

Market conditions for Bunds in the context of monetary policy purchases and heightened uncertainty

The overall state of the market for Federal securities (Bundeswertpapiere, or Bunds for short) – also referred to as its market conditions – is characterised by a generally very high degree of robustness. In conjunction with the high credit quality of the Federal Government, this is why Bunds enjoy benchmark status in the euro area. A sound assessment of market conditions in recent years is achieved by using standard and novel market indicators on volatility, price anomalies and, in particular, market liquidity.

Cash, future and repo markets are the three main segments in the market for Bunds. Although there are very close links between price and liquidity formation in these segments, there are also pronounced peculiarities and one-off effects at times. A look at various liquidity dimensions is therefore conducive to obtaining a better understanding of both the respective market segments themselves and their interrelationships. For example, although the Bund future market generally has price leadership over the cash market, liquidity shocks frequently originate in the cash market and can then spill over to liquidity in the future market. Phases of such temporary liquidity declines have been increasingly occurring in recent years. Sudden and highly symmetrical transactions by multiple agents, such as at the beginning of the COVID-19 crisis, are capable of triggering price swings and rapid changes in the liquidity situation in all Bund market segments. This can be illustrated for the Bund future market, in particular, very well with the help of a novel indicator to measure market resilience.

The changes observed in the market for Bunds since 2015 have been driven, above all, by the Eurosystem's role as a "monetary policy buyer". Although trading volumes and market-making activities may initially increase as a result of central bank purchases, in a tense market environment characterised by a high propensity to sell, this could even temporarily reduce transaction costs of purchased bonds. By reducing "free float", however, the extensive central bank purchases lead to scarcity effects and, in some cases, to price anomalies for these bonds, too. Mitigating measures taken by the Eurosystem, such as the securities lending facility, can only partly offset these effects. In the long term, therefore, reductions in Eurosystem holdings are likely to have a positive impact on market conditions for Bunds.

The current high level of uncertainty surrounding the macroeconomic outlook, which is associated primarily with Russia's war of aggression against Ukraine, is also impacting on the indicators of market conditions for Bunds. In this environment, too, the obvious contribution a central bank can make towards ultimately more relaxed market conditions is to keep medium-term inflation expectations as firmly anchored as possible.

■ Introduction

Market conditions describe the overall state of a market

The overall state of a market, known as the market conditions, is determined by its players, its structure and its framework conditions.¹ Market liquidity – i.e. the tradability of securities – is a significant and measurable component of market conditions. In addition, a high level of volatility can be a reflection of increased information processing but can also indicate a change in market conditions, especially if it is associated with reduced market liquidity and (price) anomalies. This report aims to assess the market conditions for Bunds as holistically as possible and thus looks at many of these facets.

Bunds are a benchmark in the European sovereign bond market

Market conditions for Bunds are of particular interest because they represent a benchmark in the European sovereign bond market. Financial markets are subject to a myriad of influences and constant changes, making the need for a benchmark as a guidepost for market participants particularly clear. Benchmark bonds mirror the current, broad market conditions and should therefore be as free as possible from the influence of idiosyncratic factors such as high and volatile default and liquidity risks. At the same time, they also constitute a key benchmark for macroeconomic financing conditions, which are also influenced to a large extent by monetary policy decisions.

Owing to its high credit quality and the ease with which its bonds are tradable, the Federal Government has the status of benchmark issuer in the euro area. This means that Bunds are generally in high demand and are used in many portfolios held by institutional investors, such as insurers or pension funds, as a risk-free investment and as a benchmark for other asset classes.²

Benchmark status hinges on market liquidity

The generally high market liquidity of Bunds is a decisive factor behind their benchmark status. A salient feature of a liquid market is that high volumes of a security can be bought or sold at low transaction costs with no significant impact on its price. Liquidity³ in financial mar-

kets depends largely on the market participants involved. A liquid market is associated with a low resale risk and thus attracts market participants which, by wanting to purchase a security or offering to sell a security, in turn create liquidity. It is especially in times of heightened volatility that a liquid market is of particular importance.

Episodes of liquidity slumps are rare, but they can occur in isolated cases even in the most liquid markets with benchmark status. However, such episodes have been unusually frequent in the recent past, as was the case at the beginning of the COVID-19 crisis in March 2020. Moreover, in the last few years, monetary policymakers, academics and practitioners have been wondering about the extent to which non-standard monetary policy measures, such as large-scale asset purchase programmes, have been impacting on market liquidity by reducing free float, contributing to such episodes and potentially structurally altering the market conditions for benchmark bonds.

Increasingly frequent episodes of liquidity slumps in recent times, including in highly liquid markets

In-depth insights into these observations are provided by studies that examine the dimensions and interrelationships of the market conditions for Bunds in the various, albeit interlinked segments – the cash market, the future market and the repo market. In focusing on recent years, they also look into the effects of the

¹ Whereas some facets of market conditions are static or slow to change (for example, statutory provisions or market structure), other aspects of market conditions (such as participants' trading activities and liquidity) are in a constant state of flux. The facets differ not only with regard to the time dynamics but also to their conduciveness to a quantitative description: rules or market structures, in particular, can be described in qualitative terms, whereas market activities and market liquidity lend themselves better to a quantitative analysis. As regards the two lattermost facets, market liquidity is also characterised by a generally much greater degree of transparency and data availability than market participants' activities (for instance, who purchased a given security?). Against this backdrop, the article will primarily focus on well-measurable components of market conditions such as market liquidity, volatility or price anomalies.

² See Federal Ministry of Finance (2019).

³ In this article, the terms "liquidity" and "market liquidity" are used interchangeably.

regime change from monetary policy easing to a monetary policy tightening cycle.

Key market players and market segments

Dealers and investors are equally important for liquidity developments, ...

With regard to market conditions, market participants can be divided into two groups: investors and liquidity providers. Since the start of the large-scale asset purchase programmes in 2015, the Eurosystem central banks have entered the scene as key market players. Unlike the other groups, their motive is not to make a profit. Investors represent the majority of the players and use trading venues, via which they implement their transaction decisions.⁴ The second group, composed of dedicated liquidity providers (market-makers or dealers),⁵ plays a particular role. These agents' business (sub-) model is aimed at generating earnings through the constant and, mostly, simultaneous buying and selling of securities. To this end, they provide other market players with transaction offers with executable prices and quantities ("quotes"), thereby enabling investors to implement their trading orders almost permanently and quickly. A liquid market usually features a large number of liquidity providers, a highly competitive market among them and high demand for the respective security, which makes transactions inexpensive and simple to effect. Moreover, market-makers' purchasing and selling capacity in the market has a stabilising effect on the trading process and often helps to contain short-term, strong market swings.

... as a mismatch between market players can impair liquidity

In very liquid market segments, such as the Bund future market, ten-year Bund futures alone can account for a combined total of several hundred thousand individual transactions on a normal trading day. In this complex interplay between buyers and sellers, the cumulative sales decisions can potentially significantly exceed market-makers' absorption capacity for a short period, or an abrupt onset of buying pressure can exceed liquidity providers' ability to deliver. In addition, market participants can

impair the functioning of the market by withdrawing previously issued buy and sell orders from the market even prior to execution.⁶ In these cases, liquidity deteriorates, and the market is more exposed to sharp price swings. Dealing activity in such a market is therefore the result of close interaction between investors and market-makers. It is therefore important to look at all market participants across the varying market segments in order to obtain a holistic understanding of the market.

The cash market

Trading in Bunds takes place largely over the counter (OTC). Investors usually issue requests for quote (RFQs) via electronic trading platforms in order to subsequently receive offers from dealers. In the secondary market for Bunds, these are mostly large banks (dealer banks), which are also members of the Bund Issues Auction Group of the German Finance Agency,⁷ and which often maintain close relationships with other market participants. Not

Cash market trading mostly over the counter ...

⁴ At regular stock exchanges, these transaction decisions are mostly entered as a buy or sell order into an electronic order book by the investor (or an intermediary such as a broker or a bank). There are, in principle, two types of orders: market orders and limit orders. A market order expresses an investor's desire for the order to be executed in the most timely manner possible without a specific price limit. In a limit order, by contrast, the investor specifies a fixed maximum ask price or minimum bid price at which they wish to execute. However, the actual execution cannot be guaranteed and depends on the security's price movements and the liquidity situation at the respective trading venue. Limit orders that cannot be executed immediately are transferred to the order book and, along with other pre-existing limit orders, represent the aggregate market interest in buying or selling a particular security.

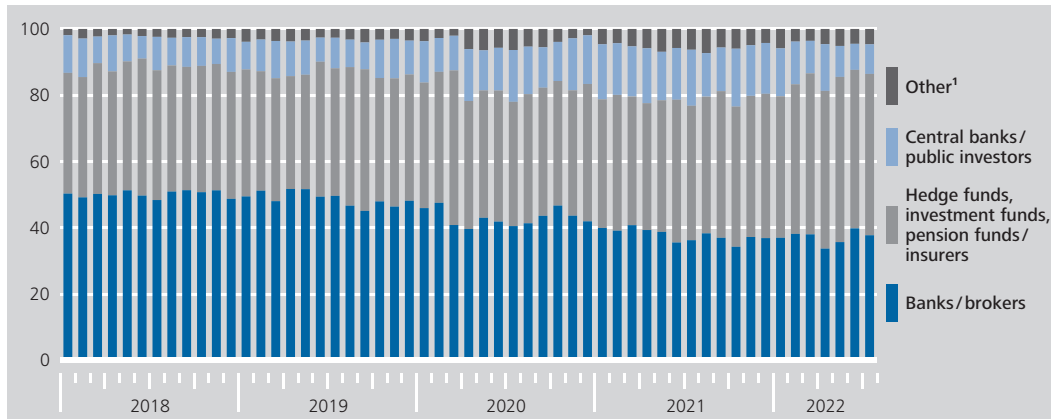
⁵ On OTC trading platforms, which are a major factor in the secondary market for Bunds, continuous market-making generally does not occur; instead, dealers submit quotes following a request for quote (RFQ).

⁶ Such sharp declines in orders in an order book are also referred to as "liquidity evaporation" or "dry-ups". They are often observed, for instance, in the last few minutes before significant and fixed dates for the publication of macroeconomic data or monetary policy decisions.

⁷ A special feature of this auction group is that – unlike standard procedures in other sovereign bond markets – they are not under any further obligations (such as regarding market-makers) above and beyond a small minimum purchase amount in the primary market. See also <https://www.deutsche-finanzagentur.de/en/federal-securities/issuances/bund-issues-auction-group>

Relative share of cash market trading by sector*

%, monthly data



Source: Finance Agency. * Captures trading counterparties of the Bund Issues Auction Group (both purchases and sales). This covers a large share of the secondary market. ¹ Finance Agency, enterprises, private investors and other investors.

