity have also been driven by a series of high volatility shocks over the last decade. These "flash events" are characterised by sharp temporary price movements in a very

[41] See Adrian et al. (2016, 2017), Baker et al. (2018), Harkrader and Puglia (2020), Fleming and Ruela (2020) and Fleming and Keane (2021) for estimates of trading costs in the US bond market.

[42] The findings of Wu (2021) provide a reconciliation of declining bid-ask spreads while overall market liquidity is narrow. One key driver is the rise in the corporate bond liquidity premium in credit spreads since the GFC. For bonds rated below BBB, about 30% of the yield spread now compensates for illiquidity compared with 15% before the GFC. US post-crisis regulations seem to have increased dealers' market-making costs, forcing them to shrink their activity. This effect has increased trading delays and so requires a higher liquidity premium than before the crisis.

short period, without having immediate consequences for financial stability. On 15th October 2014 US Treasury instruments experienced an unusually high level of volatility and a very rapid rise in the round-trip cost (cf. Joint Staff Report, 2015). The yield on the benchmark ten-year Treasury bond saw a 37 basis point intraday trading range, only to close 6 basis points below its opening level. Historically, intraday changes of such scale have been sparked by monetary policy announcements. This was not the case in October 2014. Although transaction costs and depth deteriorated significantly, trading volume was high and the market continued to function. Some of the potential factors behind the volatility, such as algorithmic trading and the participation of non-bank dealers, also came to the fore in the analysis of the March 2020 dislocation (see Section 5 for an extensive discussion of this point).

EU bond markets also saw flash events such as the "Bund tantrum", where benchmark yields jumped by 15 basis points within an hour on 3 June 2018. According to Riordan and Schrimpf (2015), ultra-long-term bonds exhibited the worst deterioration in bid-ask spreads, with a near doubling in the relative spread from 40 to roughly 80 basis points. The limited risk-bearing capacity of intermediaries is seen as one of the potential drivers of this volatility event. Bouveret et al. (2022) show that some of the flash events in EU bond markets may have influenced market liquidity on a longer horizon of up to several weeks.

2) How are swaps currently traded and how liquid are these markets?

Background: regulation of the swap market

The starting point for the current framework is the reform of the OTC market launched by the G20 Pittsburgh summit on 25 September 2009: "All standardised OTC derivative contracts should be traded on exchanges or electronic trading platforms, where appropriate, and cleared through central counterparties by end-2012 at the latest. OTC derivative contracts should be reported to trade repositories. Non-centrally cleared contracts should be subject to higher capital requirements."

In the United States, the Dodd-Frank Act was implemented on 21 July 2009. Title VII+ requires the registration of swap dealers, and the mandatory trading, clearing, margining and reporting of OTC derivatives. In the EU, the European Market Infrastructure Regulation (EMIR) entered into force on 16 August 2012. The second key EU regulatory package "Markets in Financial Instruments Directive II/Regulation (MiFID II/MiFIR)" came into force on 3 January 2018. This new legal framework for securities markets, market participants and trading venues aims to improve the functioning of EU financial markets, making them more efficient, resilient and transparent.

Based on the Pittsburgh declaration, the five key reforms that directly affect OTC derivatives trading and have been implemented in the EU and United States are:

- the derivatives trading obligation (DTO) for standardised OTC derivatives on trading venues, i.e. electronic platforms;[43]
- pre- and post-trade transparency for quotes and transactions in bonds and derivatives;

[43] According to MiFIR, derivatives contracts, which are cleared through a CCP and are sufficiently liquid, need to move to more standardised and transparent mechanisms. Similar rules are in place in the United States for index CDSs and IRSs (the swap execution facility).

- the clearing obligation for standardised OTC derivatives such as swaps: the CCP steps in as "buyer to every seller" in all trades falling under the obligation;
- the margining obligation for all non-CCP cleared OTC derivatives, requiring comprehensive buffers for major mark-to-market losses (see below for further information on margining);
- a regulatory framework for OTC trading mechanisms such as interdealer brokers or RfQ platforms.

EMIR introduces a clearing obligation for major financial and non-financial counterparties (above notional thresholds) in a similar vein to the DTO. The products falling under the mandatory clearing obligation in the EU (established by ESMA) are:

- single-currency IRSs (basis swaps, fixed-to-floating swaps and overnight index swaps) and forward rate agreements (FRAs) in EUR, USD, GBP and JPY;
- single-currency IRSs (fixed-to-floating) and FRAs in PLN, NOK and SEK;
- index CDSs (iTraxx) settled in EUR.

A CCP has unique structure in the form of a matched book that means it is not exposed to market risk but to major counterparty risk (cf. Manning and Hughes, 2016).[44] CCP risk management tools are first and foremost netting, followed by margining and then the mutualisation of any major losses that are not covered by the own resources of the defaulting clearing members (CMs). One significant advantage of CCPs vis-à-vis bilateral clearing is multilateral netting,[45] which also reduces dealers' liquidity needs.

From a dealer's perspective, the most important European CCPs are LCH Ltd (IRSs in major currencies), ICEU (short-term interest rate derivatives "IRDs" and CDSs), LCH SA (repos and CDSs) and Eurex (Bund and equity futures and IRSs). In parallel with concentration among CCPs, there is also a high level of concentration among CMs. According to analysis carried out by the FSB (2020a), the largest 11 CMs out of a total of 306 participate in up to 25 CCPs. The default of a major CM in one CCP could therefore result in defaults in up to 24 other CCPs.

CCP clearing and general margining have significantly reduced counterparty credit risk when compared with the pre-GFC period. Collateralisation of OTC derivatives such as CDSs has historically been of a discretionary nature – as also evidenced by the systemic stress after the collapse of Lehman Brothers in 2008. High bilateral exposures, which were not sufficiently collateralised, exacerbated the crisis and led to mark-to-market spirals. Counterparty risk was further increased by long chains of overlapping OTC contracts. In contrast to bilateral trades prior to the GFC, traders must now pay variation and initial margins, not only to the CCP but also to a large extent when engaging in bilateral cleared transactions. The VM is the daily change in the market value of the contract. Two counterparties must exchange VMs to cover their current exposure based on the mark-to-market (typically cash). The IM represents the potential future exposure and is often posted in cash but also in high-grade bonds. In addition to VMs and IMs, CCPs also apply concentration charges and add-ons

[44] In contrast, Systemic Risk Council (2019) argues that a CCP resembles a dealer: "A CCP is akin to a securities dealer with a completely matched book that hedges itself against counterparty risk --- the market-risk exposures opened up by a counterparty's default --- via collateral requirements of various kinds."
[45] Under bilateral netting a dealer nets with one counterparty across many assets, whereas in multilateral netting a CCP nets across its CMs.

for short positions. Stricter margin requirements for bilaterally cleared trades generally aim to provide incentives to move bilateral transactions to CCPs, thereby reducing bilateral counterparty risk (while increasing concentration in CCPs, which have stringent risk management requirements).

In summary, collateral has become a core instrument for mitigating counterparty risk, which on its own directly reduces systemic risk. The European Commission (2010) provides a detailed impact assessment of the reforms introduced by EMIR.[46] It starts by highlighting three policy concerns for the OTC market: (1) lack of transparency on exposures, (2) insufficient mitigation of counterparty credit risk and (3) insufficient mitigation of operational risks. Each of these problems can negatively affect the functioning of the financial system and their combined effect can lead to "truly devastating results". The analysis also sets out how the increase in resilience afforded by EMIR benefits the wider EU economy.

Size of the swap market

As of December 2022, the outstanding global notional of the OTC derivatives market based on the comprehensive BIS definition, which includes commodity contracts, was reported at USD 617 trillion.[47] The gross market value equalled USD 20.75 trillion (after netting), whereas the gross credit exposure was only USD 3.7 trillion. The last value is a rough estimate of the collateral needed to mitigate counterparty risk.

Globally, the largest subcategory of OTC derivatives is IRDs with a volume of USD 490 trillion. This compares with the much smaller CDS market, which has a volume of almost USD 10 trillion. For comparison purposes, FX derivatives account for USD 107 trillion. Among OTC IRDs, the dominant instrument is the IRS, where fixed and floating rate related payments are exchanged over a specified period, e.g. five years. IRD notional cleared by CCPs totals USD 373.4 trillion, equating to 76.1% of total IRD notional outstanding. Market participants reduced their total mark-to-market exposure by 82.3% at year-end 2022, as a result of close-out netting (cf. ISDA, 2023).