Deutsche Bundesbank

only banks but also hedge funds contribute to liquidity in the OTC cash market, but their importance is more difficult to quantify.⁸ A smaller percentage of Bunds are traded on conventional exchanges, where the Bundesbank, too, conducts market management operations on behalf and for the account of the Finance Agency.^{9,10} In addition, exchange trading between banks takes place on the Italian limit order book platform, MTS.¹¹

... and is dominated by the Bund Issues Auction Group

The largest group of liquidity providers in the cash market, the dealer banks, obtain Bunds from the Finance Agency on the primary market.¹² In the past, the trading partners of these dealer banks in the secondary market were also mostly banks. However, the share of banks fell from 50% at the beginning of 2018 to 38% in July 2022 (see the chart above). Over the same period, the share of financial institutions that are not banks or brokers¹³ in the monthly trading volume with the dealer banks increased from 36% to 49%. There are several possible reasons for this development, such as new regulatory requirements or changing business models. A further reason could be that banks without access to primary market issues purchased Bunds on the secondary market but, since 2014, have been holding a steadily diminishing amount of these.¹⁴ Banks are usually monetary policy counterparties of the Eurosys-

tem and thus have access to the deposit facility. Given that the interest rate on many Bunds had in recent years remained below the deposit facility rate over longer periods of time, this facility gave them a more attractive substitute for holding high-quality liquid assets (HQLA).

Central banks' share of the trading volume has increased in the aftermath of the monetary policy purchase programmes. Since net purchases under the pandemic emergency pur-

⁸ In this vein, they can contribute to levelling out valuation differences, such as between the Bund cash and future market, via relative value trades (see pp. 79 ff.).

⁹ These market management operations are targeted at prices which do not discriminate between different types of market participants such as institutional and private investors.

¹⁰ The Finance Agency's data generally show with whom the Bund Issues Auction Group is trading in the secondary market. The members of the Auction Group report their dealing activities to the Finance Agency, which then makes these data available in aggregated form. If, for instance, a bank that is not a member of the Auction Group conducts a transaction with a hedge fund, this trade is not contained in the statistics. The Auction Group, however, covers a large swathe of the market.

¹¹ Mercato Telematico dei Titoli di Stato.

¹² See also <https://www.deutsche-finanzagentur.de/en/federal-securities/issuances/bund-issues-auction-group>

¹³ Hedge funds, investment funds, pension funds and insurers.

¹⁴ See Deutsche Bundesbank (2022a).

chase programme (PEPP)¹⁵ were discontinued in March 2022, however, a declining trend has become visible.¹⁶ By contrast, the share of the trading volume of Bunds accounted for by the Finance Agency itself is growing.¹⁷

A large proportion of Bunds are tied up with long-term investors

The composition of investor groups for Bunds impacts on market functioning inasmuch as, for many of these groups, Bunds represent a long-term investment. These long-term investors are typically insurers, pension funds or foreign central banks. The securities in their port-

15 This was a temporary asset purchase programme of private and public sector securities implemented to counter the threats posed by the extraordinary economic and market conditions on the ability of the Eurosystem to fulfil its mandate. It was launched on 26 March 2020 and ran in addition to the asset purchase programme (APP). Its original envelope was €750 billion but was increased over the programme's lifetime to a total of €1,850 billion.

16 The central bank share also includes non-Eurosystem central banks.

17 In its auctions, the Finance Agency regularly sets aside a share of securities for market management purposes, most of which are then allotted to secondary market operations following the auction. In addition, it can also step up its own proprietary holdings. See <https://www.deutsche-finanzagentur.de/en/federal-securities/trading/secondary-market/activities>

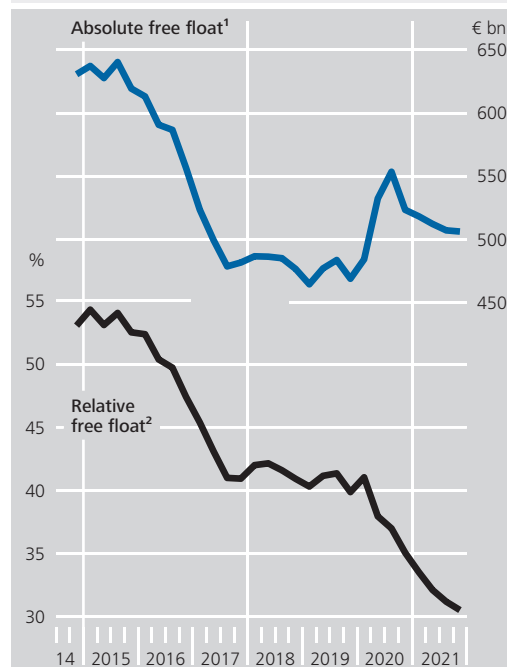
18 Free float refers to holdings of an issuance that are freely available for trading – as opposed to the stock held by investors who acquire bonds and then hold them to maturity (known as “buy and hold investors”). There is no uniform definition of free float. However, using the Eurosystem's Securities Holdings Statistics by Sector (SHSS), this can be approximated by the sum of private sector holdings less insurers and pension funds. Assets in circulation not captured by the SHSS are assigned in equal shares to free float and buy-and-hold investors. Under this approach, free float is interpreted in a broader sense, as many investment funds and banks likewise hold instruments to maturity. These percentage shares can only be estimated, however, and have therefore not been recorded. Further details on the data chosen and the analysis for the December 2014 to December 2021 period can be found in the May 2022 issue of the Monthly Report. See also Deutsche Bundesbank (2022a).

19 As a result of the higher net issuance stemming from the fiscal measures and the monetary policy measures taken, percentage and absolute free float have diverged since the second quarter of 2020. The Federal Government's strong issuance activity during the pandemic exceeded the Eurosystem's purchases of German government bonds. However, a large percentage of the issues were retained, thereby increasing the Federal Government's proprietary holdings. The percentage share of the free float thus declined further to around 30% at the end of the period under review. However, at the same time, the absolute volume in free float rose slightly by just over €38 billion to a little more than €500 billion. See also Deutsche Bundesbank (2022a).

20 The absolute free float still declined slightly as the outstanding volume went down somewhat.

Free float of Bunds

Based on nominal data, end-of-quarter data



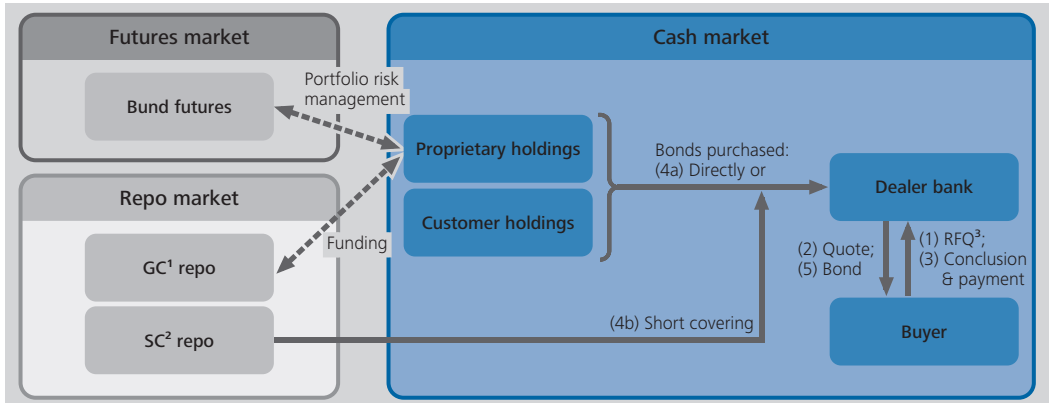
Sources: ESCB (SHSS database), Finance Agency and Bundesbank calculations. **1** Contains Bundesbank holdings and Finance Agency's proprietary holdings. Does not include the proprietary holdings of the ECB or the national central banks of the euro area. **2** Absolute free float over outstanding volume. Deutsche Bundesbank

folios are then often no longer available for market trading. The “free float”¹⁸ of an asset class, i.e. the amount which is, in principle, available for trading, is of major importance for market functioning and market liquidity.

In the wake of the Eurosystem's asset purchase programmes, both the relative and absolute free float of Bunds fell between 2014 and the end of 2021. The share of free float in the outstanding volume decreased by around 22 percentage points to 31%.¹⁹ The reduced volume of assets available for trading increasingly led to periods of scarcity that negatively affected market conditions. Following the ECB Governing Council's decision in late 2021 to discontinue net purchases under the PEPP from the end of March 2022, the relative free float rebounded slightly in the first half of 2022.²⁰ Now that the interest rate environment has returned to positive territory, this could attract banks as investors again going forward; they had previously left the market in greater num-

As a large buyer, the Eurosystem significantly reduced tradable free float

Schematic relationship between the three Bund markets when selling a bond as viewed from a dealer bank's perspective



1 General collateral. 2 Specific collateral. 3 Request for quote.
 Deutsche Bundesbank

bers in the low interest rate environment (see p. 73 f.). This ought to help increase free float as banks generally participate actively in trading. The Federal Government's net new issuance is another key determinant. Higher sovereign debt boosts supply in the market and thus also tends to increase free float.

Cash market transaction often triggers chain reaction

Cash market dealers do not necessarily have to hold a sold security in their own portfolio since the delivery time of the instrument sold is two working days after the purchase date. What they can attempt to do instead is to obtain the security through their own customer relationships, external market contacts or the repo market (short covering).

therefore also of central importance when looking at liquidity (and liquidity provision) in the cash market. The overwhelming majority of trades in this market are conducted via central counterparties (CCPs).^{22,23} If, after a transaction has been concluded on the cash market, the dealer cannot obtain the security directly, they can temporarily cover their demand for this security via the secured money market. To do so, they enter into a specific collateral (SC) repo transaction in which this security has been posted as collateral.²⁴ If demand for this particular security in the repo market rises and there is little free float, the price that repo buyers have to pay to borrow this security also rises. This leads to a higher scarcity premium, the difference between general collateral (GC)

The repo market

SC repo market helps to obtain short-term securities and thus provide liquidity in the cash market

Repo transactions are the most important instrument in the secured money market, which also includes instruments such as securities lending and securities swaps.²¹

A repo consists of two transactions in which a sum of money is exchanged for a security. At the start of the transaction, the repo buyer is lent a security as collateral for a pre-defined period of time and compensates the repo seller with a monetary amount. The repo market is

²¹ See Deutsche Bundesbank (2022b).