Euro contracts account for a sizeable volume of global IRD trading. US dollar-denominated IRD traded notional reported in the United States totalled USD 61.7 trillion in the second half of 2022, up by 8.9% compared with the second half of 2021. Euro-denominated IRD traded notional totalled USD 44.2 trillion in the second half of 2022, a rise of 93.7% compared with the second half of 2021. Euro-denominated trades made up 32.5% of total IRD traded notional in the second half of 2022, up from 20.7% in the second half of 2021. Contracts with a tenor over one year and up to five years accounted for around 18% of total IRD traded notional. Contracts with a tenor over five years totalled 10.3% (see also ISDA, 2023, for further discussion). 75.5% of the traded notional of EU IRDs was executed on trading venues, and 53.1% was cleared through a CCP.[48]

The CDS market consists of single-name contracts, which allow investors to trade the credit risk of major firms or sovereigns (notional of USD 4 trillion). It also offers index CDS contracts insuring default

[46] For a global perspective, see BIS (2013).
[47] In USD billions: BIS – OTC derivatives statistics.
[48] ISDA –Interest Rate Derivatives Trading Activity Reported in EU, UK and US Markets.

risk in a portfolio[49] (notional of USD 5.1 trillion). As in IRS trading, CCPs now account for the bulk of outstanding volume: the share of CDS notional outstanding cleared by CCPs was 69%.

The CDS sector has undergone significant changes since the GFC when it was the epicentre of the systemic crisis. The outstanding notional fell from USD 61.2 trillion at the end of 2007 to only USD 9.4 trillion ten years later (Aldasoro and Ehlers, 2018). This decline is in part due to the compression[50] of bilateral and multilateral portfolios, a mechanism which is also increasingly used due to the more punitive regulatory requirements based on notionals, e.g., in the case of the leverage ratio. Interdealer trading fell from 53% to 25% over the period studied by Aldasoro and Ehlers (2018). Reporting dealers remain net buyers of CDS protection (USD 258 billion at year-end 2017) and hedge funds have markedly reduced their net purchases of protection from dealers to only USD 16 billion at the end of 2017.

The market for standardised IRSs is very active, with the ten-year contract on the Euribor six-month rate closing almost 400 trades per day in November 2022 (Babbi et al., 2023). This activity significantly exceeds the level observed in the single-name CDS market, where fewer than 200 daily trades on major sovereign CDSs are observed (Bellia et al., 2017).

The structure of the swap market and the role of bank dealers

The group of dealer firms that operate swap markets is commonly set out in a list, which was first compiled by the Federal Reserve Bank of New York in 2005 and is updated regularly.[51] Swap dealers, also known as the G16 due to their number, are exclusively large banking groups (and mostly G-SIBs): BAML, Barclays, BNP Paribas, Citi, Crédit Agricole, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, J.P. Morgan, Nomura, Morgan Stanley, Royal Bank of Scotland/NatWest, Société Générale, UBS and Wells Fargo. The annex provides further details of the dealer business model and reports some of their key balance sheet metrics.

Swap trading structurally resembles bond trading, as both markets rely on core-periphery trading networks. We use research on available granular swap trade data to illustrate the market structure for IRSs and CDSs (see charts below). The network chart in the right-hand panel of Figure 3 highlights the robust links at the core of the CDS network and the lack of all-to-all links from the periphery.[52] A more granular perspective of the exposure structure of the CDS market is provided in Figure 4, which also compares single-name and index trading, highlighting the large size of the dealer-to-dealer market compared with the segment that trades with clients.

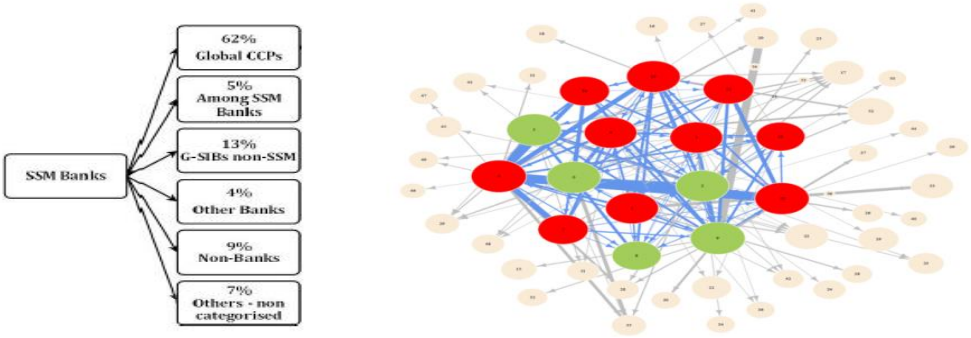
In contrast to CDSs, IRSs are used by a larger number of banks to hedge what is a fundamental risk for the banking sector, namely interest rate risk.[53] This increased participation has given the core a more

[49] The index portfolios comprise 100 or 125 firms and are based on index groups such as CDX in the United States or iTraxx in the EU.
[50] Compression is a mechanism where (at least) two offsetting trades are replaced by a new single trade without affecting the underlying exposure. This is common practice in IRSs and CDSs.
[51] https://www.newyorkfed.org/markets/otc_derivatives_supervisors_group.html#tabs-4
There is no comparable list available for the EU.
[52] See Eisfeldt et al. (2018) and Boyarchenko et al. (2019).
[53] The single-name CDS market offers hedging for only a small subset of a bank's credit risk exposures. Activity is concentrated on major G20 and emerging market sovereigns, G-SIBs and major industrials. This means there

complex structure (Figure 3, left-hand panel). Some non-dealer bank participants are also located in the core of the market, as the structure of their balance sheets implies the need for many IRS transactions.[54]

Dealers typically try to run largely matched positions, as their business model is oriented towards intermediation rather than outright risk retention. With CDSs, dealers' net long positions are 0.4% of their gross positions (Wang and Zhong, 2020). Hence, any new trade from the periphery of the network (e.g. from an asset manager) triggers the need for additional trades, often among dealers to reduce open directional exposures.[55] Net/gross ratios for IRS dealers are close to zero (Dalla Fontana et al., 2019).

Figure 3: Exposure structure in IRSs (left-hand panel) and CDSs (right-hand panel) markets



Sources: Dalla Fontana et al. (2019) and Brunnermeier et al. (2013).

Figure 4: Breakdown of gross CDS notional exposures (in USD billion)

	CDSs – single names	CDSs – index
Dealer-to-dealer	988,860	662,875
Client-to-client	9,410	6,011
CCP-to-dealer	2,060	4,024
CCP-to-client	171	1,449
Client bought from dealer	1,281	2,469
Client bought from client	180	1,455
Client sold by dealer	1,295	2,595

Sources: DTCC CDS TIW data (snapshot for the week ending 1 June 2020) and author's calculations.

is no corresponding hedge in the CDS market for many borrowers in the loan book. See Oehmke and Zawadowski (2016) and Hoffmann et al. (2018).

[54] To identify these intermediaries (i.e. banks that act as dealers but are not in the G16 list), Dalla Fontana et al. (2019) analyse trading activity across 27 major sub-segments of the IRS market by categorising transactions according to their currency, maturity or cash-flow structure. This approach adds ten firms to the 16 dealers listed above.

[55] This process results in a "flow of credit risk" (i.e. a flow of risk of default of the underlying reference entity) along the intermediation chain, which leads to interconnectedness among many counterparties, some of which are non-banks (Battiston et al, 2018).

Dealers are net buyers of protection with a pattern of selling in the single name market and buying in the index CDS market (Boyarchenko et al., 2018). There is limited activity in many reference entities: only four names see ten to 20 trades per day, whereas 762 out of a total of 799 firms have less than five trades per day (ISDA, 2019).

Electronic trading plays a major role in benchmark IRSs or index CDSs. In 2020, 58.2% of the notional of IRDs and 79.4% of that of credit derivatives in the United States was executed on swap execution facilities (SEFs) (ISDA, 2021). Since February 2014 index CDSs must be traded on platforms. At the time of writing, plain vanilla IRS SEFs hold a share of around 58%, while for US index CDSs (CDX) the share is greater than 91%.[56] As of 16 December 2019 the total weekly notional was USD 2,341 billion. SEFs offer clients several options: the exchange-replicating central limit order book (CLOB), workup, mid-market matching, RfQ and request for streaming (RfS). The RfQ protocol allows clients to select multiple dealers and request quotes from them, with bilateral execution on the response. Quotes and trades are visible only to the requester and the market-maker, ensuring privacy for both counterparties. In the RfS protocol, clients ask multiple dealers to send indicative quotes throughout the day.

Central clearing rates for CDSs continue to rise. They now stand at 64%, with short and medium-term contracts prominent here (ISDA, 2021). The clearing rate for IRDs has been relatively stable since 2015, at around 75%.[57] According to ISDA (2021), US traders centrally clear more contracts than required under the CFTC's clearing mandate. In the first half of 2020, USD 124.3 trillion of the notional of IRDs was subject to the clearing obligation, but USD 131.1 trillion was actually cleared. This represents a sharp increase relative to the first half of 2015, when only 76.5% of IRDs were cleared through CCPs. The cleared notional of US credit derivatives was USD 5.1 trillion in the first half of 2020 compared with USD 2.8 trillion in the first half of 2015. Some swap trading is therefore still cleared bilaterally, which leads to residual counterparty credit risk. This is mitigated by bilateral margining and the exchange of collateral.

Pricing and liquidity of swaps

There is a sharp difference in the CDS market between trading costs for index vs single-name contracts. For the CDX.IG, the main CDS index, the average dollar costs of D2C and dealer-to-dealer (D2D) trades are 0.66 cent and 0.48 cent, respectively (Collin-Dufresne et al., 2020). In contrast, the average effective bid ask spread for five-year single-name CDSs is estimated at around 7 basis points (Schoenemann, 2022). There is also evidence of dealer pricing power where dealers charge 1.81 basis points more for selling and pay 0.78 basis points less for buying protection. Standardised and centrally cleared IRS are generally liquid. Bid-ask spreads for centrally cleared euro-denominated IRS are currently less than one basis point, according to Reuters information.[58]

[56] CLARUS Financial Technology.
[57] Pension funds were exempt from the EMIR clearing obligation until June 2023.
[58] Source: Reuters data, October 2022.

3) How do the structural changes affect the dealer business model and market functioning?

Three interrelated trends are shaping the evolution of the dealer business model, which we will discuss in greater detail in this section:

1. signs of rising costs of balance sheet space and corresponding adjustments to dealer activity;
2. a rapid shift towards a fully electronic market infrastructure with the expansion of electronic platforms (some with all-to-all protocols) and central clearing;
3. increased trading activity of PTFs.

Two major external factors have also come into play in the last ten years. Since the GFC, fixed income markets have been greatly affected by widespread use of unconventional monetary policy tools. The ECB started to launch interventions in dysfunctional market segments on 10 May 2010, first through the securities markets programme and then using a range of other purchase programmes.[59] Furthermore, the COVID-19 crisis in March 2020 provided a "stress test" for the post-reform OTC market set-up. We will look at some of the implications of this in the next section.

Signs of rising costs of balance sheet space and adjustments to dealer activity

Looking more closely at the cost of trading bonds and swaps, the following three components should be mentioned:

- funding costs for holding a bond inventory on the balance sheet, such as use of the repo market (influenced by the monetary policy stance);
- capital required for the market and counterparty risk arising from trading and credit exposures, e.g. counterparty risk for swaps or market risk for bonds;[60]
- margining for swaps, i.e. the collateral required to exchange margin in bilateral/central clearing, which also needs to be funded.

Overall, the post-GFC reforms have brought significant system-wide economic benefits. BIS (2013) estimated the long-run macroeconomic impact of the OTC derivatives regulatory reforms as outlined above. The main positive effect of the reforms is a strong decline in counterparty risk, both through wider netting due to increased CCP clearing and through a more comprehensive system-wide collateralisation of exposures. In its preferred scenario, the BIS analysis found that economic benefits worth 0.16% of GDP per year could be gained from avoiding financial crises along the lines of the GFC. It also found economic costs of 0.04% of GDP per year were incurred from institutions passing on the expense of holding more capital and collateral to the broader economy. As this scenario results in net benefits amounting to 0.12% of GDP per year, increasing resilience in OTC derivatives trading offers sizeable macroeconomic gains.

Post-GFC regulations have increased the funding costs borne by bank shareholders, and thus the cost to buy-side firms for access to space on the balance sheets of large banks (Andersen et al., 2017). The Basel III reforms specifically require banks to meet Tier 1 leverage ratios (based on Tier 1 capital and

[59] See Hartmann and Smets (2018).

[60] For example, the standardised approach for measuring counterparty credit risk (SA-CCR) exposures, which replaces the current exposure method (CEM).

the firm's consolidated assets). This fosters the use of trading methods that reduce the amount of space on banks' balance sheets needed to conduct a given trade. In the United States, the supplementary leverage ratio (SLR) requires capital equal to at least 5% of total exposures for G-SIBs. The exposure amount encompasses cash and repo notionals, whereas for derivatives the main input is a proxy for potential future exposure, which is driven by the net/gross ratio (cf. He et al., 2020, for a discussion). The SLR therefore adversely affects Treasury holdings, in part via their repo funding due to the use of notional values rather than risk-based metrics (where Treasuries would fare better due to their low credit risk). As regards the actual impact, Bessembinder et al. (2018) show that the dealers' capital commitment to market making for US corporate bonds has decreased since the GFC.

A third effect of OTC reforms is increased demand for high-quality collateral due to the comprehensive margining of OTC trades (e.g. bilateral via ISDA SIMM methodology and CCP). These measures are motivated by the systemic risk that materialised in OTC derivatives trading following the collapse of Lehman Brothers.[61] Duffie et al. (2015) show the sizeable impact on collateral requirements in the CDS network. The FSB (2017) offers an illustration of the rising share of collateral use in OTC derivatives transactions. The general conclusion is that there is an increased need for cash (for VM calls by CCPs) and committed high-quality liquid assets, which are used in particular to post IM to CCPs. Overall, there is evidence that the rise in HQLA needs seems to be manageable. According to Bardoscia et al. (2019), aggregate liquid asset buffers for derivatives were roughly USD 700 billion, thereby providing ample resources for margin calls. We will return to the actual impact of margin calls in the analysis of the COVID-19 crisis in the next section.

The effects of the new regulations for dealers' business models and market making are extensive (CGFS, 2016). Risk weights and credit risk charges make trading of corporate bonds and credit derivatives more risk-sensitive. In particular, the incremental risk capital charge and the stressed value at risk may have led banks to adjust their estimated holding costs for corporate bonds. Furthermore, less liquid corporate bonds are not eligible for the liquidity coverage ratio (LCR), which can reduce the willingness of banks to warehouse these assets. Moreover, the leverage ratio increases the balance sheet cost of repos, including those backed by corporate bonds and structured credit, thereby increasing the financing costs incurred by bank dealers.

According to market participants, the effects of regulatory reforms differ for government and corporate bonds (CGFS, 2016). In the first case, the leverage ratio and higher risk-weighted assets are thought to have the largest impact on dealer profits. In the second, revisions to the Basel II market risk framework (Basel 2.5) are mentioned as having the greatest effect on regulatory charges. The survey responses summarised in CGFS (2016) imply that the gross revenue required for a return on capital of 8% under a fully phased-in Basel III framework would have resulted in returns of over 20% under Basel II.

Empirical analysis indicates that capital constraints and other regulatory changes may affect OTC trading (e.g. arbitrage of CDSs and corresponding bonds) through a multitude of channels, such as

[61] Prior to the GFC, derivatives trades in OTC markets had been uncollateralised, which led to a sharp jump in losses due to counterparty downgrades or defaults (e.g. Lehman Brothers).

reduced liquidity in the bond markets and reduced incentives for arbitrage.[62] Outsized "limits to arbitrage" may then contribute to dislocations in relative pricing. Bao et al. (2018) show that the liquidity of stressed corporate bonds fell after the Volcker Rule was passed. Dealers regulated by the rule reduced their market-making activities and non-Volcker-affected dealers have not offset this decrease. As Volcker-affected dealers were the main liquidity providers, these results indicate a decline in bond liquidity during times of stress, which can be linked to the implementation of the Volcker Rule. Recently, Duffie et al. (2023) comprehensively document a significant loss in US Treasury market liquidity in those periods where intensive use of dealer balance sheets is needed to intermediate trades, as in March 2020.