²² CCPs are financial market infrastructures that interpose themselves between the original counterparties of a financial market transaction in securities, derivatives or goods, etc. In doing so, a CCP replaces the original transaction between these two counterparties with two separate transactions between the CCP and the respective counterparty. See <https://www.bundesbank.de/en/tasks/payment-systems/oversight/central-counterparties-626482>

²³ According to the Euro money market study, this share amounts to 70%; see https://www.ecb.europa.eu/pub/euromoneymarket/html/ecb.euromoneymarket202104_study.en.html

²⁴ In addition to these securities-driven SC transactions, it is also possible to borrow or lend a security from a pool of several securities against cash collateral. In these cases, transactions are liquidity-driven, as the repo buyer cannot influence what security they are provided with as collateral.

and SC rates. Such tensions in the repo market can make it more difficult to intermediate between buyers and sellers of Bunds on the cash market.

Secured euro money market rates have generally been below the Eurosystem’s deposit facility rate in recent years. This has been driven by not only the scarcity of securities but also high central bank balances. These were created, in particular, by non-standard monetary policy measures, such as asset purchases, and encourage a concentration of money market activity on transactions between market participants that have access to central banks accounts and those that do not.²⁵

The future market

Bund futures are an important pricing and hedging instrument

Bund futures²⁶ are standardised futures contracts on notional Bunds. They are traded exclusively on the electronic Eurex futures exchange. Market participants can use Bund futures to hedge their bond positions or to speculate on changes in interest rates or prices in Bunds with different maturities. They serve as a pricing and hedging instrument for liquidity providers in the cash market. Turmoil in the future market can therefore also make it more difficult to provide liquidity in the cash market and vice versa. What sets the Bund future market apart from the Bund cash and Bund repo market is a high level of standardisation and centralisation and thus large trading volumes with a significant share of high-frequency traders.²⁷ This means that it usually has price leadership over the cash market (see the box beginning on p. 79).

EMIR data provide new insights into the Bund future market

Only a relatively small percentage of market players trading in Bund futures have direct access to the Eurex futures exchange. Following the entry into force of the European Markets Infrastructure Regulation (EMIR), there now exists an extensive derivatives transaction register which represents the Bund future market. The data also contain those market participants who do not have direct access to the Eurex fu-

tures exchange and thus cannot participate directly in Eurex clearing. An analysis of EMIR data from January 2020 to July 2022 shows that these mostly smaller market participants, such as investment funds or other non-banks, participate indirectly in trading via clearing participants, known as client clearers, which have direct access to Eurex. This causes business activities to be highly centralised as client clearers, which include banks, in particular, are involved in more than four out of five Bund future transactions – often, but not only, as intermediaries.

High-frequency traders are an additional important factor: they are involved in at least one-quarter of all transactions. Although they account for a large number of transactions, they have a relatively small volume per transaction compared with other market players such as banks.²⁸ In addition, high-frequency traders operate mainly on an intraday basis and thus short-term, which is why they have only a few open positions at the end of the day. They pursue a variety of different trading strategies, such as “news trading”, in which they use their speed advantage to generate short-term profits in anticipation of and following the publication of key macroeconomic data. Most high-frequency traders, however, act as liquidity providers, such as via “market-maker strategies”. Yet empirical studies show that, especially in an environment of heightened uncertainty, such

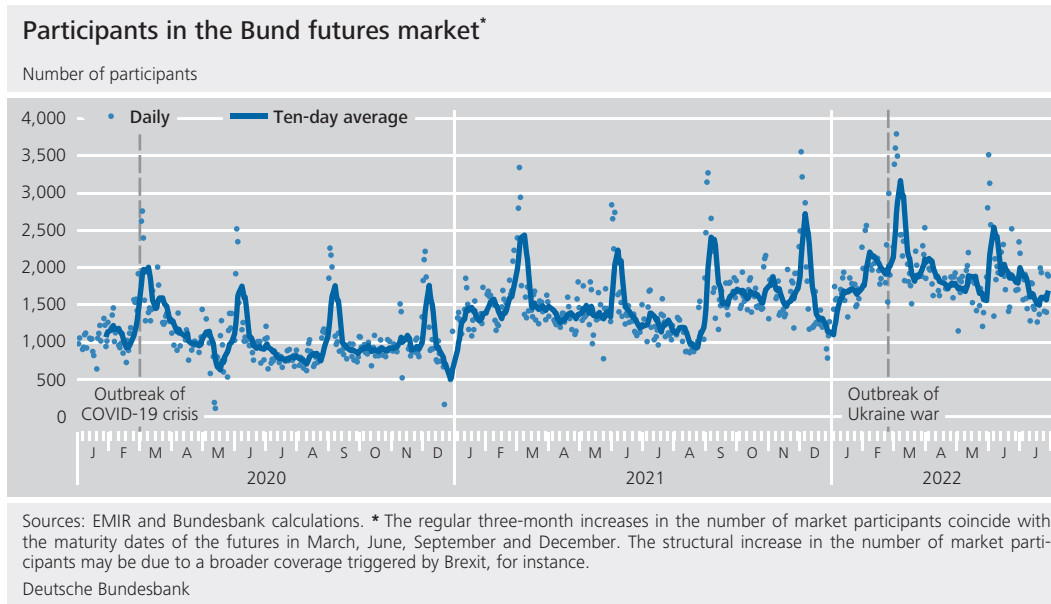
High-frequency traders in futures usually act as liquidity providers but often withdraw in critical phases

²⁵ See Deutsche Bundesbank (2022) and Åberg et al. (2021).

²⁶ The term Bund futures is used here as a synonym for the various futures contracts where Bunds are the underlying instrument. These notional Bunds have maturities of two (Schatz future), five (Bobl future), ten (Bund future) and 30 years (Buxl future). The nominal value of a contract is €100,000.

²⁷ High-frequency trading (HFT) is an algorithmic trading technique using special computer hardware and particularly fast data connections to the stock exchange. It is characterised by very high daily order counts, relatively small order sizes and, in most cases, very short holding periods for the positions taken. HFT algorithms are capable of responding extremely quickly to changes in the market and to news.

²⁸ High-frequency traders trade an average of four Bund future contracts per individual transaction. At 14, 26 and 131 contracts per transaction respectively, banks, pension funds and insurers have considerably higher contract-to-transaction ratios.



as the publication of important data, they often withdraw quickly by deleting previously submitted trading orders.²⁹ This is also reflected in the EMIR data, as high-frequency traders, in particular, are cautious immediately before anticipated, landmark ECB Governing Council decisions, such as on 9 June 2022, when the end of net asset purchases and the prospect of initial interest rate moves were announced. However, their activities increase once the news is known. By contrast, the number of market players across all sectors in a volatile market environment, such as at the outbreak of the COVID-19 pandemic or the Russian war of aggression against Ukraine, has temporarily increased. These are usually additional investors who are otherwise active in the Bund future market at only irregular intervals and mostly on a small scale and who are now using future contracts to adjust their positions. Cumulated and symmetrical transactions by these irregular market agents could then cause a trend reduction in liquidity.

chases of bonds issued by euro area central governments, agencies and European institutions under the public sector purchase programme (PSPP) began in 2015. High monthly net purchases have made the Eurosystem the largest holder of Bunds. It has therefore assumed a prominent position as a market agent.

From a theoretical point of view, it is unclear whether central bank purchases have positive or negative effects on liquidity or market functioning. On the one hand, asset purchases can stimulate trading volumes since purchases generally encourage portfolio adjustments. Moreover, the presence of the central bank as a large, solvent and reliable buyer may increase market-making activities since it can reduce unwanted positions more quickly and also execute larger orders more easily (the “backstop” buyer channel³⁰). This could also enhance market-makers’ willingness to hold larger bond portfolios, which would then facilitate trading between market participants.³¹

Central bank purchases can increase trading volumes and market-making activities, ...

The Eurosystem’s impact in its role as a market player since 2015

The Eurosystem’s share of holdings in the Bund market has been steadily growing since pur-

²⁹ See Schlepper (2016) and Deutsche Bundesbank (2016).
³⁰ See Pasquariello et al. (2018) and Boneva et al. (2018).
³¹ See Bank for International Settlements (2019).

Relationship between the Bund future and cash market

The standardisation of Bund future contracts and the significantly lower need for funds compared with cash market transactions result in a significant share of high-frequency trading in the Bund future market as well as very liquid trading under normal conditions. For instance, the prices of Bund futures react extremely quickly to news.¹

By contrast, Bunds in the cash market are largely traded over the counter (OTC) via various electronic trading platforms. The cash market is therefore more fragmented and opaque compared with Bund futures trading on Eurex. In addition, at over 60 Federal securities, the number of securities traded here is significantly greater than the four types of maturity-dependent Bund futures. The transaction figures are lower (and less transparent) than those for Bund futures, which means that price discovery processes take place less regularly.

The future and cash market are closely intertwined, as significant price differences result in arbitrage opportunities. Sellers of futures must deliver a Bund of their choice from a basket of eligible bonds to the future buyer on the maturity date. One of these bonds – the cheapest-to-deliver (CTD) bond – is the cheapest for the supplier. In an efficient market, the prices of the CTD bond and the associated future should therefore correspond after applying a conversion factor that approximates the maturity and coupon differences between the actual and the notional bond. Recently, CTD prices in the Bund market have exceeded the adjusted future prices on a regular basis, possibly driven by the scarcity of Bunds induced by central bank purchases.² This difference is known as the cash-future basis (CFB) and is regarded as an indicator of market functionality. A positive CFB indicates relatively high prices in the cash market. Market participants could benefit from these price differences by short selling the bond and buying the future at the same time.³ The price dif-

ference is gross income. At maturity, the arbitrageur receives the CTD from the future seller and can return it to the borrower. In principle, this arbitrage opportunity ensures that prices in both markets diverge only temporarily and to a limited degree in most cases. However, a lack of market liquidity and high trading costs, bond scarcity in the cash and repo markets, regulatory barriers or market turbulence can limit arbitrage opportunities and explain the existence of the CFB.

Up until the end of the 1990s, price discovery primarily took place in the cash market. Since then, new technologies, standardised contracts and the low use of funds have essentially caused price leadership to become established in the future market.⁴ Recent studies also confirm that price discovery for both US and euro government bonds primarily takes place in the future market.⁵

On electronic trading platforms such as the Eurex futures exchange, transactions in Bund futures are settled via a central limit order book. All bid and ask quotes, which include the corresponding prices and quantities, are collected here. These quotes are binding. Similarly to Eurex, data from the Italian trading platform MTS⁶ can also be used to construct a limit order book with a timestamp in seconds for the cash market for Bunds. Although the share of actual transactions is small compared with the OTC cash market, market participants consistently quote binding prices and quantities here.

¹ See Schlepper (2016) and Deutsche Bundesbank (2016).

² See Pelizzon et al. (2022).

³ In addition, the repo market can be used to finance the replication business and to receive the Bund for short selling.

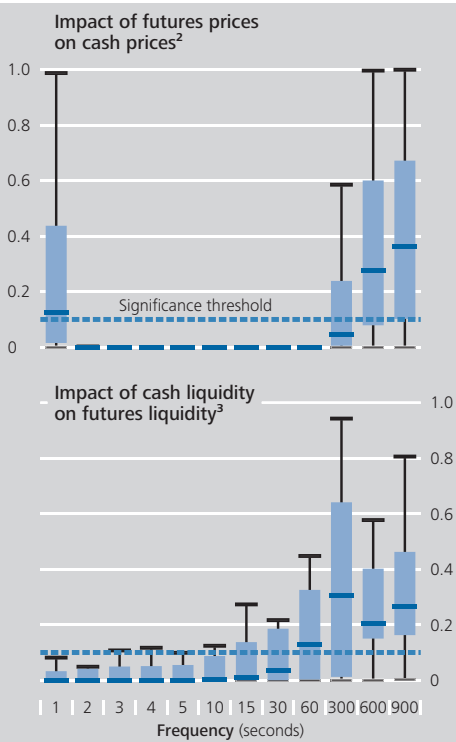
⁴ However, large transactions in the cash market can also affect prices in the future market. For more information, see Upper and Werner (2007).

⁵ See Puorro et al. (2016) and Jappelli et al. (2022).

⁶ Mercato Telematico dei Titoli di Stato.

Relationship between the future and cash market

Distribution of p-values¹



Sources: Eurex, MTS and Bundesbank calculations. The analysis was conducted for the period from January 2020 to June 2022 (563 days in total). **1** p-values of the daily Granger causality tests. Values <0.1 are weakly significant, <0.05 moderately significant, <0.01 highly significant. It can be concluded from significant values that a time series "A" Granger-causes another time series, "B". **2** The distribution of the Granger causalities of price changes in the future market on the cash market. **3** The distribution of the Granger causalities of liquidity (here as order book depth in each case) in the cash market on liquidity in the future market on the 3% most volatile days in the period under review.
 Deutsche Bundesbank

An analysis based on the high-frequency order book data from MTS and the Eurex futures exchange confirms that the price leadership of futures can also be found in the market for Bunds. To this end, a simple bivariate vector autoregressive (VAR) model is used to test for Granger causality between futures and cash prices.⁷ The analysis is applied on an intraday basis to all of the days from January 2020 to June 2022 individually, as well as to a total of 12 different frequencies. It is thus clear how long the transfer takes between markets and whether the transfer significance and duration differ on individual days. A distribution of the significances (shown as p-values) across all the individual days considered helps to categorise

the results. P-values below 0.1 can be considered statistically significant.

The results show that futures prices have a significant impact on prices in the MTS cash market within two seconds. After more than one minute, the effect is no longer detectable (see the upper panel of the adjacent chart). The spillover effect tends to be less significant on particularly volatile days. Conversely, there is no consistent significant spillover from cash prices to futures prices.

In addition, a similar analysis in the literature reveals a spillover of both price volatility⁸ and liquidity in the future market to liquidity in the cash market for sovereign bonds.⁹ This relationship is not confirmed for Bunds in short frequencies. The reverse is true since, on particularly volatile days,¹⁰ liquidity from the cash market partly spills over to liquidity in the future market (see the lower panel of the adjacent chart) as well as partly to the volatility of futures.¹¹ This effect can be seen, for instance, during the COVID-19 pandemic or Russia's war of aggression against Ukraine, when temporary shocks began. These shocks initially occurred in the cash market and then spilled over to the Bund future market.

The empirical studies confirm the close interconnectedness of the two markets in both directions. Therefore, it is always advisable to view these markets together when assessing market conditions.

⁷ This method borrows from Puorro et al. (2016).
⁸ Measured as the maximum-minimum price difference and the sum of the log price changes per interval.
⁹ See Puorro et al. (2016).
¹⁰ Top 3% of the most volatile days in the period under review as measured by the volatility of intraday Bund futures.
¹¹ Liquidity is measured here as order book depth, i.e. available liquidity and bid-ask spreads. Similar results can now also be found in Jabbali et al. (2022), but without a distinction between individual countries in some cases and with a different calculation methodology and longer frequency.

... but also lead to higher costs due to the reduction in free float

On the other hand, in addition to regulatory³² factors, asset purchases affect the quantity of securities available on the market. As a result, central bank purchases can be seen as shocks to the available supply of bonds because free float in this market segment is reduced.³³ This could impact adversely on liquidity and market functioning because the purchase of a certain bond on the market is associated with higher costs or search frictions.

Moreover, due to the relatively stable monthly volume targets (over a long period of time), central banks respond to current price and liquidity conditions when conducting purchases only with a time lag, which could disrupt price formation in the market. That, in turn, could discourage market participants from being involved in trading. If the frequency and target volume of a purchase programme are very high relative to the usual trading activities in the market segment and to bond issuance, this can likewise have a negative effect on market functioning. In that case, the markets could have trouble processing the unusually large amount of capital flows. Lastly, information asymmetries between the central banks' direct trading partners and other market participants could lead to imbalances and disincentivise the latter from participating in trading.³⁴

Empirical evidence on the impact of extensive purchase programmes on market liquidity

Empirical evidence regarding impact of purchase programmes on liquidity not conclusive ...

Whereas the impact of the announcements concerning the PSPP (stock effects) is clearly associated with falling bond market yields,³⁵ the empirical evidence for effects directly following the purchase (flow effects) is not conclusive.³⁶ The few studies which look at the impact on sovereign bond market liquidity likewise fail to reach clear-cut conclusions.

For the European bond market, there is evidence that purchases in less liquid markets lead

to improved liquidity ratios.³⁷ This does not hold for high-demand Bunds, though, for which it was found that central bank purchases improve liquidity in the short term but impair liquidity in the longer term.³⁸ The scarcity of bonds turns out to be of crucial importance for liquidity. If a bond is particularly scarce, it is also more difficult or more expensive to trade, which in turn implies worse market liquidity. Similar results are obtained by studies on the Japanese government bond market which examine the impact of the Bank of Japan's bond buying programme. These studies likewise show that market liquidity deteriorates relative to the outstanding volume particularly as from a certain threshold of the Bank of Japan's bond holdings.³⁹ On the other hand, no impact of the Federal Reserve System's purchases of US Treasuries on various liquidity ratios could be identified.⁴⁰

In the box beginning on p. 83, the effects of the purchases on the market liquidity of Bunds are examined in greater detail, taking into account the monetary policy normalisation that began in December 2021. While the results for the full period of net asset purchases (2015 to 2022) are inconclusive – the bid-ask spread expands while the order book depth increases – the exit announcements lead to a deterioration in liquidity indicators.

³² For example, the liquidity coverage ratio (LCR) leads to an increase in structural demand for HQLA such as Bunds (where they are remunerated above the deposit facility); the leverage ratio (LR), on the other hand, makes it more expensive to expand the balance sheet and thus also to hold Bunds.

³³ See Duffie (1996).

³⁴ See Bank for International Settlements (2019).

³⁵ See, for example, Altavilla et al. (2015), Blattner and Joyce (2016) and De Santis (2020).

³⁶ See, for example, Schlepper et al. (2020), De Santis and Holm-Hadulla (2017) and Arrata and Nguyen (2017).

³⁷ See De Pooter et al. (2018) on the effect of the ECB's Security Market Programme on liquidity premia on bonds issued by Ireland, Italy, Portugal and Spain.

³⁸ See Schlepper et al. (2020). Bid-ask spreads on Bunds narrow immediately after the purchase, but liquidity conditions deteriorate overall during the PSPP period under review (2015-16).

³⁹ See Pelizzon et al. (2018) and Han and Seneviratne (2018).

⁴⁰ See Kandrac and Schlusche (2013) and Kandrac (2018).

The results in the literature for the repo market, on the other hand, are conclusive: PSPP and PEPP purchases amplify scarcity effects, and the scarcity premium for bonds rises accordingly.⁴¹ Moreover, the scarcity effects are particularly strong for bonds held primarily by long-term buy and hold investors such as insurers or pension funds,⁴² which tend to reduce free float.

... and depends on the scope and duration of the programme

The experience of various central banks likewise corroborates the empirical results that non-standard monetary policy measures have positive effects particularly in markets with high liquidity premia, as these are reduced by the purchases. On the other hand, adverse effects result if the measures are in effect for an extended period of time or their scope is large. In addition to reduced market-making or lower investor participations, scarcity effects regarding government bonds are of major importance particularly where central bank purchases or already purchased bond holdings are very high relative to the outstanding volume or issuance is very high, thus reducing free float considerably.⁴³

Approaches to mitigating the “free float” problem

Rules for implementing the purchase programmes may have mitigated negative side effects

Central banks have been pursuing a variety of measures to mitigate the negative side effects of the extensive asset purchases. First, certain rules are taken into account when implementing the purchase programmes (for instance, envelopes are limited by issuer and bond issuance and, where possible within the scope of these and other restrictions, the purchase of particularly scarce instruments is avoided). Moreover, attempts are made to purchase the bonds in a market-neutral⁴⁴ manner in order to avoid interfering with the relative price formation process and mitigate unintended side effects.

The Eurosystem central banks have recently used a considerable amount of flexibility to implement the PEPP programme in some cases, rather than a predefined, strict monthly envel-

ope, in order to adjust the exact amount and timing of purchases to suit monetary policy needs. For instance, although the PEPP was geared in principle to the capital key of the national central banks, fluctuations in the distribution of purchases over time, across asset classes and across countries were also possible. The objective pursued here by the ECB Governing Council was to effectively avert pandemic-related risks to the smooth transmission of monetary policy.