Due to the changes in the post-GFC environment, bank dealers comprehensively analyse their capital requirements and profitability (e.g. using return on equity measures) by business line and then revisit their market presence. Evidence for this trend is found in the decline in US corporate bond inventories. Figure 5 below illustrates the rising volume compared with the falling inventory of corporate bonds.[63] In parallel, according to AFME (2019), the EU markets are also affected: five primary dealers left the EU sovereign market in 2019, of which a prominent example is Credit Suisse. It was formerly a major global investment bank that terminated most of its primary dealer positions in the EU.

From an EU perspective, the High-Level Forum on CMU (2020) argues that market-makers' inventories in EU corporate bonds, and therefore their ability to offer liquidity, have significantly declined. This is partly linked to the treatment of inventories and repo transactions under the leverage ratio. According to practitioner consultations for the High-Level Forum on CMU, a pragmatic interpretation of the EU rules on the netting of repos and reverse repos for the computation of the leverage ratio (that mostly concern transactions on sovereign bonds) would be beneficial. While neutral from a risk standpoint, it would generally help to revitalise market-making activity in European corporate and sovereign bonds, as both are suffering under the leverage constraint.

Rapid shift towards electronic market infrastructure

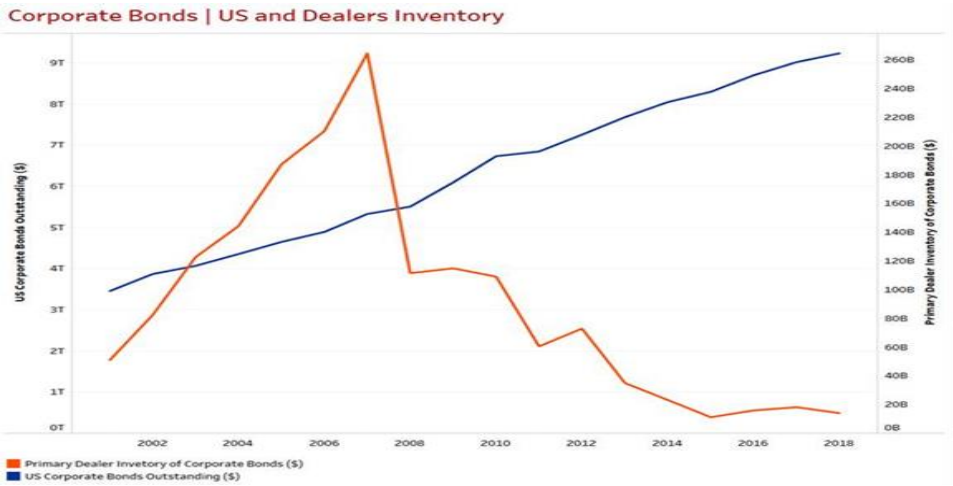
Electronic platforms focus on directing clients away from using the traditional "call-your-broker" approach towards trading on their electronic platforms. In the past, many bonds were traded by clients physically calling their brokers and inquiring about the best price they could get. Clients would be quoted a price and could then call other dealers to collect additional quotes. In addition to regulation, there are two conjunctural drivers of a wider use of electronic trading. First, the low interest rate environment over the last decade has increased the need to cut costs. Second, digitalisation and recent rapid advances in information technology, together with the availability of

[62] Boyarchenko et al. (2018) provide an illustration for bond and CDS arbitrage using a stylised balance sheet within a cost-of-capital framework. Profitability is defined as the return per additional dollar of equity required by a trade. They argue that before the GFC US bank holding companies targeted leverage ratios of around 2 to 3 percent, whereas current targets are 5 to 6 percent. Hence, for a bank targeting a 5% SLR and a 10% return on equity (ROE), an arbitrage trade with an expected return of below 50 basis points (10% * 5%) is not economical. Such a shift in the SLR target can reduce ROEs by two to three times, making previously profitable arbitrage between bonds and CDSs significantly less attractive.

[63] https://www.newyorkfed.org/markets/gsds/search.html. See Adrian et al. (2018).

"big data" (e.g. vast samples of past trades to calibrate trading algorithms), have extended the speed, accessibility and power of electronic trading tools.

Figure 5: US corporate bond inventory vs outstanding bond notional volume



Sources: Author's calculations and Federal Reserve Bank of New York.

The RfQ protocol is currently the most widely used electronic mechanism for dealers trading US or EU bonds with their clients. This approach is the next step after voice trading, as a client can see all dealer offers on a screen but cannot trade with other clients. In essence, the RfQ is 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 and what type of participants can 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. These queries typically last for up to 20 minutes and economically resemble a first-price sealed-bid auction (cf. Hendershott et al., 2021).

In contrast to RfQs, the CLOB allows for all-to-all open trading (cf. Collin-Dufresne et al., 2020, for CDSs or O'Hara and Zhou, 2019, for corporate bonds). Hence, both interdealer and client-to-client trades become possible in parallel. Trading is often anonymous. The CLOB set-up has been used by most stock and derivatives exchanges since the introduction of electronic trading systems. It is 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. Hence, the CLOB allows clients to execute against existing orders or post new orders on an order book. CLOBs are common for highly standardised securities and markets in which trade sizes can be small, such as stock or derivatives exchanges.

Finally, as a hybrid, the request for streaming protocol is a query in which market-makers provide continuous streams of firm quotes with available size and where a client can "click to trade". Hence, in an RfS, clients ask multiple dealers to send indicative quotes throughout the trading day.

Major trading platforms are steadily increasing their share in many EU segments. In 2021, 47% of EU corporate bond trades were executed electronically. This represents an increase of 47% since 2017.[64] The three largest MTFs account for 84% of annual bond MTF volumes:[65] Bloomberg Trading Facility (€4.7 trillion), Tradeweb Europe (€4.3 trillion) and Marketaxess Europe (€3.5 trillion).[66] In 2019, EEA sovereign bonds had the largest trade sizes, especially OTC with an average of €50.2 million, on OTFs (€11.9 million) and systematic internalisers (€9.4 million). The trade size of sovereign bonds was smaller on MTFs (€4.4 million) and markedly smaller on regulated markets (around €330,000), 150 times less than the average OTC trade size.[67]

In terms of how trading platforms will evolve in the future, industry analysts[68] argue that platform providers are trying to enter larger-sized block trades (above USD 5 million) which tend to be more lucrative. However, electronic platforms might find it more challenging to gain market share, as buy-side investors tend to prefer to allocate these trades to dealers.

In summary, electronic trading of bonds and swaps is not yet on the scale of the equity market. Traditionally, investors bought or sold bonds and swaps by calling dealers to find the best quotes on offer. Recently, platforms have emerged to offer cheaper and more efficient trading by means of electronic solutions, thereby making OTC bond and swap trading "faster", albeit still below the "speed level" in the equity market. The use of live and two-sided price distribution by banks and non-banks are the first steps in the evolution of trading towards a broader use of streaming. Industry analysts estimate that 60% electronification overall is realistic in the next few years.

Dynamic evolution of non-bank dealers

The importance of non-bank dealers is growing in many fixed income markets.[69] PTFs invest, hedge or speculate for their own accounts, often using low-latency strategies on electronic platforms. PTFs develop and implement quantitative trading strategies in various financial products.[70] They engage in manual, automated and hybrid methods of trading.[71]

PTFs now rank among the largest trading firms, accounting for significant volumes across the global financial markets. Among major EU contracts, they contribute almost 40% of the volume for the Bund futures contract (BoE PRA, 2020). Therefore, they have a sizeable position in the most important

[64] Electronic trading in US corporate bonds is finally taking off. But it's still early days says this investor.
[65] MTFs are designed to replicate many features of exchange trading. They bring together multiple third-party buying and selling interests in financial instruments in the system, in accordance with non-discretionary rules. OTFs have been introduced under MiFIR/MiFID II to cover trading mechanisms such as interdealer brokers.
[66] ESMA (2020).
[67] ESMA (2020).
[68] See Barclays (2018) for detailed analysis.
[69] Aramonte et al. (2021) offer an in-depth analysis of the impact on financial stability; see FSB (2020a).
[70] Members of the FIA PTG are Allston Trading; ARB Trading Group, Citadel Securities, LLC, Cognitive Capital, LLC, DRW Holdings LLC, Eagle Seven LLC, Flow Traders US, LLC, Geneva Trading USA, LLC, Hard Eight Futures, LLC, Hehmeyer LLC, Hudson River Trading LLC, IMC Financial Markets, Jump Trading LLC, Liger Investments Limited, Marquette Partners, LP, Optiver US LLC, Quantlab Financial, LLC, WH Trading and XR Trading LLC.
[71] See 07.14.2017 Matthew Andresen testimony.

exchange-traded fixed income contract in the EU, which also continues to lead the price discovery market for cash bond markets in the euro area (Fricke and Menkhoff, 2011).[72]

In the United States, PTFs are a major market-maker for on-the-run bonds and Treasury futures. Adrian et al. (2016) find that the median absolute end-of-day US Treasury position for PTFs is 4.4% of its daily volume, whereas dealers hold around 19%. The median maximum absolute intraday position for PTFs is 15.3% (28.3% for dealers), which indicates that they hold significant temporary positions during the trading day. According to Harkrader and Puglia (2020), PTFs accounted for 60% of volume in the run-up to the pandemic shock in March 2020. Trades have a high permanent price impact when a PTF is the passive party, playing the role of a liquidity provider. Conversely, dealer trades have a higher price impact when the dealer is the aggressive party, playing the role of a liquidity taker.