Securities lending by Eurosystem central banks was introduced to support liquidity in the cash and repo markets.⁴⁵ Under this scheme, sovereign bond holdings under the Eurosystem’s PSPP and PEPP are available for lending through repo transactions. The idea behind the conservative pricing of securities lending is to support market liquidity particularly in periods of stress without affecting repo market activity in normal times (backstop function).⁴⁶ Recent studies have analysed the impact of Eurosystem securities lending activities on the scarcity premium in the repo market. They show that securities lending was actually successful in mitigating tensions in the repo market for both Bunds and other European sovereign bonds. For Bunds, however, the effect is less pronounced than the quantified contribution of PSPP purchases to the scarcity premium.⁴⁷ A further study analyses an adjustment to the price conditions of securities lending. More favourable conditions increase the volume of securities lending and tend to improve market liquidity.⁴⁸ In principle, modifications of securities lending conditions need to ensure that the backstop function is

Securities lending can mitigate severe tension in the repo market

⁴¹ See Baltzer et al. (2022), Souza and Hudepohl (2022) and Arrata et al. (2020).

⁴² See Jank and Mönch (2018).

⁴³ See Bank for International Settlements (2019).

⁴⁴ See <https://www.ecb.europa.eu/mopo/implement/app/html/pspp.en.html>

⁴⁵ See <https://www.ecb.europa.eu/mopo/implement/app/lending/html/index.en.html>

⁴⁶ See also Deutsche Bundesbank (2022b).

⁴⁷ See Baltzer et al. (2022) and Carrera de Souza and Hudepohl (2022).

⁴⁸ See Greppmair and Jank (2022).

Empirical analysis of the effect of central bank purchases on market liquidity

The effect of Bundesbank purchases under the public sector purchase programme (PSPP) and the pandemic emergency purchase programme (PEPP) on market liquidity can be empirically examined using panel regressions. The results also provide information on how liquidity measures respond to announcements of the launch of, modification to and exit from the two purchase programmes. MTS¹ data for the Bund cash market from 2015 to 2022² are used as the dataset, with the more recent period since the PEPP was launched (2020 to 2022) being considered separately.

Based on a difference-in-differences regression analysis, it is possible to measure the effect on market liquidity of purchased bonds relative to bonds not purchased. Both the effect of whether a purchase takes place and the effect of the actual purchase volume (€ million) on the bid-ask spread and on depth are examined.³ In order to separate the purchase effect from possible other influences on bonds, we control for various bond-specific factors (repo scarcity premium and repo volume, eligibility, purchase one day prior and multiple purchases per bond, age, maturity). In addition, general developments in the bond market are taken into account using variables such as yield spread, volatility and month-end effects.

The results in the table on p. 84 show that central bank purchases lead to a 0.9 basis point increase in transaction costs (relative bid-ask spread) on the day of the purchase. This result hinges on the purchase and less on the purchase volume. In the analysis for the period from 2015 to 2016, however, there is a decrease in transaction costs of

purchased bonds relative to bonds not purchased, as expressed by the bid-ask spread.⁴ A similar result can be seen when looking at the more recent period since the launch of the PEPP (March 2020 to July 2022): the bid-ask spread falls – at least depending on the volume purchased – by around 1.1 basis points per €100 million of purchases.

One possible reason for these period-dependent results could be the respective interest rate developments. In both the spring of 2015, during the Bund tantrum,⁵ and in the first half of 2022 owing to expectations of an exit from the era of low rates, the interest rate level rose distinctly and with it, temporarily, the pressure to sell. In this setting, purchases by the central bank had a particularly dampening effect on the interest rate level and illiquidity, and temporarily overshadowed the effect of the relative scarcity of heavily purchased Federal bonds. In these phases, purchases thus support liquidity. During the full period, by contrast, the more dominant effect seems to be that central bank purchases lead to relative scarcity, evidenced by an increase in the transaction costs of the specific purchased bond, for example.

Bonds that are eligible but which are not purchased on that day have lower bid-ask spreads than bonds that are not eligible. This is shown by the significantly negative

¹ Mercato Telematico dei Titoli di Stato.

² This analysis is based on the paper by Schlepper et al. (2020), which calculates the effect of PSPP purchases from 2015 to 2016 on prices and liquidity in the Bund cash market.

³ Order book skewness and slope were also examined, but no clear effect of central bank purchases was found.

⁴ See Schlepper et al. (2020).

⁵ See Riordan and Schrimpf (2015).

Results of the difference-in-differences regressions*

Panel A					Panel B				
2015 to 2022					2020 to 2022				
Dependent variable	Bid-ask spread (basis points)		Depth at best bid and ask price (€ million)		Dependent variable	Bid-ask spread (basis points)		Depth at best bid and ask price (€ million)	
	Purchase dummy	0.914** (0.424)		0.413* (0.214)			Purchase dummy	-0.642 (0.426)	
Volume		-0.702 (0.477)		0.432** (0.167)	Volume		-1.143*** (0.292)		0.164* (0.0988)
Announcement PSPP launch 22.1.2015	4.861*** (0.849)	4.639*** (0.837)	3.076*** (0.274)	3.007*** (0.253)	Announcement PEPP exit 16.12.2021	4.733*** (0.723)	4.762*** (0.722)	-0.342 (0.245)	-0.358 (0.248)
Announcement PEPP launch 18.3.2020	7.652*** (0.933)	7.404*** (0.919)	-5.176*** (0.752)	-5.258*** (0.770)	Announcement PSPP exit 9.6.2022	-2.011*** (0.344)	-2.045*** (0.347)	-1.539*** (0.182)	-1.516*** (0.174)
Eligibility dummy	-4.014*** (1.017)	-3.868*** (1.024)	-0.426 (0.332)	-0.393 (0.323)	Eligibility dummy	1.494 (1.794)	1.453 (1.806)	0.573 (0.950)	0.602 (0.958)
Constant	11.32*** (1.976)	11.70*** (1.934)	19.51*** (0.613)	19.63*** (0.601)	Constant	-0.917 (8.877)	-1.075 (8.813)	22.82*** (1.528)	23.03*** (1.518)
No of observations	136,080	136,080	136,080	136,080	No of observations	44,346	44,346	44,346	44,346
R ²	0.727	0.726	0.416	0.416	R ²	0.643	0.643	0.588	0.588

* Regressions of the above liquidity measures on PSPP and PEPP purchases. For purchases, a distinction is made between the actual purchase (€ million) and a dummy variable which indicates whether a bond was purchased on a given day. The results of the purchase effects should be interpreted relative to the control group of bonds not purchased. Both regressions incorporate various bond-specific and time-specific control variables as well as dummy variables for announcements of changes to the PSPP and PEPP, which are not shown here. Robust standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1.

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eligibility effect in the full period (panel A). Pure eligibility therefore already leads to a lower liquidity premium.

Order book depth at the best bid and ask price increases as a result of PSPP and PEPP purchases. For a daily purchase volume of €100 million, depth sees an increase of €0.43 million in the full period. The fact that there is a close link between large central bank purchases and market depth is intuitive, on the one hand, as purchases should have a strong impact on the available depth in the order book of the inter-dealer platform. The positive sign suggests that central bank purchases have contributed to greater resilience and have actually supported market-making activities. Amongst other things, this may be because the central bank's presence as a reliable, major buyer in the market for Federal secur-

ities gave rise to a certain degree of competition among market-makers to trade with the central bank.

In the early days of the PSPP, the opposite was the case: order book depth decreases with the purchase volume. This could indicate that there was some adjustment effect to the purchase programmes over time and that the predictability of purchases also played a role for market participants.

Furthermore, the announcements of PSPP and PEPP cause the bid-ask spread to rise by just under 5 basis points (PSPP) and around 7.5 basis points (PEPP) on the day of the announcement (see the lower section of the table above, panel A). However, depth increases for the PSPP announcement and decreases for the PEPP announcement.

Liquidity indicators deteriorated in response to the announcement effects on the termination of PSPP and PEPP purchases (see panel B in the table on p. 84). The bid-ask spread widens significantly upon the announcement of the exit from PEPP, whereas there is a slight narrowing on the day the exit from the PSPP was announced, although this is weaker than the increase six months earlier and probably also due to general selling pressure in the context of higher interest rate expectations.

In both cases, order book depth recedes somewhat, but significantly only for the announcement of the termination of the PSPP. One factor in this could be that market participants perceive the PSPP exit as putting an end to monetary policy purchase programmes and expect less trading activity in the future.

still guaranteed and does not replace normal market activity.

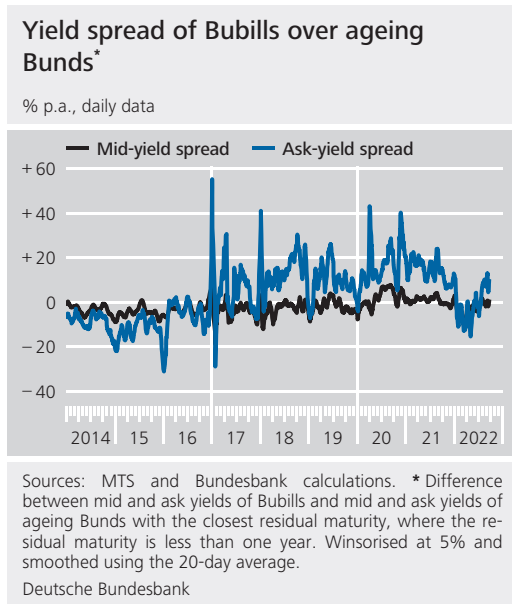
Approaches to quantifying market conditions

Market liquidity is an essential component of a functioning market

A central factor for the market conditions and the benchmark status of the market for Bunds is the high market liquidity that it generally enjoys, as this provides information on whether the market is functional at any given point in time. However, market liquidity is a multi-layered concept that cannot be viewed in isolation by looking at individual indicators alone. A simultaneous analysis of different dimensions of trading activity is, in fact, crucial. The literature usually distinguishes between the four liquidity dimensions depth, width, immediacy, and resilience, which are explained briefly below. Depth measures the market's ability to process the execution of large market orders for a security without this having a significant

impact on its price. Possible indicators are the number and volume of buy and sell orders – both at the best bid and ask price and at lower order book levels. Width refers to the spread between the bid and ask prices in a market (bid-ask spread) or their relative distance to the mid-price (relative bid-ask spread). Width measures the transaction costs incurred when buying or selling a security. The “wider” the spread, the more expensive and thus illiquid the market is. Immediacy measures the time needed to execute a transaction of a certain size. The shorter the time period, the more liquid the market in question is. Possible indicators are “time to unwind”⁴⁹ or, more generally, indicators used to measure how long it takes to dis-

⁴⁹ The time it takes to settle a US\$5 million position – see Bank for International Settlements (1999). This measure is important in practice, but in the empirical analysis strongly depends on the data used and can therefore easily lead to inaccuracies in the calculation. It is therefore not used in the analyses on which this article is based.



cover a security's price.⁵⁰ Resilience describes the speed at which a market returns to near "normal" market behaviour in the event of fluctuations in key trading metrics (e.g. the security price) following a shock, for example in response to new information or a large market order. Possible measures are ticket size⁵¹ or the market efficiency coefficient.⁵² In addition, this chapter also presents a new method for measuring resilience for the Bund future market.