4) A case study of OTC market functioning: the impact of the COVID-19 crisis on fixed income liquidity

The COVID-19 shock significantly affected pricing and trading in the major bond markets. The market turmoil in March 2020 started with a "flight to liquidity" (government bond yields fell as investors fled to safe assets in the period between 24 February and 6 March), followed by a "dash for cash" (widespread selling of government bonds, leading to rising yields between 9 and 19 March).[73] In the second part of the period, demand for bond intermediation strongly exceeded dealers' willingness to make markets and central banks, in particular the Federal Reserve System, intervened on a massive scale. The sharp fall in bond market liquidity is a distinguishing feature of this episode of market turmoil compared with the peak of the GFC in October 2008.

The high volatility of many instruments mechanically led to a sharp increase in margins required by CCPs. Daily VM calls increased from around USD 25 billion in February 2020 to peak at USD 140 billion on 9 March 2020 (BIS, 2021). This increase of 460% affected many asset classes and both house and client accounts in CCPs. VM calls on equities jumped by 2,000% compared with their February average. However, the size of the calls was much smaller on an absolute basis compared with other asset classes. IMs increased by USD 30 billion, mostly due to higher volatility and higher trading volume, and to a lesser extent to margin add-ons. Margin outflows as a percentage of dealers' total funding liquidity remained below 5%, even at the height of the crisis.

Faced with these large margin calls, non-banks that lacked access to central bank operations needed to raise cash quickly (in particular for VMs). They therefore turned to repo markets and asset selling. One illustration of this dash for cash was the withdrawal of USD 800 billion from US prime money market funds (MMFs).

The dash for cash caused a sharp drop in market liquidity. According to BIS (2021), there was a perceived breakdown in liquidity in FX forwards and swaps, investment grade credit markets, money markets (including the repo market) and sovereigns, including US Treasuries and UK Gilts. US

[72] Panzarino et al. (2016) show that the growth of Eurex BTP futures has reduced the bid-ask spread in the MTS cash segment. For recent evidence, see also Di Gangi et al. (2022).

[73] See for example Bank of England (2020), ECB (2020), Federal Reserve System (2020), IMF (2020), Eren et al. (2020), FSB (2020c), Huang and Takáts (2020), Schrimpf et al. (2020) and Eren and Wooldridge (2021).

Treasuries, corporate bonds and municipal bonds were particularly affected. Yield volatility in US Treasuries approached the level observed in the GFC. The charts below show the ten-year yield in 2020 and a long-term volatility time series[74] for the ten-year note. The yield showed a zigzag pattern, first falling (flight to liquidity) and then rising (fire sales of liquid assets in the dash for cash period). 30-year off-the-runs were particularly affected, with bid-ask spreads multiplying compared with trading costs for on-the-run bonds. Signs of "limits to arbitrage" between Treasury futures and underlying bonds, and between on-the-run and off-the-run bonds, also materialised. The daily trading volume in the US Treasury market overall reached a record high in the week ending 4 March, averaging at over USD 1 trillion, roughly twice its post-crisis average. On 3 March BrokerTec intermediated its highest level of Treasury security trading activity since the flash rally of 15th October 2014.

Market liquidity for US corporate bonds also deteriorated sharply. Transaction costs peaked at over 90 basis points before the Federal Reserve System interventions, almost three times the levels seen in early February, and fell once again after the interventions (O'Hara and Zhou, 2021). Dealer inventories fell by USD 8 billion. Client-to-client trade volume rose almost threefold compared with the levels seen before the start of the crisis but remained small relative to overall corporate bond market volume (O'Hara and Zhou, 2021, Figure 5a). However, transaction costs in client-to-client trades, which were lower than those of client-to-dealer trades before the crisis, shifted dramatically during the period, with client-to-client trading costs more than double the level for trades with dealers (O'Hara and Zhou, 2021). Trade sizes in client-to-client transactions also remained smaller than those of client-to-dealer trades (O'Hara and Zhou, 2021). In March 2020 obtaining liquidity from other clients therefore proved to be an expensive and limited alternative (O'Hara and Zhou, 2021).

Yield volatility in the EU markets also rose to levels last seen during the euro area sovereign debt crisis and bid-ask spreads increased sharply (see the comparison of Italy, France and Germany below). The level of systemic stress is clearly indicated by the contribution of bond market sub-indices to the systemic stress (CISS, see chart below).[75]

As Poli and Taboga (2021) show, the promptness and boldness of the ECB's interventions[76] significantly contributed to the rapid stabilisation of market liquidity. In some markets, such as Italy, bank dealers provided capacity to absorb client sales.[77] Another key factor in the long-term comparison of German and US bond liquidity is the public sector purchase programme (PSPP), which provided one-sided support to market liquidity, thereby reducing the impact of potential inventory shocks on market pricing. This was also a factor behind the lower volatility in the Bund market (see below for the GARCH time series of US and German yield volatilities). In the swap market, trading conditions for CDSs deteriorated sharply, with bid-ask spreads jumping from 9 basis points to 140 basis points for a basket of actively traded names.[78]

[74] Estimated by GARCH (1,1) on yield differences.
[75] For a description of the CISS approach, see Holló et al. (2012).
[76] In particular, the pandemic emergency purchase programme (PEPP).
[77] See Barone et al. (2022) for international evidence.
[78] Risk.net – CVA desks arm themselves for the next crisis.

Several explanatory factors, none of which are mutually exclusive, were put forward by researchers, market analysts and central banks.[79]

- Uncertainty: the speed at which the economy deteriorated in March caught most traders by surprise. This caused market expectations of asset values to shift rapidly, increasing price volatility.
- Immediate liquidity needs: VMs called by CCPs were around five times higher relative to pre-pandemic levels, which created the need to raise cash in short periods of time. This cash pressure was particularly strong for non-bank financial institutions.
- Large-scale deleveraging: arbitrage traders who had large relative value positions in cash and futures markets funded by repos sharply reduced their leverage, exacerbating the market stress. Daily volumes in the US overnight repo market had doubled since 2016. The unwinding of these positions prompted more selling, as investors rushed to further reduce their exposures. Waves of heavy selling in an already dysfunctional market led to a vicious cycle of losses, broken risk management limits and further selling.
- Fragility in bond market microstructure and balance sheet costs: dealers who are essential liquidity providers were unwilling to warehouse Treasuries for longer periods, in part because of balance sheet constraints and risk limits, which had been in place for several years. Furthermore, Treasury issuance had been rising sharply, requiring the market to absorb sizeable new volumes.