Trading volume often correlates with volatile periods

The actual trading volume is often used as an additional indicator of market liquidity. However, in some instances, a high trading volume correlates with a deterioration in other liquidity dimensions. Nevertheless, it is important for quantifying market conditions, as high trading volumes often indicate exceptional market situations.

Volatility is regarded as a market stress indicator and is often a sign of high uncertainty

Price volatility also has an important role to play in assessing market conditions. Periods of high volatility often point to increased uncertainty among market participants in terms of their risk assessment for the security concerned. Volatility can thus be an indication of market stress and is considered a measure of risk. However, it also occurs as new information is priced into a security. Generally, volatile price developments up the risk for dealers and market-makers, which is why they sometimes

respond by increasing the cost at which they provide liquidity (higher bid-ask spread) or by reducing their provision of liquidity (lower market depth).

Finally, market conditions and inefficiencies can lead to (price) anomalies. For example, the Eurosystem's asset purchase programmes reduced the free float (see p. 75), causing a certain scarcity of many bonds. This can be seen, amongst other things, in rising scarcity premia in the repo market for Bunds that are particularly sought after. Consequently, price differences between bonds which are otherwise broadly similar may become more frequent.⁵³

Price anomalies as another indication of adverse effects on market conditions

One example of such price anomalies are yield deviations between ageing, originally long-dated Bunds and short-dated Treasury discount paper (Bubills) with the same residual maturity. Since 2017, these deviations have increasingly affected ask yields⁵⁴ and, from 2020 onwards, are also more evident in mid yields.⁵⁵ In an efficient, frictionless market, if these bonds have the same residual maturity, they should also have the same yield. With the abolition of the maturity restriction (from a remaining maturity of 70 days) and the increase in the purchase limit under the PEPP, the ageing Bunds were increasingly purchased, and have since then traded at higher prices than short-dated bonds with the same residual maturity. The shorter the residual maturity, the more pronounced the difference was. Before the start and at the be-

Anomalies in the Bund yield curve as a possible sign of disruptions to market functioning

⁵⁰ See International Monetary Fund (2002).

⁵¹ In the event of impaired functioning, larger orders may have to be split into several smaller ones.

⁵² The market efficiency coefficient measures the ratio between short-term and longer-term price changes: large short-term price changes accompanied by constant long-term price changes can be an indication of noise trading and therefore point to decreasing liquidity; see Da Silva (2013).

⁵³ This can be quantified, for example, using "spline spreads", in other words, yield deviations from the estimated yield curve. However, these can also increase due to shifts in the yield curve.

⁵⁴ Ask yields are the yields relevant from the buyer's point of view (for example, in the context of monetary policy purchases), at which a dealer offers a Federal security for sale.

⁵⁵ Average of the best bid and ask yields.

Indicators by dimension and market						
Composite indicator	Indicator type	Liquidity dimension	Market segment			Data frequency
			Spot market	Future market	Repo market	
Cross-segment indicator of market conditions (MCI)	Liquidity	Width (actual/executable)	Bid-ask spread	Bid-ask spread	Trading volume (SC) ² GC-SC repo spread ²	Daily
		Depth (executable)	Top 3 levels order book depth	Top 15 levels order book depth		
		Order book slope ¹	Top 3 levels order book slope	Top 15 levels order book slope		
	Depth (actual)	Trading volume	Trading volume			
	Price anomalies		Spline spread KfW-Bund spread	Cash-Future-Basis		
	Volatility		Standard deviation of intraday prices	Standard deviation of intraday prices		
Special indicator of market conditions (FCI) ³	Liquidity	Width (executable)		Bid-ask spread		Seconds
		Depth (executable)		Top 1 level order book depth bid		
		Depth (executable)		Top 1 level order book depth ask		
		Order book slope		Top 1 level order book slope		
		Depth (executable)		Frequency of the changes per sec. top 1 level bid		
		Depth (executable)		Frequency of the changes per sec. top 1 level ask		
		Depth (actual)		Trading volume per sec.		
		Depth (actual)		Transactions per sec.		
Special resilience indicator ³	Resilience	Time to normalisation		Average duration of extreme price movements >5 standard deviations		Seconds

¹ Measures the price effect per tradable additional quantity in the order book. ² Special collateral, general collateral. ³ For 2-year, 5-year, 10-year and 30-year Bund futures.

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gining of the PSPP, the relationship had been the reverse, i.e. the yield on Bubills was higher than the yield on ageing, originally long-dated Bunds, mainly because Bubills are more liquid. Regression analyses have been used to show that PEPP purchases now promoted the abnormal⁵⁶ yield spreads. Moreover, the higher issuance volumes of Bubills from 2020 onwards are probably also a key reason why Bubills have higher yields in relative terms. Since the decision to end the PEPP in December 2021, the positive deviation of short-dated and ageing bonds with the same residual maturity has come back down again, and has even entered negative territory at times. However, it has

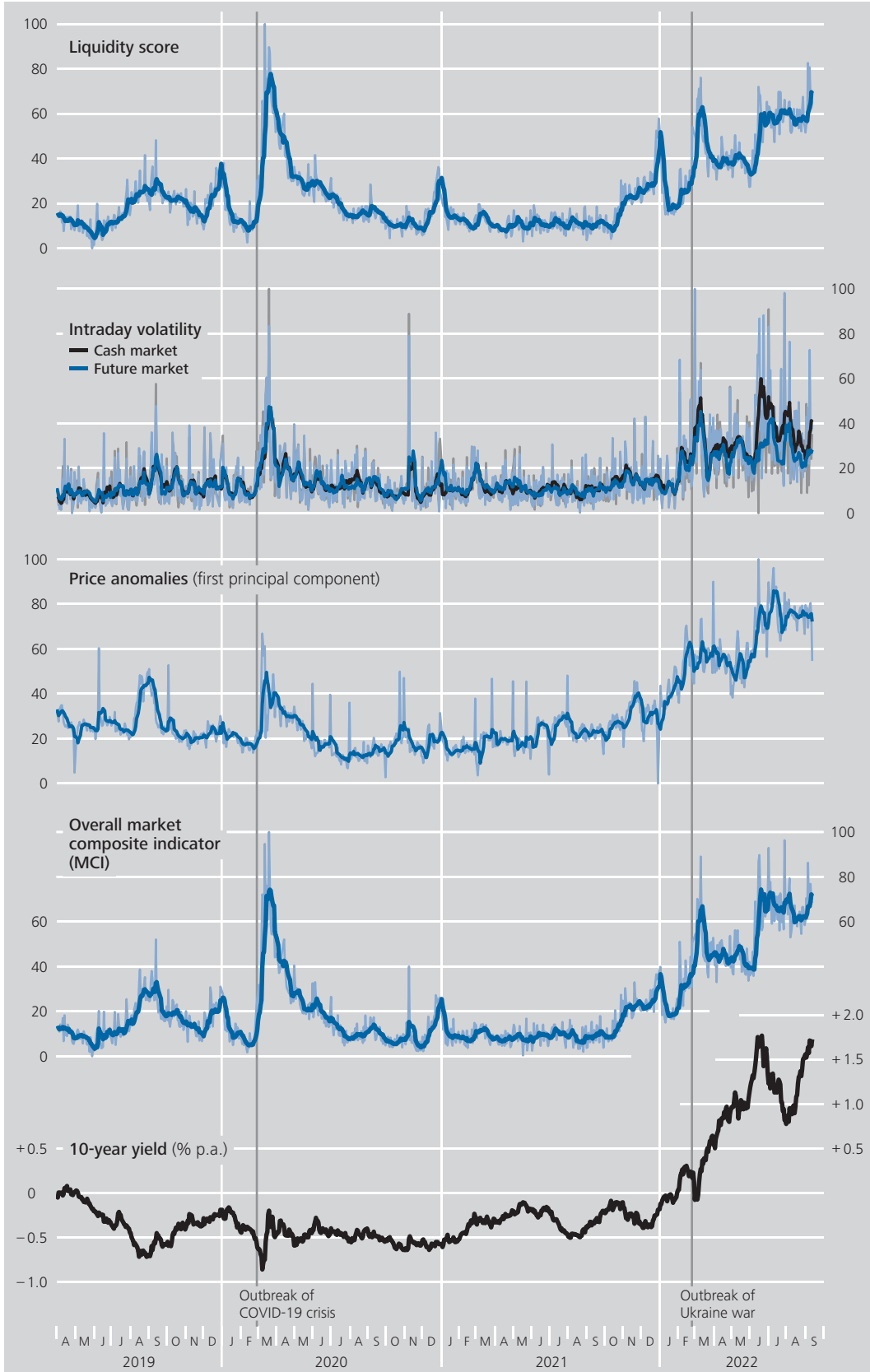
risen again significantly over the course of 2022.

The difference in the price of bonds with the same residual maturity but issued by agencies with the same default risk, such as the Federal Republic of Germany and Kreditanstalt für Wiederaufbau (KfW), could also point to certain scarcities in the market for Bunds. A small yield spread between the two bond issuers

⁵⁶ "Abnormal yield spread" is understood to mean a yield spread between ageing, originally long-dated Bunds and Bubills with the same residual maturity, which should average close to zero in normal times, but actually differs significantly from zero.

Dimensions of market conditions and composite indicator

The indicators are normalised to between 0 and 100 — Moving 10-day average — Daily data



Sources: Bloomberg, Eurex, MTS, Refinitiv, Trax and Bundesbank calculations.
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may be fundamentally justified, for example, because Bunds have higher issuance volumes. This difference can be understood as a liquidity premium⁵⁷ for KfW bonds as compared to Bunds. However, it has widened sharply of late, which illustrates the particularly high demand for Bunds and the scarcities that this has caused. Price anomalies between the Bund cash and the Bund future market, two very closely related markets, are examined in the box on pp. 79 ff.

The high-frequency indicators on the Bund future market can be used to represent a composite indicator (future market composite indicator, or FCI) for which measured values are available for every second of trading. It is primarily intended to allow an analysis of dynamic processes and developments on small time scales (for example, market reactions to the publication of economic data or monetary policy decisions) on an intraday basis.⁶² The possibility provided by the FCI of examining short time scales is particularly important given that market conditions are heavily influenced by algorithmic trading strategies.