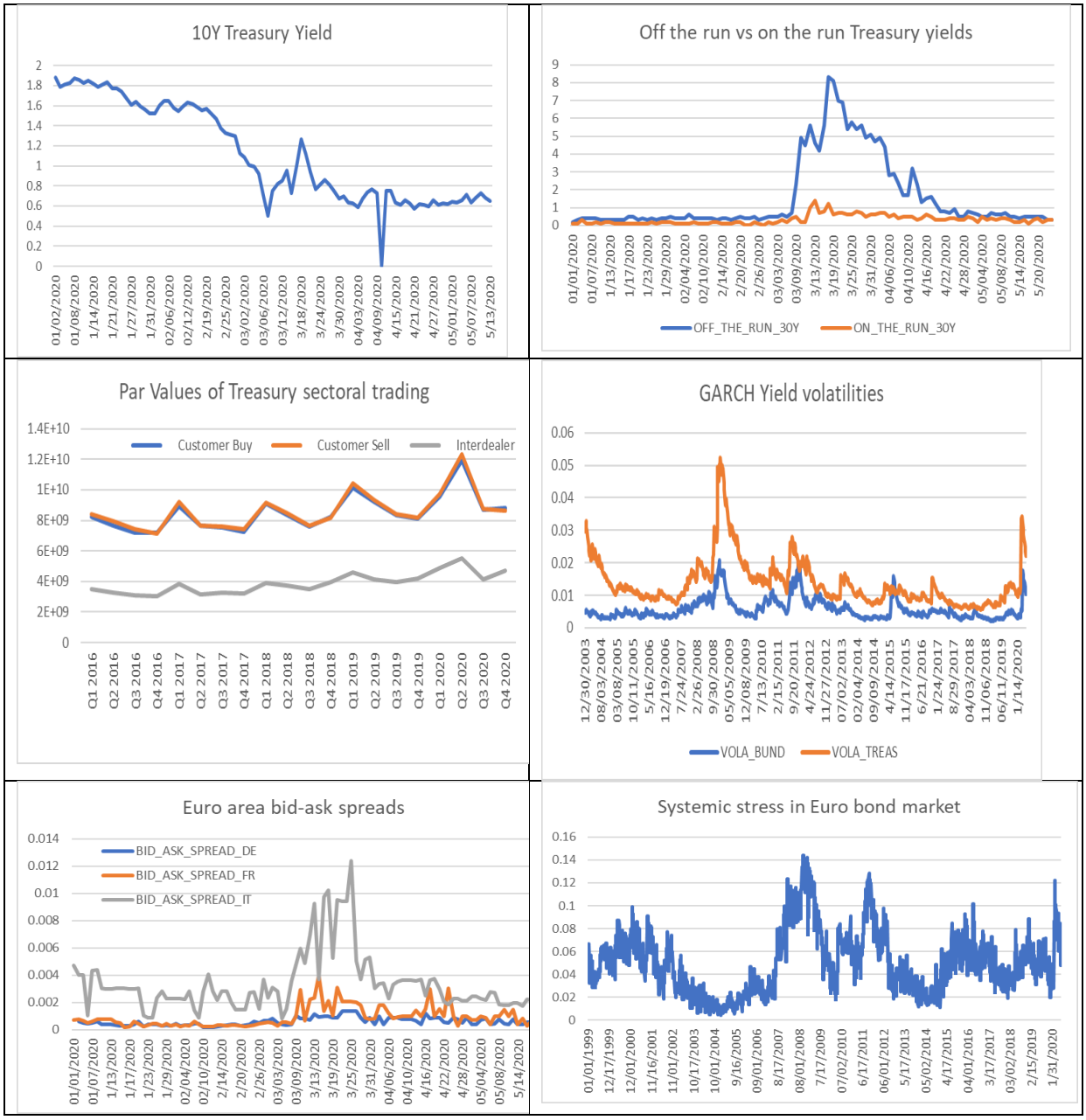
Overall, this stress episode led to multiple policy measures being implemented by major central banks. In particular, and directly related to the functioning of US OTC markets, the Federal Reserve System stepped in "*to support the smooth functioning of (US) markets*" with new facilities such as the Primary and Secondary Market Corporate Credit Facility (buying bond ETFs), the Commercial Paper Funding Facility and the Municipal Liquidity Facility.[80] The Federal Reserve also vastly expanded its repo operations, essentially providing unlimited amounts of cash in short-term loans to US dealers. Furthermore, and directly related to the collapse in intermediation activity, it purchased USD 1.45 trillion in Treasury securities and USD 575 billion in agency mortgage-backed securities, thereby increasing its balance sheet by around USD 3 trillion. These measures helped US fixed income dealers to intermediate new trades more confidently. At the same time, the Federal Reserve temporarily eased the leverage ratio rule, allowing banks to exclude cash and Treasuries from their "total assets". This exclusion effectively reduced capital requirements for US dealers.

In the aftermath of the market turmoil, a broad discussion was started among US policymakers and academics about the need to reform the market infrastructure. The consensus was that the rapidly growing size of the Treasury market was exceeding intermediation capacity under stressed conditions. In particular, the Group of 30 (G30) published a wide-ranging set of recommendations, covering additional Federal Reserve System repo facilities, wider central clearing, fine-tuning banking regulation and extending transparency (G30, 2021). For instance, all Treasury securities and Treasury repo trades executed on electronic interdealer trading platforms that offer anonymous trading by

[79] See Bank of England (2020), Duffie (2020), Kargar et al. (2021), Liang and Parkinson (2020), Schrimpf et al. (2020), Spatt (2020), Vissing-Jorgensen (2021), Aramonte et al. (2021), FSB (2021b) and Barone et al. (2022).
[80] See table 1 in Clarida et al. (2021) for a detailed list of measures.

interposing an interdealer broker between buyers and sellers should be centrally cleared.[81] In parallel, banking regulators should review how market intermediation is treated in existing regulation, with a view to identifying provisions that could be modified to avoid disincentivising market intermediation, without weakening the overall resilience of the banking system. Furthermore, the TRACE reporting system should be expanded to capture all transactions in US Treasury securities and repos, including those of bank dealers and PTFs. SEC Regulations ATS and SCI should be applied to all significant trading platforms for Treasury securities, including both interdealer and multi-dealer dealer-to-client platforms

.Figure 6: The COVID-19 crisis in US and EU financial markets



Sources: Bloomberg, BIS, ECB, Federal Reserve System, FINRA TRACE and author's calculations.

[81] See Fleming and Keane (2021) for empirical analysis of netting in US Treasury trading.

Based partly on these deliberations, the Federal Open Market Committee established two new standing facilities on 28 July 2021. Under the domestic standing repo facility, the Federal Reserve System will conduct daily overnight repo operations against Treasury and agency securities, with a maximum operation size of USD 500 billion. The minimum bid rate for repos will be set initially at 25 basis points. In addition to primary dealers, this facility will also over time be open to certain other banks providing a wider range of traders with access to a liquidity backstop. Under the repo facility for foreign and international monetary authorities (FIMA repo facility), the Federal Reserve will enter into overnight repurchase agreements with foreign official institutions against the Treasuries they hold at the Federal Reserve Bank of New York. This temporary source of dollar liquidity can also reduce pressures in global USD funding markets.

From a euro area perspective, some of the proposals put forward by the G30 do not seem to require urgent implementation. In particular, the Eurosystem facilities are open to a very wide range of banking institutions. Furthermore, there is already widespread clearing of repo transactions through LCH SA (in particular for trades among dealers). In contrast, the measures for enhanced transparency, such as extending TRACE and Regulations ATS and SCI, which at the time of writing are still being fleshed out in the United States, are also a potential area of further work in the EU. Market participants[82] argue that MiFID II has not fully improved transparency in EU bond markets, due to the lack of a central database which aggregates the various post-trade data sources into a "consolidated tape". Post-trade data are still fragmented across the different platforms with no harmonised formatting. The European Commission has finished its review of the MiFID II/MiFIR regime and published a proposal on 25 November 2021, which is currently being discussed. Regarding the clearing of bond trades, BTPs from the interdealer sector are often centrally cleared, while this is much less common for Bunds and for OATs (Barone et al., 2022).

5) Conclusions

This paper has focused on answering the following three questions:

1) How are bonds and swaps currently traded and how liquid are these markets?

At the time of writing, the OTC markets are still evolving. In particular, the electronification of trading is still increasing in segments such as US corporate bonds. Central clearing is currently being extended to non-banks (e.g. pension funds under EMIR) in the EU and potentially to a broader range of US Treasury transactions (cf. G30, 2021). Except for on-the-run US Treasuries and some BTP issues, which use central limit order books (CLOBs), fixed income instruments in the EU and United States are largely traded through request for quote mechanisms. In the United States, market liquidity is generally good for benchmark instruments. Globally, however, liquidity provision has shown increasing vulnerability in the last decade. This is highlighted by the number of stress episodes (most recently in the United Kingdom). At the current juncture, smooth OTC market functioning is also increasingly important due to the global tightening of monetary policy and a corresponding need for many market participants to rehedge many interest-sensitive positions.

[82] EU Consolidated Tape for Bond Markets. Final report for the European Commission.

2) How do the structural changes affect the dealer business model and market functioning?

First and foremost, it is important to stress that the post-GFC regulatory reforms of OTC markets in the form of the DFA (United States), and the CRR, EMIR and MiFID (EU), have together significantly reduced systemic risk. Against this backdrop, a plausible scenario for the further evolution of OTC markets is one in which a sizeable part of OTC trading activity will be contributed by non-banks, such as PTFs that clear their trades through CCPs directly or via bank clearing members.[83] Principal trading firms are currently subject to less stringent regulation than dealer banks. There are no capital requirements at the level of G-SIBs and PTFs cannot access central bank operations. Therefore, bank dealers would become "gatekeepers" and continue to play a crucial but probably more indirect role. Bank dealers, principal trading firms and CCPs interact in highly concentrated OTC derivatives markets. As these interactions could potentially lead to destabilising feedback loops, the risks of banks, principal trading firms and CCPs should be monitored jointly, rather than in isolation.

3) How did the COVID-19 shock in March 2020 affect the OTC bond and swap market in its new post-reform set-up?

The COVID-19 crisis and the turmoil on the repo market in September 2019 highlighted the sensitivity of fixed income markets to volatility events and to central bank operations. One potential propagation channel is the fact that the higher share of transactions cleared via CCPs has raised the importance of holistic liquidity risk management for CMs and their clients. Mechanical margining regimes run by many CCPs have increased the need for cash buffers held by CMs, which also implies that the resilient functioning of collateral markets is vital.[84] If used repeatedly, central bank intervention may over time increase moral hazard[85] or reduce price discovery.

Against this backdrop, the main policy question now is how to foster the resilience of intermediation in key market segments. Given the complexity[86] and national heterogeneity[87] of government bond trading, it seems unlikely that a single "silver bullet" reform would be able to universally increase market resilience. This multi-dimensional policy topic is the subject of major ongoing work by international policymakers (cf. BIS, 2021; FSB, 2021a, 2021b; FSB, 2022b).

As regards the EU's progress in implementing derivatives market reforms, the FSB has recently attested major progress in key areas (FSB, 2022c). The EU has made important progress in key areas for increasing the resilience of derivatives markets:[88]

- trade reporting;

[83] See Bank of England – Does the reliance of principal trading firms on banks pose a risk to UK financial stability?

[84] ESRB (2020) discusses the systemic concerns of large margin calls. Two financial stability-related issues are discussed: (i) large amounts of margins called from mid-February to mid-April 2020 and (ii) the adverse impact of such margin calls on both bank and non-bank entities, also in view of market concentration and interconnectedness.

[85] FSB (2020c) argues that there is a risk that "markets do not fully internalise their own liquidity risk in anticipation of future central bank interventions in times of stress".

[86] Bond trading occurs in a decentralised structure with a primary and secondary market and multiple diverse participants such as DMOs, G-SIBs, PTFs, asset managers and hedge funds.

[87] The role of PTFs is more prominent in the United States than in EU cash markets, the level and intensity of electronic trading varies, and the size of arbitrage activity.

[88] See in particular the tables B, E, H, I, J and K in the annex of FSB (2022c).

- regulatory requirements underpinning clearing obligation;
- capital requirements and margin requirements for non-centrally cleared derivatives;
- regulatory requirements underpinning exchange or electronic platform trading.

From a global perspective, the reforms of the US Treasury market are a major step towards improving the resilience of vital dealer-run markets.[89] Here, the FSB (2022b) sees three areas as important:

- more central clearing for government bond cash and (especially) repos;
- use of all-to-all trading platforms to encourage a more diverse set of participants;
- measures to enhance the transparency of bond and repo markets (both pre- and post-trade).

Ongoing work on the European CMU also considers questions of transparency and market liquidity. As mentioned earlier, MiFID II and MiFIR are intended to support the objectives of the CMU, in particular promoting fair, transparent, efficient and integrated financial markets. Among the 16 legislative and non-legislative measures put forward by the European Commission,[90] the measures for a single rulebook for capital markets will affect the functioning of EU fixed income markets. This policy work will also be seen in the context of the rising EU bond issuance. The latest (and very sizeable) step is the *NextGenerationEU* programme to finance the EU's recovery from the COVID-19 downturn, which amounts to planned issuance of €800 billion from 2021 to 2026.[91]

Since early 2022 central banks have been acting resolutely to preserve price stability by tightening monetary policy. This process is ongoing at the time of writing.[92] At the current juncture and against the backdrop of monetary policy tightening, work on granular, holistic and timely monitoring of fixed income market activity and liquidity is crucial in order to effectively deploy macroprudential tools. In this context, the turmoil in UK Gilt markets in September 2022 offers another case study of bond market stress. In late September 2022 an unprecedented jump in Gilt yields led to considerable liquidity pressure for liability-driven investment funds. A margin spiral developed quickly, threatening the smooth Gilt market functioning.[93] A temporary and targeted programme of Gilt purchases by the Bank of England quickly helped to restore market functioning. This stress episode illustrated the sizable systemic impact of non-banks (in particular, pension funds) and the fragility of the dealers' capacity to intermediate in periods of large-scale one-way flows. Hence, vulnerabilities in fixed income trading, which have also been highlighted by the Gilt market volatility stress in 2022, emphasise the need for further detailed analysis of OTC market functioning in a substantially changed environment.[94] In order to broadly capture systemic drivers, this monitoring[95] needs to take both an entity perspective (e.g. with particular emphasis on the liquidity risk of non-banks) but also an instrument perspective, considering e.g. the differences in the cash and derivatives market structures.

[89] See Yadav (2020) for a discussion; see G30, 2022, for an update on reform measures in the United States.
[90] Bruegel – Europe should not neglect its capital markets union.
[91] EC Press Corner – NextGenerationEU.
[92] See SUERF (2022), Scheicher and Schrimpf (2022) and Federal Reserve System (2022).
[93] See discussion in BoE (2022).
[94] Duffie and Keane (2023) investigate the goals, costs and benefits of official-sector purchases of government securities for the purpose of restoring market functionality.
[95] For an example, see the ESRB Risk Dashboard, ESRB December 2022.

Annex: The dealer business model and some key metrics

Publicly available data provide a detailed overview of the balance sheet structure, risk-bearing capacity and business model of dealers.

A dealer's business model is focused on intermediation (i.e. the simple brokerage of two transactions with opposing signs) rather than proprietary trading (i.e. outright positions generating market risk). In their intermediation role, dealers aim to "pass the hot potato" (Burnham, 1991) because they target a "flat" book with minimal exposure to price changes. In bond trading, this business model implies the need for an inventory, which requires funding and creates a capital requirement. Furthermore, direct access to a large investor base is necessary. For swaps, this "balanced" approach naturally creates a demand for hedging, which then leads to further trading (often starting again among dealers). From a systemic perspective, the result of this microstructure is a "flow of risk" along the intermediation chain (see D'Errico et al., 2018, for empirical evidence in the CDS market). As a result, dealers extensively "trade with each other".[96] [97]

In addition to direct market making, dealers also indirectly contribute to market liquidity by providing credit to hedge funds and high-frequency traders, e.g. via repos. Dealers therefore indirectly affect major non-banks' readiness to provide market liquidity. This interaction of market and dealer funding liquidity is a key feature of both the GFC and the COVID-19 crisis (see Federal Reserve System, 2020, Chapter 1 for a detailed discussion).

Bank dealers often have a balance sheet size of over €1 trillion. The balance sheet of the entire dealer sector totals €21.6 trillion. J.P. Morgan, HSBC and BNP Paribas report balance sheets in excess of €2 trillion. Total assets of the other firms exceed €1 trillion, except for Goldman Sachs, Morgan Stanley and Royal Bank of Scotland. The first two do not have extensive commercial and retail banking operations, while Royal Bank of Scotland is undergoing post-crisis restructuring after being rescued by the UK Government during the GFC. Given their market making activity, a very large part of the balance sheet is accounted for by securities. A large share is held as "cash and cash equivalents" and a material portion of instruments are in the HFT[98] category. We also observe substantial portfolios of Level 3[99] assets.