Intraday indicator allows depiction on small time scales

Holistic analysis helpful in identifying exceptional market phases

The dimensions outlined above suggest that a comprehensive assessment of market conditions must necessarily be based on a holistic approach encompassing a wide range of indicators. At the same time, however, it is desirable to use as few indicators as possible to present market conditions in order to better understand and communicate the outcome. The wide-spread method of principal component analysis⁵⁸ can be employed to reduce the number of dimensions used to explain an empirical situation without significantly curtailing the information content of the resulting composite indicator. Indicators that can be used to measure market conditions empirically will therefore be presented below.

Overall, the indicators (see the chart on p. 88) and the resilience indicator presented in the box on pp. 90 f. represent clear and complementary methods for quantifying market conditions. They can help to bundle dynamic market developments that are driven by numerous simultaneous factors and thus make them easier to understand and communicate. Essen-

Set of indicators points to differences between the various crisis phases

Cross-segment indicators allow an assessment of market conditions as a whole

A principal component analysis can be used to calculate a liquidity score from the nine liquidity indicators on the Bund cash, Bund future and SC repo market (see the table on p. 87).⁵⁹ By contrast, the level of intraday volatility is shown individually for the cash and the future market, as no aggregation is necessary. Developments in the four indicators of possible price anomalies can be clearly seen in their first principal component.⁶⁰ Moreover, all 15 indicators can be merged into a cross-segment composite indicator (overall market composite indicator, or MCI).⁶¹ The MCI thereby maps events in the three segments cash, Bund future and repo market on a daily basis. To make interpretation easier, all indicators are normalised to values between 0 and 100.

⁵⁷ See Deutsche Bundesbank (2018).

⁵⁸ Principal component analysis is a statistical method that extracts common time-varying determinants from several correlated variables. Each determinant is a linear combination of the variables used. In most cases, only one or two common factors, known as the principal components, are considered, as these generally explain the majority of the total variance in all the variables included. See also Deutsche Bundesbank (2008).

⁵⁹ The liquidity score is calculated from the first (46% of variance) and the second principal component (17% of variance), weighted by their empirical explanatory power. The first principal component is determined relatively evenly from all input variables – except trading volume. Trading volumes and other indicators are inverted in some cases so that low (high) values always represent good (poor) liquidity.

⁶⁰ It represents 48% of the variance of the input variables.

⁶¹ The first principal component of the MCI represents 45% of the variance of all individual indicators and is explained relatively homogeneously by all remaining indicators. The second principal component represents 12%. The MCI is derived from the first and second principal component weighted by their empirical explanatory power. Apart from the three inverted volume indicators, all individual indicators are positively correlated. The volume indicators are key determinants of the second principal component.

⁶² With the exception of a few details, the model is designed using the same procedure as for the first indicator. Important differences are the much larger amount of data available for the future markets (for two and a half years, data are available for around 14.7 million trading seconds), the smaller number of individual indicators that are incorporated into the model (8 rather than 15) and the use of four principal components rather than two.

A novel approach to measuring market resilience

When it comes to measuring market conditions, resilience, as mentioned above, plays a special role. Resilience implies that, even during periods of high market stress, market participants can still make investment decisions without complications or interruptions to trading as part of a continuous trading process. In resilient markets, shocks therefore do not cause disruptions with prolonged phases of illiquidity, but instead lead rapidly to a new steady state and to a level of trading activity that does not differ significantly from that of the previous days.

Quantifying resilience is a complex process that involves a degree of discretionary scope and for which there is no uniform standard. Below, we will introduce an empirical method for quantifying resilience in the Bund future market separately from the other indicators in order to more clearly communicate the exact procedure and to allow the results to be replicated.¹

To measure resilience, we look at the duration of particularly unusual market events accompanied by extreme fluctuations in securities prices.² We examine how long the price changes persist outside their normal range following a strong price shock. The more resilient the market is to extreme price volatility, the faster trading activity should normalise and revert to the steady state after such a shock.³

The calculations produce a simple indicator that provides information with a high temporal resolution on the market's ability to "process" strong price fluctuations. For each time period, the value of the indicator shows how many seconds an extreme price event lasted on average.⁴ Here, a higher value equates to weaker resilience to price fluctuations. The longer-term trend clearly shows the marked period of stress at the beginning of the COVID-19 pandemic (in which the market took an average of five seconds to normalise again after an extreme event) and a further period of reduced resilience in Febru-

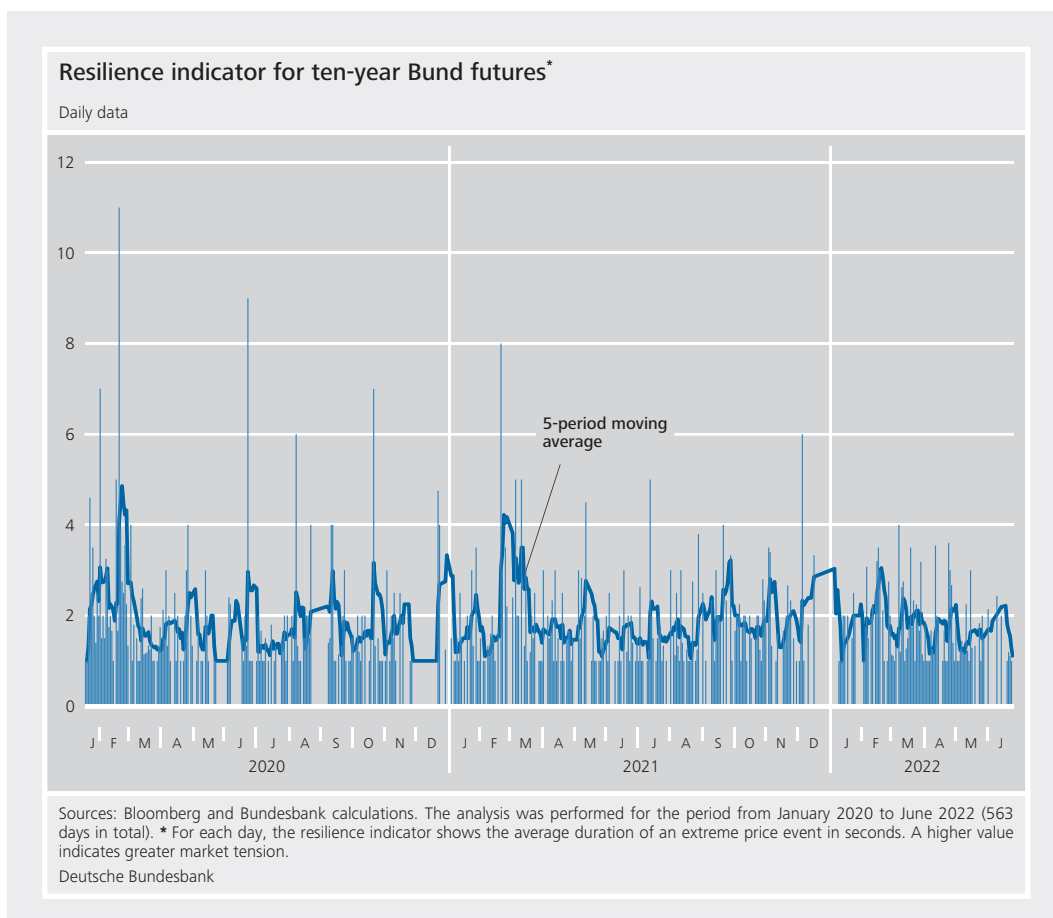
ary 2021. Interestingly, in recent months, the resilience indicator has not pointed to a marked decline in market resilience. This can be interpreted to mean that the reduction in market liquidity for ten-year Bund futures currently measured by the overall market composite indicator and the FCI has not yet had the same effect on resilience up until the summer as was the case at the start of the COVID-19 crisis.

1 Given the fast pace at which electronic markets respond, the resilience study focuses on short time scales (frequency: one second), which helps gain a clearer picture of the observed rapid market fluctuations and dynamic development processes in the order books. The underlying data sample is the same as that used for the futures market composite indicator (FCI). The data sample runs from 17 January 2020 until 24 June 2022. It contains data totalling around 15 million seconds of trading activity. These data are taken from normal German trading hours (9:00 to 17:45).

2 This method is based on Danielsson et al. (2018).

3 In order to identify extreme price events, we begin by calculating intraday volatility for each individual trading day since the beginning of 2020 based on the one-second price changes. The point at which an extreme price change begins is defined as the second in which the percentage price change is more than five times the standard deviation for that day. For simplicity, normal distribution is assumed for the underlying price changes at the one-second level. In this context, a 5-sigma price change represents an intense and rare event which, for example, occurred only 1,578 times within the 14.7 million-second time frame for the ten-year Bund future under review here. This means that a price movement such as this occurs approximately once every 9,500 seconds on average. In actual fact, however, extreme events tend to occur in clusters. Several "calm" days without any extreme movements may then be followed by a short period featuring a particularly large number of major price events (volatility clustering). Starting from this moment, we analyse the price change over the next 60 seconds, measuring the time that price volatility takes to return to normal levels. As markets and liquidity change over time, this normal range is not static either. The limit of the normal range is defined as a five-day moving median, +/- two standard deviations from the last four trading days prior to the event and on the day of the event itself and thus contains data from around 140,000 trading seconds. Each successive change in the price outside the defined normal range counts toward the duration. This means that the duration indicates the length of the extreme event up to the point at which the price movements first return to normal.

4 The average duration of an extreme price event for ten-year Bund futures is 1.9 seconds. This means that, on average, it takes two seconds for the intensity of the price changes to return to the normal range observed in the four preceding trading days.



tially, the indicators identify three periods in which market conditions have been tense since 2019: the COVID-19 crisis, the Ukraine war, and the increasing expectations of monetary policy normalisation as a result of the inflationary environment.

Developments in market conditions in an environment of heightened uncertainty

The COVID-19 crisis

In the spring of 2020, the COVID-19 pandemic dominated the capital markets and led to, in some cases, massive disruptions in many market segments. As of 1 March 2020, yields on Bunds initially declined as risk aversion rose. This flight to safety is not unusual in uncertain times.⁶³ However, starting on 9 March, ten-year Bund yields temporarily spiked up 75 basis points within the space of eight trading days,⁶⁴

thereby displaying volatility that is many times higher than is usual for this asset class. In this uncertain environment, there were also repeatedly periods of high illiquidity. Such price dynamics are exceptional for a benchmark segment such as Bunds, especially given that yields were rising and not falling (as is more common in risk-averse periods). This episode illustrates that even market segments generally regarded as very robust, such as Bunds, are not immune to temporary market distortions.