Derivatives portfolios held by bank dealers reflect the figures observed in the earlier discussion on the swap market. The notional of OTC derivatives far exceeds its balance sheet size. The total share of

[96] As John Kay put it: "In London I am often asked to give talks about developments in the finance sector to a general audience. One question which routinely comes up is "what do people who work in the finance sector, in those large office blocks and in the City of London and Canary Wharf, actually do?" And the answer I give is that, to an extent that almost defies belief, **what they do is trade with each other**". Technological change and the future of financial intermediation.

[97] Based on Federal Reserve Y-15 reports and G-SIB disclosures we observe that intra financial system claims account for a large share of dealer balance sheets. For example, at J.P. Morgan (with a balance sheet at the time of writing exceeding USD 2,000 billion), the largest components are deposits (at USD 244 billion) and OTC with a positive or negative value (both around USD 1,100 billion).

[98] Fair value of all securities that are intended to be held principally for the purpose of selling them in the near term. Trading activity includes active and frequent buying and selling of securities for the purpose of generating profits on short-term price fluctuations.

[99] Gross fair value of all assets that are priced on a recurring basis on the balance sheet using Level 3 measurement inputs. Level 3 fair value measurement inputs, while not readily observable in the market, are used to develop an exit price for the asset (or liability) from the perspective of a market participant.

contracts cleared via a CCP is over 50%, which highlights their systemic importance. For example, for BNP, the notional of total OTC derivatives is €20,735 billion and the total notional in CCPs is €8,416 billion. Potential future exposure with a net positive fair value stands at €39.4 billion and potential future exposure with a net negative fair value is roughly the same size, leading to a net value of close to zero.

The concentration and size of dealer OTC books further highlight the "trading with each other" concept:[100] the three largest SSM and US dealers together represent 36.2% of the total notional of OTC derivatives. Concentration is also illustrated by the share of major firms in CCPs.

Finally, risk-bearing capacity has been rising significantly due to stronger post-GFC regulation:[101] compared with the early 2000s, more capital and more liquidity are being held by dealers. Major banks doubled their common equity Tier 1 (CET1) capital, increasing the level of CET1 from USD 2.2 trillion in the first half of 2011 to USD 4.4 trillion in 2021. The average CET1 capital ratio for selected banks increased from 7.0% to 12.8% in 2021 (ISDA, 2021).[102] Total deposits range from more than USD 1 trillion (J.P. Morgan) to slightly more than USD 100 billion (Goldman Sachs and Morgan Stanley). The liquidity coverage ratio is between 120% and 140%.

[100] Source: Linking BIS data and G-SIB data, 2018 edition; Top 3 SSM: Deutsche Bank, BNP Paribas and Société Générale.

[101] Major elements (see IMF, 2018, and FSB, 2020b,) are (1) tightening the risk weights for bank trading books via the "Fundamental Review of the Trading Book"; (2) leverage ratio as a back stop to the internal-model based capital requirement; 3) more resilient funding liquidity with LCR and IM cash outflow analysis; 4) the "Volcker rule" introduces a ban on proprietary trading by commercial banks to prevent bank deposits being used to fund trading on the bank's own accounts (Section 619 of the Dodd-Frank Act); and 5) all G16 US and European dealers now have full banking licences, thereby giving them direct access to the central bank for lender-of-last-resort liquidity.

[102] In parallel, securities holdings at G-SIBs have also gone down significantly (cf. Goel et al., 2019). For EU firms, securities holdings went from €60 to €140 trillion and then fell to €97 trillion.

Glossary

ALL-TO-ALL: Centralised network structure where all nodes in the network trade with each other.

BID-ASK SPREAD: Difference between the price which buyers and sellers are willing to pay for an instrument.

CAPITAL MARKETS UNION (CMU): Plan of the European Commission to mobilise capital in the EU by creating deeper and more integrated capital markets, and therefore complement direct bank financing and reduce reliance on traditional bank-based credit intermediation.

CENTRAL COUNTERPARTY (CCP): A clearing house that acts as buyer to every seller and vice versa to clear securities or derivatives transactions executed by CMs.

CENTRAL LIMIT ORDER BOOK (CLOB): A trading system where 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.

CREDIT DEFAULT SWAP (CDS): A swap contract that trades the default risk of firms or sovereigns.

CLEARING OBLIGATION: Regulation which requires mandatory CCP clearing of derivatives transactions.

CLEARING MEMBER (CM): Direct participants in a CCP who can clear transactions on their own account or on behalf their clients, typically a bank.

CORE-PERIPHERY NETWORK STRUCTURE: Semi-decentralised network structure where all nodes in the core are linked to each other and with the periphery whereas nodes on the periphery are not linked within their segment.

DEALER: A financial firm that offers the service of standing ready to buy or sell assets from other traders.

DEALER-TO-CLIENT (D2C) SEGMENT: Transactions executed between a dealer and a client. To clear this transaction through a CCP, the dealer usually acts as the clearing member.

DEALER-TO-DEALER (D2D) SEGMENT: Transactions executed between two dealer firms, both of which are usually clearing members.

DERIVATIVES DEALER: 16 G-SIB banks with material derivatives trading identified by the Federal Reserve Bank of New York: BAML, Barclays, BNP Paribas, Citi, Credit Agricole, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, J.P. Morgan, Nomura, Morgan Stanley, Royal Bank of Scotland, Société Générale, UBS and Wells Fargo.

DODD-FRANK ACT: US financial reform and consumer protection law that entered into force in July 2010.

EMIR: European Market Infrastructure Regulation (Regulation 648/2012).

EXCHANGE TRADED DERIVATIVE (ETD): Derivatives traded in regulated exchange, e.g. futures.

INTERDEALER BROKER (IDB): Firm providing trading services to dealers, typically via an electronic platform.

INTERDEALER MARKET: A private market for trades between dealers (which can be banks or PTFs).

INTEREST RATE SWAP (IRS): Derivatives contract where two counterparties agree to exchange cash flows based on pre-defined fixed and floating rates.

LIQUIDITY: The degree to which an instrument can be bought or sold at a price reflecting its fundamental value.

MARGIN CALL: Process by which a CCP calls additional cash or high quality bonds from a CM due to the deteriorating market value of the CM's positions in the CCP.

MIFID/MIFIR: Markets in Financial Instruments Directive 2004/39/EC and Markets in Financial Instruments Regulation are commonly referred to as MiFID II and MiFIR.

MULTILATERAL TRADING FACILITY (MTF): Under MiFID II, MTS is a multilateral system operated by an investment firm or market operator, which brings together multiple third-party buying and selling interests in financial instruments in the system, in accordance with non-discretionary rules.

OFF-THE-RUN: Previously issued Treasury bond that remains outstanding, i.e. former benchmark bond.

OVER-THE-COUNTER (OTC): Bilateral financial trade transacted outside an exchange. The opposite of ETD. Standardised segment consists of swaps; also includes bespoke contracts negotiated between the two counterparties instead of being traded on an exchange.

ON-THE-RUN: Most recently issued Treasury bond with tenor in multiples of one year, i.e. current benchmark bond.

ORGANISED TRADING FACILITY (OTF): A multilateral system that is not a regulated market or MTF and in which multiple third parties can buy and sell bonds, derivatives or other instruments.

PRINCIPAL TRADING FIRM (PTF): Non-bank intermediary focused on intraday liquidity provision.

PRIMARY DEALER: A dealer firm that buys government bonds on issuance.

REGULATED MARKET (RM): Under MiFID II, RM is a multilateral system that is managed by an operator, which brings together or facilitates the bringing together of multiple third-party buying and selling interests in financial instruments within the system, to execute transactions on a non-discretionary basis.

REQUEST FOR QUOTE (RfQ): A trading platform where several members can simultaneously provide executable quotes following the notification sent out by another member.

REQUEST FOR STREAMING (RfS): A query in which dealers provide continuous streams of executable quotes with available size.

SUPPLEMENTARY LEVERAGE RATIO (SLR): US implementation of the Basel III Tier 1 leverage ratio, which uses unweighted positions.

SWAP EXECUTION FACILITY (SEF): Under the Dodd-Frank Act, a trading platform which provides pre-trade information on swaps for eligible participants.

TRACE: The Trade Reporting and Compliance Engine (TRACE) is the FINRA-developed electronic platform that facilitates the mandatory reporting of OTC transactions.

TRADING PLATFORM: Electronic system offering cheaper and more efficient trading than over the phone, often using electronic matching algorithms.

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