The turmoil was largely triggered by a global supply shock in leading government bond markets owing to numerous sell orders from market participants whose liquidity needs had shot up at short notice (dash for cash). A prime example are foreign central banks, for whom Bunds constitute an important component of

Worldwide sales of benchmark bonds in March 2020 prompting central bank interventions

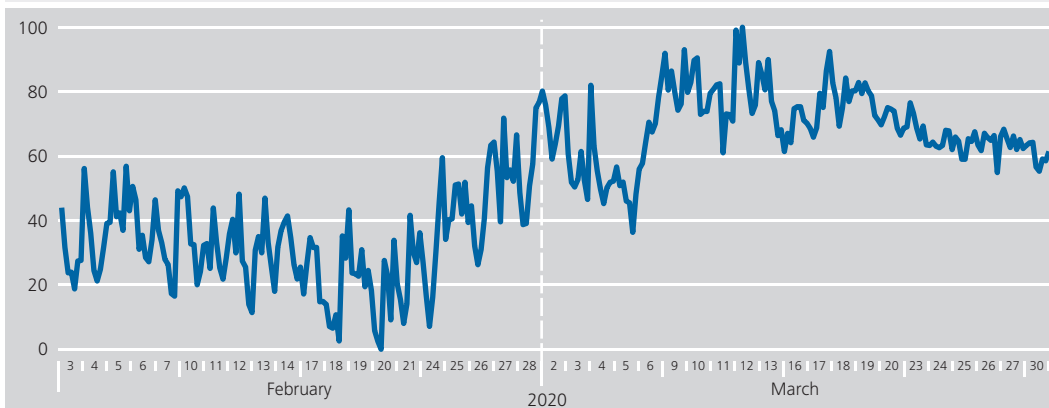
The COVID-19 pandemic has caused tensions in the Bund market as elsewhere

⁶³ See Deutsche Bundesbank (2018).

⁶⁴ Taking account of intraday movements. On a closing price basis, this figure works out at 56 basis points.

Futures market composite indicator for ten-year Bund futures at the start of the COVID-19 crisis

Hourly values over the course of the day; normalised to values between 0 and 100¹



Sources: Bloomberg and Bundesbank calculations. ¹ Higher values indicate greater market tension.

Deutsche Bundesbank

euro reserve assets. In March 2020, they sold an exceptional volume of Bunds, possibly in order to allow them to intervene more flexibly in the foreign exchange market should the situation escalate. However, Bunds were by no means the only market with benchmark status to experience the above-described phenomena. For example, a similar supply shock also led to a sharp drop in the liquidity of US Treasury bonds.⁶⁵ Moreover, as compared with the Bund market, the US Treasury market came under comparatively greater pressure.⁶⁶ In response, the Federal Reserve System absorbed considerable volumes of US Treasuries. On 18 March 2020, the Eurosystem, too, announced, that it was responding to the pandemic by launching a temporary pandemic emergency purchase programme (PEPP) of private and public sector securities, with an initial envelope of €750 billion. The announcement and start of purchases on 26 March 2020 helped to calm the market.

Inflation and the war in Ukraine

After a period of around 16 months in which market conditions were robust, a new market phase started to emerge at the end of October 2021. This was mainly due to the high degree

of uncertainty about future interest rate developments in an increasingly inflationary environment, which was initially driven by global supply chain bottlenecks. In a zero interest rate environment, bonds are particularly sensitive to rising interest rates, which meant that investors were also very uncertain about the valuations of Bunds. As a result, liquidity conditions deteriorated.

In this situation, with supply chains already vulnerable and inflation rising, the Russian war of aggression against Ukraine had a multiplier effect. The rapid rise in energy prices and renewed shocks to global supply chains not only weighed on the capital markets, they simultaneously put pressure on large swathes of the real economy. Faced with the sharp deterioration in the outlook for inflation over the medium term, the ECB Governing Council initiated monetary policy normalisation in the euro area by ending net purchases under the APP and PEPP monetary policy purchase programmes and undertaking its first interest rate hikes. Growing expectations of rising key interest

First expectations of interest rate changes since the end of 2021 due to growing inflationary concerns

War in Ukraine is additionally fuelling uncertainty and concerns about inflation

⁶⁵ See Fleming and Ruela (2020) and Duffie (2020). Furthermore, dealers had already increased their holdings of Treasuries sharply at the outbreak of the crisis, limiting their ability to absorb more. For more information, see He et al. (2020). Schrimpf et al. (2020) also identify sales by hedge funds as a reason for the supply shock.

⁶⁶ See Barone et al. (2022).

rates as a result of the inflationary environment and the high level of uncertainty in the real economy were accompanied by a decline in liquidity in the cash and future market for Bunds.

Scarcity premia in the repo market and asset swap spreads very high since 2022

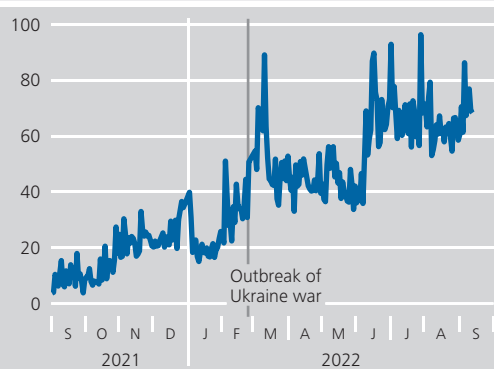
Other selected indicators, such as repo market rates and asset swap spreads,⁶⁷ are also displaying signs of certain tensions in the trade in Bunds. In 2022, the scarcity premium in the repo market again hit the record level last seen in 2016 and 2017, when monthly PSPP purchases were carried out at their maximum volume of €80 billion. One factor here was increased risk aversion as a result of Russia's war of aggression on Ukraine, which has significantly buoyed demand for Bunds, another was adjusted market positioning by investors due to expectations of an interest rate hike.⁶⁸ There is therefore nothing yet to suggest that the scarcity issue will ease given the end of the APP and PEPP monetary policy purchase programmes. Asset swap spreads have also risen significantly, which may be due to demand for hedging interest rate risk given rapidly rising expectations of an interest rate hike and market uncertainty about the extent of monetary policy tightening. At the Governing Council meeting on 8 September 2022, the deposit rate was raised to 0.75%. In order to prevent an abrupt outflow of deposits into the market and the associated collateral scarcity in some segments of the repo market, the ceiling for remuneration of government deposits with the Eurosystem was removed for a transitional period up to the end of April 2023. This adjustment contributed to a slight decline in asset swap spreads and the scarcity premium in the repo market in September.

The current environment and the COVID-19 crisis compared

In contrast to developments in the COVID-19 crisis, where market conditions normalised significantly after around two months, market conditions have remained tense ever since the

Overall market composite indicator

Daily data normalised to values between 0 and 100¹



Sources: Bloomberg, Eurex, MTS, Refinitiv, Trax and Bundesbank calculations. The analysis was conducted for the period from April 2019 to September 2022. ¹ Higher values indicate more strained market conditions.

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summer, despite a moderate recovery in April and May 2022.⁶⁹ Given this high degree of uncertainty and illiquidity reached in recent months, one might think that market conditions for Bunds currently bear similarities to the turbulent initial phase of the COVID-19 pandemic.

Market conditions strained for relatively long period in recent months ...

However, a nuanced analysis of the situation shows that the market phase currently being observed differs substantially from the period from mid-February to end-April 2020. In the first few days of the COVID-19 crisis, the indicators moved with significantly stronger momen-

... but not identical to the situation during the COVID-19 crisis

⁶⁷ The asset swap spread is the difference between the interest rate swap rate and the yield on a bond with the same maturity. A Bund asset swap spread combines the purchase of a fixed interest Bund with an interest rate hedge using an interest rate swap and reflects not only demand for interest rate hedging but also the general liquidity situation, as Bunds are considered to be the most liquid bonds.

⁶⁸ Numerous investors went short in the cash market as a bet on rising interest rates and financed these positions via the repo market.

⁶⁹ An important event in this development was the Governing Council meeting on 9 June 2022, as a result of which the end of net purchases under the PSPP was announced and fresh signals of monetary policy tightening were given. Intraday indicators such as the FCI or the resilience indicator show a very strong response from investors, which started immediately in the first few seconds after the announcement of the results of the Governing Council meeting (13:45 CET) and saw market conditions deteriorate sharply. In these first few seconds, the resilience indicator also registered a particularly long 5-sigma price event, which lasted for 12 seconds.

tum than the more gradual changes observed since October 2021, which have taken place over the course of several months. Moreover, during the COVID-19 crisis, market liquidity, in particular, deteriorated amid only temporarily elevated volatility (see the overview of indicators on p. 88). In the current environment, meanwhile, volatility and price anomalies are above the levels seen during the COVID-19 crisis, while liquidity is comparatively less tight. The observation that market conditions were subject to greater strain during the COVID-19 crisis than is the case in the current environment is further corroborated by a supplementary evaluation of the resilience indicator. Looking at the past few months, this indicator likewise suggests that the market has, when experiencing high volatility, remained subject to extreme volatility for longer periods of the day overall than was the case a year ago. However, looking at the average duration of individual extreme price events, it is clear that the market's resilience did not deteriorate significantly up until the summer of 2022 (see the box on pp. 90 f.). Overall, the COVID-19 crisis therefore caused a more severe slump in market conditions, the scale and dynamics of which have not so far been matched during the current market phase.

The current, exceptional market environment puts impairment of market conditions into perspective

Overall, the current market conditions should be seen in the context of the exceptional macroeconomic and geopolitical developments. As the associated uncertainties fade, market conditions for Bunds should pick up again.

■ Conclusion and outlook

Looking at Bunds, market conditions in general and market liquidity as a significant component have changed, not least as a result of the Eurosystem's monetary policy purchases. Analyses suggest that the central bank's net purchases may hurt the market liquidity of Bunds. This is particularly true if purchases are carried out over a long period of time and on a large scale. Central bank measures to mitigate undesirable side effects, such as securities lending, can then only partially compensate for these negative effects.

Future market conditions depend on developments in the market environment as well as on central bank activity and structural factors

The sudden crises of the past two and a half years, the considerable uncertainty about future inflation developments and, most recently, the transition to a positive interest rate environment have also caused certain tensions in market conditions for Bunds and the market segments directly linked to them. Similar observations have also been made in other countries, such as the leading market for benchmark bonds, the United States.

At least some of the described stress factors are likely to recede over time. A central bank's contribution is to keep medium-term inflation expectations well anchored. Looking forward, the Eurosystem is also likely to reduce its holdings of Bunds again – as other central banks are already doing – thus helping to raise the free float.

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